



Development Higher Order Thinking Skills Instruments in Human Respiratory System Material

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Abstract

Higher Order Thinking Skills is one of the skills that is needed in studying the human respiratory system. Since the heart is one of the most vital organs in people and pumps blood, the human system respiratory is one of the most significant biology concepts for students to comprehend. The goal of this research is to create accurate and valid breathing equipment for humans. Research and Development (R&D) using the 4D model is the methodology employed in this study. Define, Design, Develop, and Disseminate are some of the stages. The study's findings show that the instrument the human respiratory system produced is practical to use. Because it is greater than 0.325 and the reliability is greater than 0.6, the empirical validation results indicate that there are 10 valid claims.

Keywords: Biology, Instruments, Higher Order Thinking Skills, Human Respiratory System

INTRODUCTION

The natural science field of biology examines a range of issues pertaining to living things, including both unicellular and multicellular creatures (Harahap et al., 2020). Biology is another scientific discipline that offers a variety of learning opportunities for comprehending ideas and the scientific method, including hands-on activities like observation, inquiry, and logical analysis to generate facts and ideas (Harahap, 2020). System respiratory is one of the most challenging biological concepts for students to comprehend and master.

Respiratory, also known as gas exchange, is the process by which molecules of O₂ are taken up from the environment and CO₂ is released into it (Campbell et al., 2010). Respiratory encompasses two processes: external respiratory, which includes the body's overall intake of oxygen and its overall removal of carbon dioxide. Next comes internal respiratory, which includes gas exchange between cells and their fluid medium as well as the use of oxygen and the creation of carbon dioxide by cells (Utamy & Rosdiana, 2023; Dhaniawaty & Fadillah, 2022; Syahriani & Hasruddin, 2024; Karina & Lisdiana, 2022).

System respiratory is the subject of several primary discussions, including tool respiratory, stages respiratory, gas transport mechanism, and the impact of air pollution on system respiratory (Campbel et al., 2008; Wafi et al., 2022). A learning process that involves problem-solving is necessary due to the abstract nature of the material, which encompasses a wide range of information and demands a high degree of comprehension (Osman et al., 2024; Karina & Lisdiana, 2022).

Participant education in science fosters the development of high-level, inductive thinking, scientific attitudes, and communication abilities that are all interwoven (Rustaman, 2003). To achieve comprehension, learning involves more than just memorization; it also involves deep and sophisticated thought. The ability to think complexly will help participants become accustomed to facing challenging situations, therefore students' higher order thinking skills are necessary.

Higher Order Thinking Skills are the ability to think of somebody based on newly obtained information (Abdul Razak et al., 2024; Kwangmuang et al., 2021). Then relate it to information that has been saved in the memory and integrate it with the conditions moment now for can solve a problem which difficult to solve. HOTS is used in a way wider to find new challenges (Michalsky, 2024; Jansen & Möller, 2022). Applying information to new knowledge previously and arranging information to reach the possible answer in the new situation is part of hope for someone who has the ability to HOTS. The method gets the knowledge contained therein there is a level of think synthesis, analytical, and evaluative, furthermore involving activity mentally in business explore experience yes complex, reflective and creative which is done in a way conscious to achieve the objective is the definition of HOTS (Nowlan et al., 2023; Imjai et al., 2024; Oo et al., 2024).

HOTS is a process of thinking that sets students to organize information And ideas with methods certain Which give them understanding and implications (Prasetyo & Wilujeng, 2023), the ability to logic and reason, analysis, evaluation, and creativity. Students' HOTS can basically be trained through science learning including biology learning. This is because biology needs learning competencies in the domain of understanding high level. Biology own important role in preparing students to overcome real-world problems (Belawati, 2023).

HOTS is used in real-time learning to examine how the respiratory organs function, which necessitates reasoning in order to How each organ involved in the system's breathing functions Next, start with the occurrence of breathing. How does the body go through this process? respiratory, as well as the ability to assess airflow mechanisms, respiratory, and gas exchange Next, resolve the issue that arose in the respiratory of the material system by

formulating a hypothesis. Students will become acclimated to comprehending challenging information through process learning that incorporates HOTS. According to (Harahap et al., 2020; Yudha, 2023) material biology is a complex subject that involves a lot of science and is also challenging for students to understand.

According to observations, system material respiratory scores for students are still low. Because teachers are accustomed to giving a lot of level questions, students are not accustomed to thinking at that level. The development of cognitive tools with a higher level of thought is therefore required (Gou, 2024). The implementation of learning models that involve students actively in the learning process or that are centered on them is not enough to make HOTS learning in the classroom successful; it also requires the use of instrument evaluation that is HOTS based and critical thinking so that students are trained and accustomed to answering HOTS questions. The capacity of educators to carry out an assessment or additionally, the exam is meant to help teachers determine if pupils have comprehended and understood the material. Assessing students' HOTS on the system content is crucial for educators. breathing, as this information pertains to circumstances that high school pupils frequently encounter. Smoking behavior, whether within or outside of schools, is one of the major issues that is commonly experienced.

If the teacher conducts evaluation and assessment, it will be possible to determine the level of competence that the students possess (Harahap, 2023; Asomaku, 2023). Evaluation is a measurement method used to determine how well students have understood the teacher's lessons. Evaluation is the process of identifying activities to determine if a program has been successful or not, whether it is worthwhile, and whether it can be used to assess the degree of implementation efficiency (Faradisa et al., 2024; Santosa & Razak, 2023; Kurniahtunnisa et al., 2023; Harahap & Harahap, 2024). Therefore, the development of HOTS student instruments on system material digestion is required. Teachers can utilize the findings from assessments to refine and enhance their subsequent lesson plans.

RESEARCH METHODS

Methods used in this research are research and development (R&D), to make HOTS based student test instrument products on system material respiratory human for class XI MIA Telukjambe. This study adapted the development model of Thiagarajan, Semmel, & Semmel (1974) namely in Figure 1. Define stage consists of front-end analysis, learner analysis, task analysis, and analysis concept.

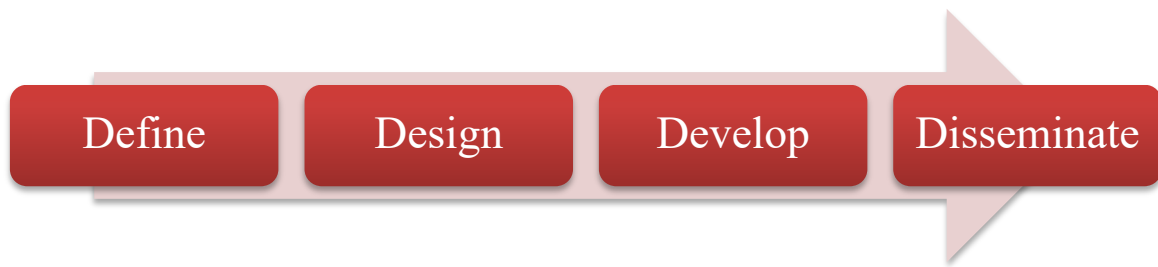


Figure 1. Development Model

The design stage is stage planning or design the beginning such as making an outline, determining the indicators to be used measured, and developing HOTS essay system instrument complete respiratory with rubric assessment. The Develop stage consists of instrument assessment by validator and validation empirically on students to find out the level of feasibility of the developed instrument in measuring HOTS system respiratory man. This research is limited to the develop stage only.

The population of this study is all students of class XI MIA SMAN 2 Telukjambe. Data collection techniques sample use *Purposive Sampling* that is class XI MIA 2 because has the largest number of students compared to other science classes namely as many as 37 students. Each student was given sample HOTS questions on the human respiratory system. The data was obtained in the form of quantitative and qualitative data. Qualitative data was obtained from the validator's comments and suggestions regarding the format, materials, and suitability of the HOTS system instrument respiratory. Quantitative data was obtained from the average score of student instrument validation results.

RESULTS AND DISCUSSION

The results of this study are in the form of a Higher Order Thinking Skills questionnaire instrument. The following are the results of development in each phase. The results of this study are in the form of HOTS essay instruments in the discussion of the system. respiratory human. The following are the results of the development of each instrument and its phase.

1. Define

a. Front-end Analysis

This analysis is in the form of unstructured interviews conducted with biology teachers who teach in class XI regarding learning activities. From the interview obtained information that teachers often vary the learning models, especially learning models related to discussions between students. Not only that, teachers also often make the atmosphere active for students through learning games. Students are also used to working on questions in essay form, but

essays that are still in category light. The teacher has not yet made it a habit students to answer HOTS questions because Still has difficulty with his assessment.

b. Analysis Student

Based on interviews conducted with teachers, the HOTS student's learning is still low. This is seen from the results of the preliminary tests carried out, it was included in category low which is 68.92 which means still below standard.

c. Task Analysis

Based on front-end analysis and analysis of students, there needs to be an effort to improve the HOTS system material respiratory of human beings in students. One of them is by habituation provide HOTS essay assessment instruments and instruments that cover all sub-chapters of the system material respiratory.

d. Analysis Draft Content

Analysis results obtained from competency standards and competencies base.

2. Design

a. Stage of creating outlines and determining indicators

Designing HOTS System Instrument respiratory man in essay form requires several considerations such as font, selection, placement of picture or table, and arrangement of question sentences so as not to produce ambiguous questions. The following is presented in Figure 2.

A. ANALISIS

1. Berikut ini merupakan gambar pencemaran berasal dari puntung rokok.



- a. Buatlah rumusan masalah yang berhubungan dengan gambar di atas!
 - b. Buatlah hipotesis yang sesuai gambar di atas!
2. Terkait tekanan parsial gas pernapasan, apakah terdapat perbedaan antara situasi di pantai dengan di atas gunung Jaya Wijaya? Jelaskan tentang pengaruh ketinggian tempat pada tekanan atmosfer!
 3. Hemoglobin merupakan pigmen respiratori yang paling dikenal dan cara kerja yang efisien. Hb ditemukan dalam darah manusia, protozoa dan beberapa filum, Hb tersusun atas senyawa porfirin besi (hemin) yang berikatan dengan protein globulin. Jelaskan faktor-faktor yang mempengaruhi afinitas oksigen oleh hemoglobin!
 4. Bagaimana O₂ dan CO₂ bergerak secara melintasi epitel atau membran respirasi? Faktor apa saja yang mempengaruhi kapasitas pergerakan O₂ di paru-paru?
 5. Transpor CO₂ dalam bentuk H₂CO₃ dan HCO₃⁻ sering menyebabkan terjadinya penurunan pH karena keduanya bersifat asam, keadaan jaringan yang asam akan

Figure 2. Higher Order Thinking Skills Instrument Design

The outline in Figure 2 consists of the Higher Order Thinking Skills indicators, questions, and answer keys. The questions used in this study in the form of test questions *Higher Order Thinking Skills* (HOTS) with the category cognitive in Revised Bloom's Taxonomy (Anderson and Krathwol, 2001) that is level *Analyzing* (C4), *Evaluating* (C5) And *Creating* (C6).

b. HOTS instrument development

Indicators that have been determined Then developed and grouped in several aspects in Table 1.

Table 1. Instrument Grid HOTS

Aspect	Aspect Cognitive			Amount Question
	C4	C5	C6	
Organs compiler systemrespiratory	2,	11		2
Transportation gas	15*	7,	4,	3
Binding of oxygen andcarbon dioxide	3*		6, 8,	3
Danger cigarette and health	5*	12*	1	3
Phase inspiration And expiration,And respiratory volume	13*, 14			2
Arrangement respiratory	10,	9		2
Amount				15

Note: *No Valid

3. Develop

a. Expert Score

Two biology education master lecturers with expertise in HOTS and system materials served as the study's validators. human respiratory. Lesson Plan Learning Implementation (RPP), Syllabus, and HOTS indicators are all mentioned in the validation process. Throughout the validation process, the validator offers feedback and recommendations regarding the questions' correctness, presentation, HOTS concept, HOTS indicator applicability, and system material indicators' respiratory man suitability. The validator will evaluate the completed development tools in numerical form, ranging from 1 to 100. Aspects such as question construction, language, appropriate topic, completeness instrument, and conformance approach assessment are all evaluated. The average search will then be used to determine eligibility instruments, are shown in Table 2

Table 2. Expert validator scores for HOTS on the human respiratory system

Component	Type of Questions	Validators	Percentage Eligibility	Total Average	Conclusion
Higher Order Thinking Skills	Essay	Validator I	77.35	81.24	Worthy
		Validator II	85.12		

Based on Table 3 it can be concluded that the instruments developed are appropriate or worthy to measure HOTS system respiratory man Because reached an average of 81.24. Therefore, further research can be carried out to validate empirically.

b. Validation Results in Empirical and Reliability

Tables 1 and 2 demonstrate that, due to a Rtable of 0.325, there are a minimum of 10 eligible HOTS questions that meet or surpass the qualifying mark. With the question criteria, "reliable," the reliability outcomes instrument had a score of 0.881. This indicates that the instrument has a high level of reliability, meaning that it will consistently produce the same outcome when used anywhere and at any time.

Table 3 Calculation results validity test questions

Criteria Validity of Questions	Question Number	Amount
Valid	1, 2, 4, 6, 7, 8, 9, 10, 11, 15	10
Invalid	3, 5, 12,13,15	5

Instrument Higher Order Thinking Skills

HIGHER ORDER THINKING SKILLS INSTRUMENTS

Student Name :

Class :

Instruction :

1. Write down the identity you are in the place that has been provided
2. Answer the questions that have been provided
3. When working on questions, you are not permitted to cheat.

1. Following This is a picture of pollution originating from butt cigarettes.



- a. Make it formulate the problem that relates to the picture in one!
 - b. Make it hypothesis that matches the image above!
2. Related to pressure partial gas breathing, there is a difference between the situation on the beach with the Jaya Wijaya mountain on top? Explain about the influence height places on pressure atmosphere!
 3. Hemoglobin is the most well-known respiratory pigment and its mode of action Which efficient. Hb is found in human blood, protozoa, And a number of phylum, Hb is composed of compounds porphyrin iron (hemin) which binds to protein globulin. Explain the factors that influence affinity oxygen by hemoglobin!
 4. How do O₂ And CO₂ move in a way across epithelium or membrane respiratory? What factors influence the capacity movement of O₂ in the lungs -lungs?
 5. Transport of CO₂ in the form of H₂CO₃ and HCO₃⁻ - often causes the occurrence decrease in pH due to both of their natural sources, condition acidic network can interfere with the work of enzymes and activity metabolism cells because it's an opportunity the emergence acid should be avoided. How does the mechanism work? transportation CO₂ Which is done so that maintain balance pH?
 6. Effect Bohr And Haldane are two characteristic hemoglobin, they help separate gas breathing from molecule hemoglobin based on the condition's physiological final destination. Explain the occurrence Bohr Effect and Haldane!
 7. The body will react to various matters and reasons for sneezing, However, basically sneezing is triggered by the reflex body. How does the mechanism breathe when it happens to sneeze?

8. How is it? mechanism reflex between channel breathing And channel digestion of food in the pharynx when swallowing food so that food No entered into in channel breathing?
9. If the volume of air that enters the lungs during normal breathing of a person woman is 400mL and the frequency of breathing for 10 minutes is 150 times, what amount of respiratory volume per minute?
10. If the known volume of tidal lungs is 380 mL, volume backup expiration 800 mL, and reserve volume inspiration 1,900 mL, what is the capacity? inspiration?

Here are the answers for the highest scores

1. Based on picture

- a. Cigarettes are not only air pollutants, ash and the rest of the butts too will become polluter land from Lots of people who smoke. The impacts that generated not only for users of cigarettes but also for those who are in their surroundings Because they inhale substances dangerous said. It is also very dangerous for the environment, one of which is if someone throws away cigarettes that are still There is an axis to the grass, which can result in burning grass.
- b. This pollution causes damage to fertile land because insidecigarettes there are Lots of substances That dangerous And can bother until damage the land. butt cigarettes are not easily decomposed, Fiber Cellulose acetate is a pollutant in general, it could be a cigarette swallowed by animals that cause death

2. There is a difference when we are on the beach And on the mountain, We will have difficulty breathing in pressure and partial oxygen on the mountain. The pressure atmosphere on the mountain is far, far low from in beach (presentation oxygen remains 20.9%) against air, but the pressure of the atmosphere on the mountain is only around 400mmHg, meaning only around half the pressure partial oxygen on the plains is low. Method count pressure partial:

$$P_x = (x/100) P$$

$$P_x = \text{gas pressure } x \text{ (mmHg);}$$

$$x = \% \text{ volume of gas } x;$$

$$P = \text{total pressure of the gas mixture (=air pressure) (mmHg)}$$

$$PO_2 = 20.9/100 \times 760 \text{mmHg} = 159 \text{mmHg}$$

3. Factors affecting

- a. PO₂ or Pressure Partial O₂
PCO₂ or Pressure Partial CO₂ Blood PCO₂ increases in the systemic capillaries so that

CO₂ diffuses from cells to blood following a decreasing gradient causing a decline in Hb affinity for O₂

b. Temperature or Temperature Hot

BPG Increase in BPG is generated from metabolic glycolysis and there is in blood so that Hb binds to BPG to reduce affinity Hb to O₂ and curve shift to the right

4. O₂ and CO₂ move in a passive way across epithelium or respiratory membrane (lungs or gills) by diffusion. Factors that determine diffusion gas respiration across membrane respiration are the partial pressure of the gas, the permeability of the respiratory membrane, the area surface of the respiratory membrane, speed circulation blood, And reaction chemistry Which happens inside the blood.
5. Transport of CO₂ in compound form bicarbonate is how to maintain a balanced pH. In the process This ion HCO₃ (ion bicarbonate) will bind to Na⁺ or K ions in abundance contained in the network, to form NaHCO₃ (compound bicarbonate). Mechanisms maintain pH with a method like That named buffering mechanism, maintaining pH balance is a task addition to the system respiration, outside of its main task of transporting O₂ and CO₂.
6. Bohr effect is the decreased oxygen binding capacity of hemoglobin with an improved concentration of carbon dioxide or declined pH that helps release oxygen from oxyhemoglobin in network metabolism.

Effect Haldane is a declining capacity binding carbon dioxide hemoglobin with increased concentration oxygen, effect Haldane helps release carbon dioxide from carboxyhemoglobin in the lungs.

Equation = are two properties of hemoglobin, They help gas separation respiration from molecule hemoglobin based on condition physiological objective end they

7. Receptors in the air channels and lungs are innervated by myelinated vagus fibers and unmyelinated (c fibers), location of the ends of the C fibers is close to the blood vessels pulmonary, so that is called J receptor. This receptor is stimulated by things that cause sneezing (like capsaicin), the response caused is stop breathing followed by rapid respiration. Sneezing begins with inspiration, followed by the expiration of strong opposition glottis Which closed. Matter This increase pressure intrapleural reach 100mmHg or more. Glottis opens in a way suddenly, this reflex helps expenditure irritants and maintain the respiratory tract keep it clean

8. Between channel digestion And channel respiration There is one layer valve That limits both of them, At the moment so valve will close channel respiration. Because of that, Don't Eat while talking because the valve will open, No There is a divider between channel breath And Eating, sofrom there it is incident choked
9. The total respiratory volume can be calculated using $150/10 = 15$ times in 1 minute. Volume = $400 \times 15 = 6000$ ml
10. It is known :
 - Lung volume = 380 ml,
 - Volume reserve = 800 ml
 - Inspiratory reserve volume = 1,900 ml
 - Total capacity lungs = $1,900 \text{ ml} + 800 \text{ ml} = 2,700 \text{ ml}$
 - So $2,700 \text{ ml} - 380 = 2,320 \text{ ml}$

CONCLUSION

Based on the results of the study, it can be concluded that the higher order thinking skills instrument on respiratory system material developed in the form of essay tests that has been developed is appropriate for measuring students' higher order thinking skills. There are 10 valid and reliable instruments. Developed essay questions It is hoped that it can help teachers in direct student in mastery of system material respiratory and most importantly is to be able to guide students to think more high , because student will required to answer questions to become more complex and detailed.

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