Universitas Muhammadiyah Malang, East Java, Indonesia

JPBI (Jurnal Pendidikan Biologi Indonesia)

p-ISSN 2442-3750, e-ISSN 2537-6204 // Vol. 7 No. 2 July 2021, pp. 136-148

*Research Article*

# Learning Progression: How should we teach about disease to determine students' level of understanding?

Roni Ardiansyah [a,1], H. Harlita [b, 2], Murni Ramli [b, 3*]

[a] Department of Biology Teacher Education, Postgraduate Program, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Kentingan, Jebres, Surakarta, Central Java 57126, Indonesia.

[b] Department of Biology Teacher Education, Faculty of Teacher Training and Education, Universitas Sebelas Maret, Jl. Ir. Sutami 36A, Kentingan, Jebres, Surakarta, Central Java 57126, Indonesia.

[1] ardiansyahroni457@student.uns.ac.id, [2] harlita@staff.uns.ac.id, [3]mramlim@staff.uns.ac.id*.

* Corresponding author

ARTICLE INFO

Article history
Received: 29 April 2021
Revised: 16 Juny 2021
Accepted: 26 Juny 2021
Published: 31 July 2021

Keywords
Disease
Learning progression design
Learning progression

ABSTRACT

Strengthening Learning Progression (LP) for students' reasoning abilities is important, especially learning about diseases in Indonesia. This study aimed to map the learning progression of disease in Indonesia, compare and analyze its similarities and differences with the LP designed by National Reseaarch Council (NRC). This qualitative research to map LP, using the analysis documen method by comparing the content analysis of Basic Competencies of Curriculum 13 with benchmark analysis from the NRC 2007 on Science and Biology textbooks published in 2016, 2017, and 2018 at the elementary, junior high, and high school levels published by the Ministry of Education and Culture of the Republic of Indonesia. The findings are the LP on disease in the curriculum and life science textbooks in Indonesia has not met the benchmarks, especially in three categories, namely; pathogens, the immune system, and infection spanning learning from K-2 (elementary) to K-12 (high school). Therefore, it is necessary to categorize LP topics in diseases based on conceptual abilities from the simplest to the most complex.



How to cite: Ardiansyah, R., Harlita, H. & Ramli, M. (2021). Learning Progression: How should we teach about disease to determine students' level of understanding? *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 7(2), 136-148. doi: https://doi.org/10.22219/jpbi.v7i2.16431

## INTRODUCTION

Learning Progression (LP) is a sequence of students' conceptual understanding by looking at their concept constructions developed from core ideas into several big ideas (Duschl, 2019). LP is a complex way of thinking in understanding a topic or concept (National Research Council, 2007). LP is a hypothesis on howstudents understand a topic that shows their achievement according to their grade (Todd et al.,, 2016). LP is also a complex way of thinking over time in understanding ideas or concepts in sequence (Herrmann-abell & Deboer, 2018). Basically, the sequence and scope of concepts that should be taught at school will be the aspect that teachers need to concern to develpop the learning design and learning activities of certain subject. It is also a basis for curriculum developer to think about the flow of core concepts that should be set up to learn the simple concepts to the complex one from the lowest level of school to the highest.

Previous works had revealead the important utilization of LP. LP has a role in developing biology learning from kindergartens (Elmesky, 2013), elementary and middle schools (Duncan et al., 2014), high schools (Stevens et al., 2013; Todd et al., 2016), and higher education (Todd et al., 2017). It is also very useful to map students' understanding from the basic concepts to more complex (Herrmann-Abell & Deboer, 2018). LP is also identified as the approach used by teachers to explore concepts from simple to more complex ones (Wulandari & Ramli, 2019). Since the difficult and complex science topic urge the students to be more creative in seeing problems from all points of view, it is important to help students understanding the complex concepts from it simple format. LP can probe students' understanding of complex concepts from their point of view (Van et al., 2016). LP also can integrate and expand strategies to develop core ideas in science learning. LP is not only a tool to revise a curriculum, but also to make the more effective and optimal curriculum implementation (Gallacher & Johnson, 2019).

LP on disease was initially promoted by NRC 2007. The concepts of disease by the NRC are divided into three sub concepts, i.e., the genetic factors influence the disease of organism, the human defense or immune system, and the infecton of pathogen. Based on the NRC's LP scheme, there were many researchers developed LP on the biology topics. For example, the LP genetics, which was reviewed by (Todd & Kenyon, 2015). It received good responses from researchers who focused on the concepts of modern genetics. LP in genetics and biodiversity are two of issues that have been studied widely (Duschl, 2019; Elmesky, 2013).

The concept of disease has been introduced to kindergarten students in many ways in several countries, including Indonesia. For example, students have been trained on how to brush teeth properly. This is an important step to maintain the child's immune system. At this age, they have a great curiosity about the surrounding environment, so they are very susceptible to contracting diseases. Primary school children have been educated about the immune system. However, this was introduced only as a way of how to wash hands properly, and not to buy food from unhygienic places to avoid disease (Juriah et al., 2018; Megawati et al., 2018; Utami & Waladani, 2018).

The topic of disease, especially infectious disease becomes more urgent and crucial to be studied in Indonesia and other countries, particularly in this current pandemic of Covid-19. Although, the topic of disease has already set up in the science curriculum of many countries, strengthening the topic of the human infectious diseases such as dengue fever, influenza, SARS, MERS, and other corona virus infectious disease, becomes more important recently. However, the topics related to disease in the Indonesia science curriculum seems have not yet have a well-defined sequence and scope as well.

A clean and healthy lifestyle can be trained by studying vector organisms that carry or spread diseases, as has been done by Norista & Norfai (2019). The introducing of the concept of infectious diseases is very important due to Indonesia, as a tropical country, has many types of infectious diseases and their vectors (Swara, 2020). Not all diseases can be transmitted, but maintaining health and cleanliness can reduce the risk of contracting infectious diseases in the future (Su & Yang, 2015). Moreover, understanding about viruses and the environment will increasing the awareness of humans about its infection and less prone to panic when a pandemic occurs (Benjamin et al., 2020; Drucker & Then, 2015; Pascapurnama et al., 2018; Randolph & Barreiro, 2020; Sarkar et al., 2021).

The concept learned in high school students is more difficult and complex compared to elementary or middle schools. It may result in frequent misconceptions (Coley & Tanner, 2015). Misconceptions occurred at the high school levels showed that students' understanding of basic concepts was unsystematic. The concepts learned by students should be systematized from the simplest to the most complex ones and should be firm. If not, it can lead to misconceptions (Potvin et al., 2020). Conceptual understanding is expected to develop by connecting one concept with another (Wyner & Doherty, 2017).

So far, learning about disease has focused on diseases caused by the environment and social activities (Afridah & Fajariani, 2017; Juriah et al., 2018; Yang et al., 2016). Various studies found inconsistent and sporadic learning about the disease across all levels of education. LP about the disease is expected to systematize the learning sequence and scope of disease from elementary to high school.

National Research Council (NRC), conducted four topics related to LP: (1) Defining LP; (2) Development of LP; (3) Modeling and interpreting LP; and (4) Use of LP. Point 4 refers to the application of LP in reviewing science education, including the design of standards, curriculum, and teacher education (Duschl et al., 2011; Kobrin et al., 2015). The conference also spurs the popularity of LP. Research on LP has been developed in various disciplines, and in evaluating the LP itself in terms of content, use, and validation (Kobrin et al., 2015). LP has the potential to set standards, assess, and provide direction to promote scientific literacy. Big ideas can be explored in a period of continuous learning. LP is used by practitioners as an improvement in the high-

quality curriculum in Korea (Lee & Yeo, 2015). LP promises a better approach to science education by aligning various aspects of the education system that focus on scientific social information and students' learning styles (Scott et al., 2019).

Meanwhile, a clear and concise LP about disease will help teachers in designing lesson plans according to the class level and students' ability to understand the certain concepts. Therefore, it is urgent to design the proper learning progression of disease which will be a basis for teachers in Indonesia or other countries to construct learning design or lesson plan. For that reason, the first step must be run is to analyse the concepts of disease taught at school through curriculum and textbooks analysis. To analyse the curriculum and textbook, the benchmark from NRC was used. NRC has formulated the Construct-Modeling Approach to develop a Learning Progression according to the level and component analysis connected at each level (Duschl et al., 2011). Three categories were used as the basis to develop LP about the disease in Indonesia. They were pathogens, body immune system, and infection.

This research aims to provide information regarding the sequence and scope of disease concepts in Indonesian curriculum and textbooks. Based on this analysis, the suitable LP of Diseases was constructed. The LP is expected to ease the teachers to develop more effective lesson plans. The research questions focused on how does the sequence and scope of concept of disease is composed in the Indonesia's science curriculum, and the textbook? Do the sequences have met the ones promoted by the NRC? What kind of LP design which can be recommended based on the analysis?

## METHOD

The qualitative research design was applied with the following stages: 1) analyzing the basic competencies in the 2013 Curriculum about the concept of disease; 2) analyzing elementary school thematic books, junior high school science textbooks, high school biology textbooks; 3) comparing the results of the analysis with the benchmark from National Research Council (NRC) 2007; and (4) compiling the LP about disease according to the 2013 Curriculum based on textbooks used by Indonesian students. The books analyzed are science and Biology textbooks published in 2016, 2017, and 2018 by the Indonesian Ministry of Education and Culture.

Document analysis was used to map the material related to disease in the 2013 Curriculum and the textbooks. At primary school, they are thematic books that explain all subjects in one theme. Meanwhile, middle school textbooks are science textbooks that contain physics, chemistry, and biology in one book but are separated in each chapter. The textbooks for high school students were the biology textbooks, and the content analysis focused on the topics directly related to pathogens, the body's immune system, and infection. The 2013 Curriculum analysis was used to map the concept of disease. It then, was used as a reference to design LP about the disease.

## RESULTS AND DISCUSSION

NRC has divided the concept of disease into levels for various sub-topics. Those levels were level 1 for K2, level II 3–5, level III for 6–8, and level 4 for 9–12. The concepts were divided into three sub-topics: 1) genetic problems, 2) the body's defenses, and 3) infection. The subtopics were coded as follows: 1) LPA for genetic diseases, 2) TBSA for the immune system, and 3) LPC for infection. Each concept also to be coded as follows: LPA 1, LPB 1, LPB 2, LPB 3, LPB 4, LPB 5, LPB 6, LPB 7, LPB8, LPB9, LPB10, and LPC1, LPC2, LPC3, LPC4, LPC5, LPC6, LPC7, LPC8, LPC9, LPC10, LPC11. For LP found specifically in Indonesian Textbooks, the codes were: 1) LIA for pathogens, 2) LIB for the body's defenses, and 3) LIC for infection. The codes were detailed in Table 1.

The mapping of concepts related to disease in the 2013 Curriculum is presented in Table 2. There are 19 Basic Competencies (BC) about the disease, and all of them are taught in elementary, middle, and high schools. Five BC are taught in elementary school grades 4, 5, and 6. They are related to maintaining personal health and the environment, and the importance of maintaining cleanliness. In middle school, seven BC are taught in grades 8 and 9. They are related to the human immune system. In high school, seven BCs are taught in grades 10, 11, and 12. For tenth graders, they learn about viruses, bacteria, fungi, and protists, while eleventh graders study diseases related to human organ systems and twelfth graders are immunity and genetics, can be seen in Table 2.

**Table 1.** The NRC's learning progression of disease

| Grade | Genetic problems (LPA) | The body's defenses (LPB) | Infection (LPC) |
|---|---|---|---|
| K2 | NR | Some things people take into their bodies from the environment can hurtthem. LPB-1<br><br>Diseases caused by germs may be spread by people who have them. Washing one's hands with soap and water reduces the number of germs that can get into the body or that can be passed on to other people. LPB-2 | Some diseases are caused by germs, some are not. LPC-1<br><br>Most microorganisms do not cause disease, and many are beneficial. LPC-2<br><br>If germs are able to get inside one's body, they may keep it from working properly. LPC-3 |
| 3–5 | NR | Skin keeps the body from drying out and protects it from harmful substances and germs.<br>For defense against germs, the human body has tears, saliva, skin, some blood cells, and stomach secretions. LPB-3<br><br>A healthy body can fight most germs that do get inside. However, there are some germs that interfere with the body's defenses. LPB-4 | There are many diseases that can be prevented by vaccination, so that people don't catch them even once. LPC-4<br><br>There are some diseases that human beings can catch only once. LPC-5<br><br>Specific kinds of germs caused specific diseases. LPC-6 |
| 6–8 | In organisms that have two sexes, typically half of the genes come from each parent. LPA-1 | White blood cells engulfinvaders or produce antibodies that attack them or mark them for killing by other white cells. The antibodies produced will remain and can fight off subsequent invaders of the same kind. LPB-5<br><br>White blood cells engulf invaders or produce antibodies that attack them or mark them for killing by other white cells. The antibodies produced will remain and can fight off subsequent<br>invaders of the same kind. LPB-6<br><br>Gene mutation in a cellcan result inuncontrolleddivisioncalled cancer. Exposureof cells to certainchemicals and radiationincreases mutations andthus the chance of cancer. LPB-7<br><br>Psychological distress may affect an individual's vulnerability to biological disease. LPB-8 | Viruses, bacteria, fungi, and parasites may infect the human body and interfere with normal body functions.A person can catch a cold many times because there are many varieties of cold viruses that cause similar symptoms. LPC-7<br><br>Pasteur found that infection by disease organisms (germs) caused the body to build up an immunity against subsequent infection by the same organisms. He then produced vaccines that would induce the body to build immunity to a disease without. LPC-8<br><br>The length and quality of human life are influenced by genes and environmental factors, including sanitation, diet, medical care, and personal health behaviors. LPC-9 |
| 9–12 | NR | Some allergic reactions are caused by the body'simmune responses to harmlessenvironmental substances. Sometimes the immune system may attack some of the body's own cells. LPB-9<br><br>Faulty genes can cause body parts or systems to work poorly. Some genetic diseases appear only when an individual has inherited a certain faulty gene from both parents. LPB-10 | The immune system protectsthebody from microscopic organisms and foreign substances and against some cancer cells that arise within. LPC-10<br><br>Some viral diseases, such as AIDS, destroy critical cells of the immune system, leaving the body unable to deal with multiple infection agents and cancerous cells. LPC-11 |

The topics related to disease were presented in Table 3. In elementary schools, the topics are related to maintaining personal health and a healthy environment. Several elementary thematic books have presented the concepts of disease which state that the cause of the disease is germs. Middle school students study disorders in the digestive, respiratory, excretory, and circulatory systems. The high school students deal with more complex topics such as viruses, bacteria, fungi, and human organ systems.

Those topics are not all directly related to the concepts of the LP from NRC. It showed that for third, fourth, sixth grades did have topics about diseases. For middle school, no concepts about the immune system that concur with the LP from NRC. The concept about disease contained in the textbooks was shown in Table 3.

**Table 2.** Analysis of concepts related to disease in the 2013 Curriculum.

| Grade | Basic Competencies | NRC |
|---|---|---|
| 4 | 4.3.7. Explain the importance of preserving natural resources and the environment | NR |
| 5 | 5.3.2. Describe the respiratory organs and their functions in animals and humans, and how to maintain their health. | NR |
| 5 | 5.3.3. Describe the digestive organs in animals and humans, their functions, and how to maintain their health. | LPB1, LPB2 ,LPB3, |
| 5 | 5.3.4. Describe the circulatory organs in animals and humans, their functions, and how to maintain their health. | NR |
| 6 | 6.3.2. Link puberty in boys and girls to reproductive organs' health. | LPB6,LPB7 |
| 8 | 8.3.1. Analyze human locomotory systems, and efforts to maintain its' health | NR |
| 8 | 8.3.5. Analyze the digestive organs in humans, their functions, and how to maintain their health. | LPA1,LPC6,LPC7,LPC8 |
| 8 | 8.3.6. Describe various additives in food and beverages, addictive substances, and their impact on health. | NR |
| 8 | 8.3.7. Explain and understand the circulatory system, diseases and disorders related to the circulatory system, and efforts to maintain the health of the circulatory system. | NR |
| 8 | 8.3.9. Analyze and understand the respiratory system, disorders and diseases of the respiratory system, and maintain the health of the respiratory system. | LPB6,LPB7 |
| 8 | 8.3.10. Analyzing the excretory system in humans, understanding disorders of the excretory system, and efforts to maintain the health of the excretory system | NR |
| 9 | 9.3.1. Connecting the human's reproductive system and its disorders with the healthy lifestyle that supports the reproductive system. | LPB8, |
| 10 | 10.3.4. Analyzing the structure, replication, and role of viruses in life. | LPB9 |
| 10 | 10.3.5. Identify the structure, way of life, reproduction and role of bacteria in life. | LPB10 |
| 10 | 10.3.6. Classify protists based on their general characteristics and their role in life. | LPB11 |
| 10 | 10.3.7. Classifying fungi based on characteristics, modes of reproduction, and their role in life. | LPB2 |
| 11 | 11.3.14. Analyzing the role of the immune systems and immunization on physiological processes in the body. | LPC9 |
| 12 | 12.3.8. Analyze mutation in living organisms. | LPB12, |
| 10 | 10.4.4. Conducting a campaign about the dangers of viruses, especially HIV/AIDS. | LPC10 |

Description: Ordinance of Ministry of Education No. 27/2018, NR = not related.

**Table 3.** Textbooks chapters related to Disease Topics.

| Grade | Topics | Books or chapters | NRC |
|---|---|---|---|
| 1 | Diseases caused by not maintaining a healthy lifestyle. | Book: 1: Myself; 6: Clean, Healthy, and Beautiful Environment; and 7: Things, Animals, and Plants Around Us. | LPB-1 |
| 2 | Unclean environment can cause disease. | Books: 2: Playing in My Environment; 3: Daily Tasks; and 4: Clean and Healthy Living. | LPB-2 |
| 3 | NR | Books: 1: Growth and Development of Living Things and 2: Caring Plants and Animals. | NR |
| 4 | NR | Book 3: Caring Living Beings. | NR |
| 5 | Awareness of heart health and clean air for health. | Books: 1: Locomotoric Organs in Animals and Human; 2: Clean Air for Health; 3: Healthy Food; 4: Importance of Health; 5: Ecosystems; 8: Our Healthy Environment. | LPB-3<br>LPB-4<br>LPB-5<br>LPC-2<br>LPC-3<br>LPC-4 |
| 6 | NR | Books: 1: Save the Living Beings; 8: Our Earth. | NR |
| 7 | Lack of protein is not good for the body.<br>Metabolic disorders in the form of acetone compounds can cause respiratory problems.<br>Organ damage caused by agricultural waste pollution. Organ damage caused by water pollution. | CHAPTER 6 Energy and Living Systems.<br>Semester II CHAPTER 3 Environmental pollution. | LPA-1 |
| 8 | Bone abnormalities in humans.<br>Diseases of the digestive system. Diseases caused by additives.<br>Diseases caused by addictive substances.<br>Diseases caused by circulatory system disorders.<br>Respiratory system diseases.<br>Diabetes mellitus and kidney damage. | CHAPTER 1. Locomotion system of organisms in the surrounding environment.<br>CHAPTER 6. Human circulatory system.<br>CHAPTER 8. Human respiratory system.<br>CHAPTER 9. Human excretory system. | LPB-6LPB-7<br>LPC-6<br>LPC-7<br>LPC-8 |

| Grade | Topics | Books or chapters | NRC |
|---|---|---|---|
| 9 | Diseases caused by bacteria, fungi, or viruses. Color blindness, hemophilia, and cancer. | CHAPTER 1. The human reproductive system. | LPB-2<br>LPB-8 |
| 10 | Diseases caused by viruses, bacteria, or fungi. | CHAPTER 3: Viruses, CHAPTER 5: Protists, and CHAPTER: 6 Fungi. | LPB-9LPB-10<br>LPC-6<br>LPC-7<br>LPC-8 |
| 11 | Disorders and diseases in human organ systems due to hormone deficiencies. | CHAPTER 4: the locomotoric system, CHAPTER 7: the respiratory system, CHAPTER 8: the excretory system, CHAPTER 9: the regulatory system, CHAPTER 10: the reproductive system, and CHAPTER 11: The immune system | LPB-11,<br>LPC-7<br>LPC-9 |
| 12 | Problems and diseases due to protein deficiency. | CHAPTER 2: Enzymes and cell metabolism, CHAPTER 3: Genetic substances, and CHAPTER 4: Cell division. | LPC-1O |

Description: Ordinance of Ministry of Education No. 27/2018, NR = not related.

The disease LP was developed based on the benchmark from NRC (2007). The concepts to be compiled were based on the analysis of Indonesian students' textbooks. The concepts were divided into several sub-topics with some difference from the NRC subtopics. The genetic diseases were compiled under the subtopic pathogens because elementary students have not yet studied the genetics. The concepts in LP were sequenced according to the level of understanding from the NRC (2007). The concepts were divided into Level I for 2 grades, Level II for 3–5, Level III for 6–8, and Level IV for 9–12. In this research, the concepts were divided into Level I for 2 grades, Level II for 3–6, Level III for 7–9, and Level IV for 10–12. These concepts can be seen in Table 4.

**Table 4.** Compatibility between the concepts in NRC's LP about disease and topics covered by the 2013 Curriculum.

| Topics Covered by 2013 Curriculum | NRC, 2007 |
|---|---|
| The proposed LP contains 32 concepts: nine concepts about pathogens, 14 concepts about immune system, and nine concepts about infection. | NRC's LP about disease consisted of 22 concepts which were divided into genetic disorders, immune system, and infection. |
| The proposed LP consisted of four levels: Level I for grades 1–2, Level II for grades 3–6, Level III for grades 7–9, and Level IV for grades 10–12. | NRC's LP was divided into four levels: Level I for K-2, Level II for 3–5, Level III for 6–8, and Level IV for 9–12. |

The existing LP helps researchers to understand the importance of basic concepts to develop students' conceptual understanding, such as learning genetics (Todd et al., 2017). Based on the curriculum and the textbooks analysis, this study develops the Disease LP by following the 2013 Curriculum structure of BC, and the Disease LP by NRC. The suggested LP is distributed into subtopics of 1) genetic disorders, 2) immune system, and 3) infection. The LP differed from the NRC's structure of 1) pathogens, 2) immune system, and 3) infection. The compiled concepts about genetic disorders and pathogens also differed. The NRC's LP has 22 concepts while the suggested LP has 32 concepts. Details of those concepts are figured out in Table 5.

**Table 5.** Proposed Constructions of LP about Disease for Indonesian Students.

| Levels | Subtopics | | |
|---|---|---|---|
| | Pathogens | the body's defenses | Infection |
| I (Grade 2) | 2 | 5 | 3 |
| II (Grades 3–6) | 1 | 5 | 1 |
| III (Grades 7–9) | 3 | 1 | 2 |
| IV (Grades 10–12) | 3 | 3 | 3 |

In our proposed LP, the subtopic of pathogens replaced the subtopic about genetic diseases. It was based on the textbook analysis that showed in elementary school, students were familiarized with concepts about pathogens rather than genetics. The concepts about pathogens can be found in many elementary schools' textbooks such as Book 1: Me; Book 6: Clean, Healthy, and Beautiful Environment; and Book 7: Objects, Animals, and Plants around Us. Those themes showed that the concept of disease has been learned at the

elementary school level by introducing students to a clean and healthy lifestyle from an early age. In middle school, students were taught about addictive substances and viruses, and so they've learned diseases can be caused by substances or organisms. It showed that concepts about the disease have been mastered but have not yet become the main topic in learning. The subtopic about pathogens showed that elementary students' basic understanding of disease existed, but not yet coherent.

Middle school students' understanding of pathogens is more advanced than elementary school students. It can be seen in the middle school textbooks which contain topics explaining several diseases caused by pathogens. It can be seen in the topics about organ systems and their disruption by pathogens such as bacteria and viruses. High school students' understanding of pathogens was more complex. But their textbook repeated what they've learned in middle schools. They differed on how the pathogen infects the human body. The analysis resulted in the following conceptual arrangement: Nine concepts about pathogens were to be divided into two concepts for second grade, one concept for 3–6, three concepts for 7–9, and three concepts for 10–12. The arrangement is presented in Figure 1.


**Figure 1.** The Sequence of the Concept about Pathogens.

### The sequence of the concepts about immune system

The subtopic about the immune system was studied in elementary, middle, and high schools. Thus, it was to be included in the proposed LP. This concept was to be taught from elementary. It began with students learned about protecting themselves against infectious diseases, such as covering their mouth when sneezing or coughing. They also taught that human's tear protects eyes from foreign substances. At middle schools, students began to recognize that human body parts are the means of defense, for example, skin. At high schools, they learned about the immune system in more detail. The analysis resulted in the following arrangement: five concepts about the immune system were to be learned in second grade, five concepts for 3–6, one concept for 7–9, and three concepts for 10–12. The arrangement was presented in Figure 2.

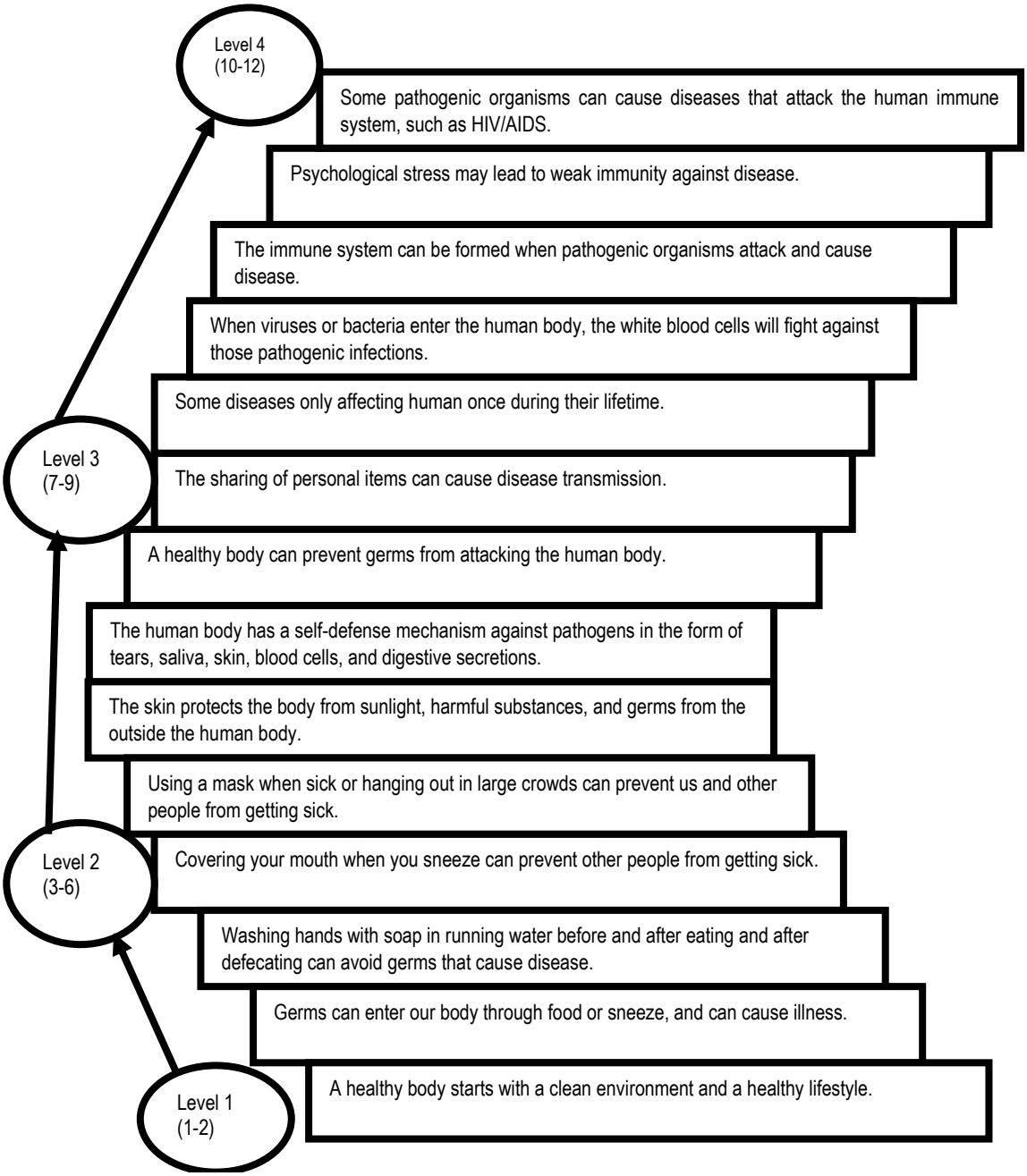


**Figure 2.**The Sequence of the Concepts about Infection.

## The sequence of the concepts about infection

The concepts about infection have also been studied during elementary, middle, and high schools. It has been studied systematically and coherently. It resulted in students can understand how diseases spread and how pathogens such as bacteria or viruses enter the human body through various vectors. These initial concepts showed that their understanding was still low. Grades 3–6 students understand that disruptions in the function of organs indicate a viral or bacterial infection.

Middle and high school students have learned the mechanism of viruses or bacterial infection and how they damaged the cells and tissues, causing disease. The analysis resulted in the following arrangement: three concepts for second grades, one concept for 3–6, two concepts for grades 7–9, and three concepts for grades 10–12. The arrangement was presented in Figure 3.

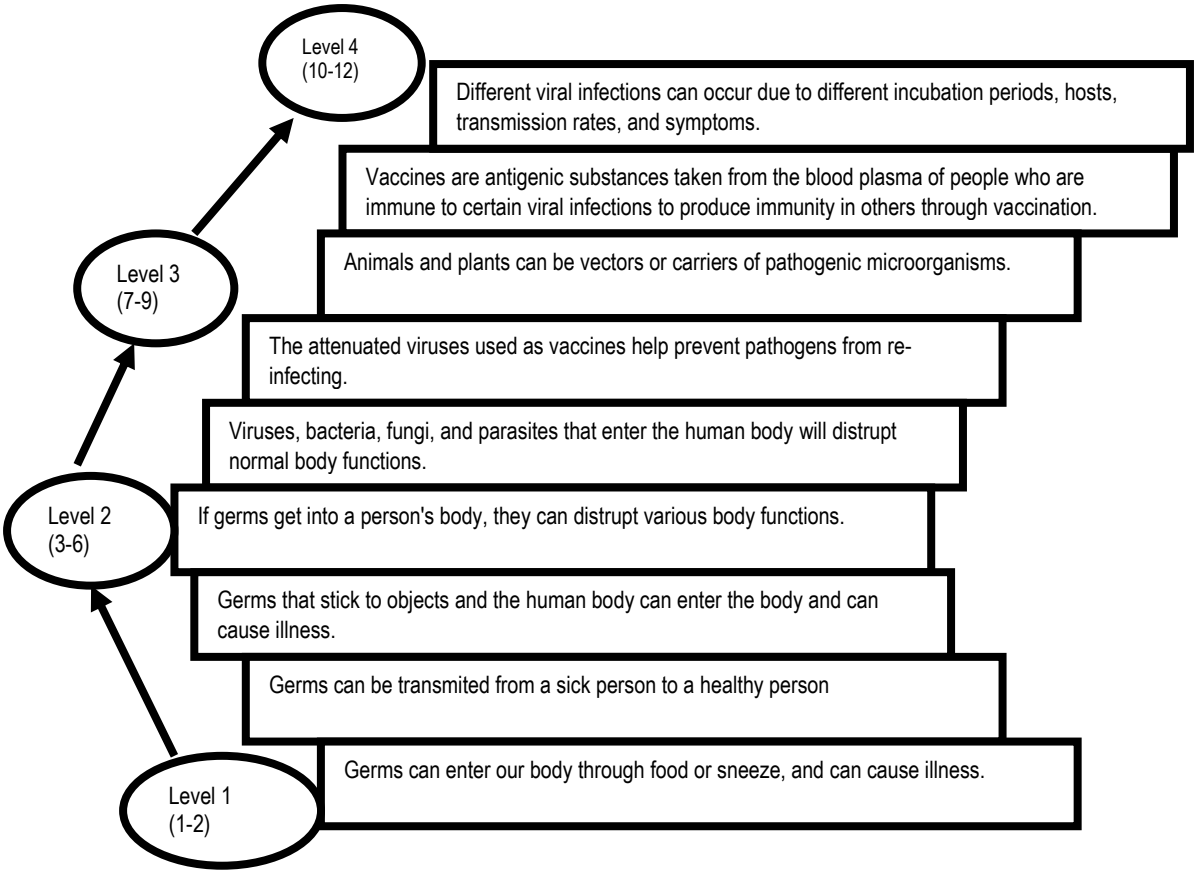


**Figure 3.** The Sequence of the Concepts about Infection.

Learning progression on disease developed by the NRC (2007) was focused on three categories: 1) Genetics: the diseases caused by genetic disorders in humans. 2) Body defense: how the immune system fights against viruses and prevents them from entering the human body. And 3) infection: show the disease infects humans and how the pathogens or infectors infect the cells. They were further divided into 4 levels: Level 1/K2 (Kindergartens-2nd grades), Level 2 (3rd-5th grades), Level 3 (6th-9th grades), and Level 4 (10th-12th grades). Thirty-two basic concepts for understanding the disease were found from the textbook analysis. Those concepts were distributed and adjusted according to the grades or levels. The analysis also found the discontinuity among the concepts taught in the current system.

The analysis showed that the concepts about the disease have been taught to students according to the 2013 Curriculum. Thirty-two basic concepts have been developed and adapted from the NRC's formulation (22 basic concepts). Some concepts about diseases were known by students from their prior knowledge and experience. The analysis also showed a mismatch between one concept with the following concepts. Understanding basic concepts are very important because it can influence subsequent understanding (Duschl, 2019; Elmesky, 2013).

Simple and basic concepts help students understanding more complex concepts learned during middle and high school. LP design also important and can help teachers as a standard for curriculum preparation (Duschl et al., 2011). LP has been widely studied on science topics (National Research Council, 2007). Biological concepts can also relate to other concepts in science (Kohn et al., 2018). The interconnected concepts should be mastered by students, especially in high school.

The proposed LP design was different from that of the NRC 2007. It was to accommodate the differences in culture and understanding. For example, the US and Chinese students differed in their understanding of the Carbon Transformation process (Jin et al., 2013). The conceptual understanding should be based on the relevant Indonesian local wisdom. The concepts compiled from the textbook analysis resulted in two points of view. Elementary school students' understanding of the disease was very different from the middle schoolers. Knowledge about health from an early age can help students avoid disease and can affect students' academic intelligence (Mcisaac et al.,2015; Peralta et al., 2016).

Knowledge about diseases differed according to age and grades. The upper graders should understand more complex concepts about diseases such as AIDS, influenza, and cancer (Sigelman & Glaser, 2019). Middle and high school students have understood various scientific terms related to the pathogens, but elementary school students did not. Some students might have misconceptions about several concepts. They might know about fungi, but they might categorize them as the plant, not as a separated taxon with different types, species, sizes, and other characteristics.

The concept of disease has been conveyed to elementary school students in themes about how to avoid disease. This concept was introduced and intended so that students can socialize even if the environment has various disease vectors (Cauchemez et al., 2011). The basic concepts to be mastered were not to contract the disease vectors while doing activities outside the home.

The concepts studied by middle school students were more complex and require a deeper understanding. The learning topics were very diverseand interrelated to Chemistry and Physics during practical laboratory tasks (Darminto & Side, 2012; Subamia et al., 2019) learn about photosynthesis (Ariandini et al., 2014; Rohman & kurniati, 2015) and the digestive enzymes (Minarti et al., 2012). Introducing infectious diseases in the reproductive system was very important for junior high school as part of sexual education (Yang et al., 2016).

The concepts learned by high school students were complex and related to other disciplines such as Chemistry, Physics, Mathematics, and others. For example, during learning, there were processes of observing objects using a microscope with light projections, magnification, and chemical reagents (Cisterna & Williams, 2013; Freidenreich et al., 2011; Goetz et al., 2016; Kohn et al., 2018; Williams et al., 2011). Proper learning frameworks help students understand interrelated science topics. For example, US students can generate ideas about the structure of matter, conservation, interaction, and energy when learning about transformation (Stevens et al., 2013).

## CONCLUSION

The results showed that the concepts related to disease studied from elementary to high school have not been welldefined and integrated in the curriculum 2013. The textbooks analysis showed that the concepts of disease taught in Grades 1 and 2 did not continue in Grades 3 and 4 but taught again in Grade 6. The learning cycles were repeated at each Grade. The concepts taught to junior high school students contain clear concepts about disease, but at the high school, the topics were repeated without any concept progression from the previous level.

This research produces a sequence of disease concepts that can probe the students' conceptual understanding from elementary to high schools. The LP design has three main concepts: The pathogens, immune system, and infection. Those three main concepts have nine sub-concepts of pathogens for elementary school level (two sub-concepts for K2 and one sub-concept for grades 3-6), and three sub-concepts for grades 7-9 and 10-12. The immune system has 14 sub-concepts which are divided into five sub-concepts for K2 and grades 3-6, one sub-concept for grades 7-9 and three sub-concepts for grades 10-12. The infection has nine sub-concepts with three concepts for K2 and 10-12, one concept for grades 3-6 and one concept for grades 7-9.

The LP design can act a consideration for education practitioners to improve the curriculum, especially those related to the concept of disease. The results were expected to be informing educational practitioners to develop more effective learning plans. The researcher did not unilaterally claim that the current curriculum is not good, but only provides suggestions for further improvements. This study can be a reference in reviewing LP in other disciplines. In this study, the LP has not been tested for its' validity and effectiveness.

The students' understanding of the disease should be strengthened from the most basic, so they can understand the next concepts easily. The sequence of concepts must be clarified to bring up the interconnectivity among the concepts. Categorizing the concepts was necessary to ease the students in understanding the topics. The LP about the disease was expected to help the students build their conceptual understanding from the very basic concepts to the most complex ones.

## ACKNOWLEDGEMENT

The researcher would like to thank the Institute for Research and Community Service at Sebelas Maret University for the 2019–2020 academic year led by Murni Ramli, who has funded this research.

## REFERENCES

Afridah, W., & Fajariani, R. (2017). Tingkat pengetahuan kesehatan reproduksi pada siswa sma kanjeng sepuh gresik, *1*(1), 53–57. https://doi.org/10.33086/mhsj.v1i1.616

Ariandini, D., Anggraeni, S., & Aryani, A. (2014). Identifikasi miskonsepsi siswa SMP pada konsep Fotosintesis melalui analisis gambar. *Jurnal Pengajaran Matematika Dan Ilmu Pengetahuan Alam*, *18*(2), 178. https://doi.org/10.18269/jpmipa.v18i2.36

Benjamin, C., Brohlin, O., Shahrivarkevishahi, A., & Gassensmith, J. J. (2020). Virus like particles: Fundamental concepts, biological interactions, and clinical applications. *Nanoparticles for Biomedical Applications*, 153-174. https://doi.org/10.1016/B978-0-12-816662-8.00011-4

Cauchemez, S., Bhattarai, A., Marchbanks, T. L., Fagan, R. P., Ostroff, S., & Ferguson, N. M. (2011). Role of social networks in shaping disease transmission during a community outbreak of 2009 H1N1 pandemic in fl uenza. *PNAS*, *108*(7), 2825–2830. https://doi.org/10.1073/pnas.1008895108

Cisterna, D., & Williams, M. (2013). Students' understanding of Cells & Heredity: Patterns of understanding in the context of a curriculum implementation in fifth & seventh grades. *The American Biology Teacher 75*(3), 178–184. https://doi.org/10.1525/abt.2013.75.3.6

Coley, J. D., & Tanner, K. (2015). Relations between intuitive biological thinking and biological misconceptions in biology majors and nonmajors. *CBE-Life Sciences Education*, *14*( 1), 1–19. https://doi.org/10.1187/cbe.14-06-0094

Darminto, & Side, S. (2012). Pengembangan perangkat pembelajaran IPA Kimia SMP berbasis kontekstual pada materi pokok bahan kimia di rumah. *Chemica: Jurnal Ilmiah Kimia dan Pendidikan Kimia*, *13*(1), 55–62. https://ojs.unm.ac.id/index.php/chemica/article/view/599

Drucker, M., & Then, C. (2015). Transmission activation in non-circulative virus transmission: a general concept ?. *Current Opinion in Virology, 15, 63–68.* https://doi.org/10.1016/j.coviro.2015.08.006

Duncan, R. G., Castro-faix, M., & Choi, J. (2014). Informing a learning progression in Genetics: Which should be taught first, mendelian inheritance or the central dogma of Molecular Biology? *International Journal of Science and Mathematics Education*, *14*(3), 1–28. https://doi.org/10.1007/s10763-014-9568-3

Duschl, R. A. (2019). Learning progressions: Framing and designing coherent sequences for STEM education. *Disciplinary and Interdisciplinary Science Education Research*, *1*(4), 1–10. https://doi.org//10.1186/s43031-019-0005-x

Duschl, R., Maeng, S., & Sezen-barrie, A. (2011). Learning progressions and teaching sequences : A review and analysis. *Studies in Science Education Learning*, *47*(2), 123–182. https://doi.org/10.1080/03057267.2011.604476

Elmesky, R. (2013). Building capacity in understanding foundational biology concepts: A K-12 learning progression in genetics Informed by research on children's thinking and learning. *Res Sci Educ*, *43*(3),1155–1175. https://doi.org/10.1007/s11165-012-9286-1

Freidenreich, H. B., Duncan, R. G., Shea, N., Freidenreich, H. B., Duncan, R. G., & Shea, N. (2011). Exploring middle school students' understanding of three conceptual models in genetics. *International Journal of Science Education, 33(17)*, 2323-2349. https://doi.org/10.1080/09500693.2010.536997

Gallacher, T., & Johnson, M. (2019). "Learning Progressions": A historical and theoretical. *UCLES*, (28), 10–16. https://www.cambridgeassessment.org.uk/Images/561967--learning-progressions-a-historical-and-theoretical-discussion.pdf

Goetz, K., Tarjan, L. M., Wade, C. E., Yovovich, V., Baumgart, S., Bard, D. G., … Gilbert, G. S. (2016). Exploring models in the biology classroom. *The American Biology Teacher, 78(1), 35–42*. https://doi.org/10.1525/abt.2016.78.1.35

Herrmann-abell, C. F., & Deboer, G. E. (2018). Investigating a learning progression for energy ideas from upper elementary through high school. *Journal of Research in Science Teaching, 55(1), 68–93*. https://doi.org/10.1002/tea.21411

Jin, H., Zhan, L., & Anderson W, C. (2013). Developing a fine-grained learning progression framework for carbon transforming processes. *International Journal of Science Education, 35(10), 1663–1697.*

https://dx.doi.org/10.1080/09500693.2013.782453

Juriah, S., Yusrita, E., Darmadi, D., Irawam, mega pratiwi, & kurniati, ilham. (2018). Pengenalan, pemantauan dan penyuluhan pentingnya. *Jurnal Pengabdian Masyarakat Multidisiplin*, *1*(3), 254–259. https://doi.org/10.36341/jpm.v1i3.424

Kobrin, J. L., Larson, S., Hill, C. T. B. M., Antonio, S., & Antonio, S. (2015). A framework for evaluating learning progressions on features related to their intended uses. *Journal of Educational Research and Practice*, *5*(1), 58–73. https://doi.org/10.5590/JERAP.2015.05.1.04

Kohn, K. P., Underwood, S. M., & Cooper, M. M. (2018). Connecting structure–Property and structure–Function relationships across the disciplines of chemistry and biology: Exploring student perceptions. *CBE-Life Sciences Education, 17*(2), 1-15. https://doi.org/10.1187/cbe.18-01-0004

Lee, H., & Yeo, C. (2015). International comparison study on the articulation of the science curriculum: Focus on the concept of Photosynthesis. *Journal of The Korean Association For Science Education*, *35*(5), 805–815. https://doi.org/10.14697/JKASE.2015.35.5.0805

Mcisaac, J. D., Kirk, S. F. L., & Kuhle, S. (2015). The association between health behaviours and academic performance in Canadian elementary school students: A cross-sectional study. *International Journal of Environmental Research and Public Health, 12(11), 14857–14871*. https://doi.org/10.3390/ijerph121114857

Megawati d, A., Hastuti dwi, E., & Sari Mugita, D. E. (2018). Peningkatan kualitas keshatan anak dengan penerapan cara mencuci tangan yang benar dan pengenalan tentang obat kepada anak usia dini. *Jurnal Pengabdian Kesehatan*, *1(1), 1-14.* https://jpk.jurnal.stikescendekiautamakudus.ac.id/index.php/jpk/article/view/6/6

Minarti, I. B., Susilowati Endang, S. M., & Indriyanti, D. R. (2012). Pengembangan perangkat pembelajaran IPA terpadu bervisi SETS berbasis edutainment pada tema pencernaan. *Journal of Innovative Science Education*, *1*(2), 105–111. https://journal.unnes.ac.id/sju/index.php/jise/article/view/632

National Research Council. (2007). *Taking science to school: learning and teaching science in grades K-8*. (E. R.A. Duschl, H.A. Schweingruber, & A.W. Shouse, Ed.). Washington, DC: The National Academies Press. https://doi.org/10.17226/11625

Norista, A., & Norfai, N. (2019). Edukasi pengenalan jentik *Aedes aegpty* pada anak dengan pendekatan DAI (Dongeng Anak Islam) di SDN 5 Guntung Manggus Kota Banjarbaru. *Jurnal Balireso: Jurnal Pengabdian Masyarakat*, *4*(2), 121–128. https://jurnal.umi.ac.id/index.php/balireso/article/view/122

Pascapurnama, N.D., Murakami, A., Chagan-yasutan, H., & Egawa S. (2018). Integrated health education in disaster risk reduction : Lesson learned from disease outbreak following natural disasters in Indonesia. *International Journal of Disaster Risk Reduction*, (March), 0–1. https://doi.org/10.1016/j.ijdrr.2017.07.013

Peralta, L. R., Dudley, D. A., & Cotton, W. G. (2016). Teaching healthy eating to elementary school students: A scoping *Review of Nutrition Education Resources. Journal of School Health, 86(5), 334–345*. https://doi.org/10.1111/josh.12382

Potvin, P., Nenciovici, L., Malenfant-robichaud, G., Sy, O., Mahhou, M. A., Bernard, A., … Bélanger, M. (2020). Models of conceptual change in science learning: Establishing an exhaustive inventory based on support given by articles published in major journals. *Studies in Science Education*, 1–55. https://doi.org/10.1080/03057267.2020.1744796

Randolph, H. E., & Barreiro, L. B. (2020). Primer herd immunity: Understanding COVID-19. *Immunity*, *52*(5), 737–741. https://doi.org/10.1016/j.immuni.2020.04.012

Rohman, syaful, & kurniati, ilham. (2015). Penerapan model pembelajaran kooperatif tipe circ untuk meningkatkan hasil belajar konsep metabolisme dan respon peserta didik kelas XII IPA-7 SMA Negeri 1 Sampang tahun pelajaran 2011/2012. *Jurnal Pena Sains, 2(1), 8-13*. https://journal.trunojoyo.ac.id/penasains/article/view/1275

Sarkar, P., Debnath, N., & Reang, D. (2021). Coupled human-environment system amid COVID-19 crisis : A conceptual model to understand the nexus. *Science of the Total Environment*, 141757. https://doi.org/10.1016/j.scitotenv.2020.141757

Scott, E. E., Wenderoth, M. P., & Doherty, J. H. (2019). Learning progressions: An empirically grounded, learner-centered framework to guide Biology instruction. *CBE Life Sciences Education*, *18*(4), 1–11. https://doi.org/10.1187/cbe.19-03-0059

Sigelman, C. K., & Glaser, S. E. (2019). Characterizing children's intuitive theories of disease: The case of flu. *Cognitive Development*, *52*, 1–25. https://doi.org/10.1016/j.cogdev.2019.100809

Stevens, S. Y., Shin, N., & Peek-brown, D. (2013). Learning progressions as a guide for developing meaningful science learning: A new framework for old ideas. *Educación Química*, *24*(4), 381–390. https://doi.org/10.1016/S0187-893X(13)72491-1

Su, R., & Yang, H. (2015). Comprehensive understanding of developmental origins of health and disease concepts: Early intervention to non-communicable diseases in China. *Chronic Diseases and Translational Medicine, 1(3), 141–144*. https://doi.org/10.1016/j.cdtm.2015.08.002

Subamia, D. P., Wahyuni, I. G. A. . S., & Widiasih, N. N. (2019). Pelatihan penguatan literasi kimia bagi laboran dan pengelola laboratorium ipa. *Jurnal Widya Laksana*, *8*(2), 190–201. https://ejournal.undiksha.ac.id/index.php/JPKM/article/view/19237

Swara, G. Y. (2020). Pemanfaatan visualisasi 3D pada multimedia interaktif dalam pengenalan penyakit demam berdarah. *Jurnal TeknoIf, 8(1), 19-24*. https://dx.doi.org/10.21063/JTIF.2020.V8.1.19-24

Todd, A., & Kenyon, L. (2015). Empirical refinements of a molecular genetics learning progression: The molecular constructs. *Journal of Research in Science Teaching*, *53*(9), 1385–1418. https://doi.org/10.1002/tea.21262

Todd, A., Romine, W. L., & Correa-menendez, J. (2017). Modeling the transition from a phenotypic to genotypic conceptualization of genetics in a University-Level introductory biology context. *Reseacrh in Science Education*. https://doi.org/10.1007/s11165-017-9626-2

Todd, A., Romine, W. L., & Whitt, K. C. (2016). Development and validation of the learning progression-based high school context. *Science Education, 101(1), 32–65*. https://doi.org/10.1002/sce.21252

Utami, W., & Waladani, B. (2018). Pengenalan jajanan sehat dan jajanan berbahaya di SDN 2 Kalibeji Kecamatan Sempor. *Proceeding of The 8th University Research Colloquium 2018: Bidang MIPA dan Kesehatan, 308–312*. http://repository.urecol.org/index.php/proceeding/article/view/357

Van mil, M.H.W., Postma, P.A., Boerwinkel, D.J., Klaassen, K., & Waarlo, A.J. (2016). Molecular mechanistic reasoning: Toward bridging the gap between the molecular and cellular levels in life science education. *Science Education, 100(3), 517–585*. https://doi.org/10.1002/sce.21215

Williams, M., Debarger, A. H., Montgomery, B. L., Zhou, X., & Tate, E. (2011). Exploring middle school students' conceptions of the relationship between genetic inheritance and cell division. *Science Education, 96(1), 78–103*. https://doi.org/10.1002/sce.20465

Wulandari, A., & Ramli, M. (2019). Learning progression on conceptual understanding of biology: A systematic review. In *AIP Conference Proceedings* (Vol. 020142). https://doi.org/10.1063/1.5139874

Wyner, Y., & Doherty, J. H. (2017). Developing a learning progression for three-dimensional learning of the patterns of evolution. *Science Education*, *101*(5), 787–817. https://doi.org/10.1002/sce.21289

Yang, H., Yao, L., Wu, L., J, Z. H., & Wen, H. (2016). Status of reproductive health knowledge forjunior high schoolstudents in Guangzhou city. *Journal of Reproduction and Contraception*, *27*(1), 41–49. https://doi.org/10.7669/j.issn.1001-7844.2016.01.0041