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Assessing High School Students' Misconceptions of the Human Reproductive System Using a Three-Tier Diagnostic Test

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ABSTRACT

Misconceptions about reproductive system topics remain a persistent challenge in high school biology learning. This study aimed to assess students' misconceptions about the reproductive system using a three-tier diagnostic test. A descriptive quantitative method was employed involving 57 twelfth-grade students from a senior high school in Parepare, South Sulawesi. Data were collected using a three-tier diagnostic test covering six reproductive system subtopics and analyzed descriptively by classifying students' conceptions into scientific understanding (SU), misconception (Mi), and lack of knowledge (LoK). The results revealed misconceptions across all six subtopics of the reproductive system. The highest percentage of misconceptions was found in reproductive hormone regulation (38.60%), followed by gametogenesis (35.09%). Meanwhile, the highest percentage of lack of knowledge was observed in reproductive system disorders (45.61%) and gametogenesis (43.86%). In contrast, reproductive organs showed the highest percentage of scientific understanding (57.89%). Overall, the findings indicate that students still experience considerable misconceptions and conceptual difficulties in several reproductive system subtopics, particularly those involving abstract processes and hormonal mechanisms. These findings highlight the need for targeted instructional interventions, especially in subtopics with high rates of misconceptions and lack knowledge levels, to support conceptual change and improve students' scientific understanding.

INTRODUCTION

Biology education plays a crucial role in fostering scientific literacy and developing students' understanding of living systems. As one of the fundamental science disciplines, biology requires learners to construct accurate conceptual frameworks to explain natural phenomena (Luft et al.,

2022) and apply scientific knowledge in various contexts (Appiah-Adjei et al., 2025; Cukurova et al., 2018). However, students often develop understandings that differ from scientifically accepted explanations, commonly referred to as misconceptions. These misconceptions are not simply the absence of knowledge but rather coherent alternative conceptions that students actively construct and firmly hold (Chen et al., 2020). Because they are often resistant to change, misconceptions can hinder meaningful learning and the development of scientific reasoning (Achor et al., 2022). Consequently, identifying and addressing misconceptions remains an important concern in biology education research and practice.

Research in science education has identified multiple factors that contribute to the development of misconceptions, including everyday experiences, informal sources of information, oversimplified textbook explanations, and ineffective instructional practices (Chew & Cerbin, 2021; Dellantonio & Pastore, 2021). Because students actively construct knowledge by integrating new information with their existing beliefs, misconceptions can become deeply embedded within their cognitive structures, making conceptual change particularly challenging (Menz et al., 2021). As a result, misconceptions often persist across different educational levels and may remain unchanged despite formal instruction. This persistence highlights the need for their early and accurate identification as a prerequisite for meaningful conceptual change (Pekel & Hasenekoğlu, 2020). Without systematic diagnosis, educators may fail to recognize students' underlying misunderstandings and, consequently, may inadvertently reinforce rather than correct scientifically inaccurate conceptions.

Among the various topics taught in high school biology, the human reproductive system represents a particularly challenging area for students (Aulia & Christijanti, 2024; Wahyuni et al., 2019). Understanding the reproductive system requires learners to integrate knowledge of anatomical structures, physiological processes, hormonal regulation, gamete formation, fertilization, and embryonic development (Ampatzidis & Armeni, 2022). The complexity of these interconnected concepts, combined with the abstract nature of many reproductive processes, often makes it difficult for students to develop scientifically accurate understandings. Furthermore, students' conceptions of reproduction may be influenced by cultural beliefs, social norms, personal experiences, and information obtained from peers, family members, and digital media (Bolin et al., 2021; Ouahid et al., 2025). As a result, misconceptions related to reproductive

anatomy, reproductive functions, menstruation, fertilization, pregnancy, and reproductive health are frequently reported among secondary school students.

Beyond its academic importance, an accurate understanding of the reproductive system is essential for developing reproductive health literacy. Misconceptions about reproductive-system concepts may lead to misunderstandings related to menstruation, pregnancy, sexually transmitted infections, and other aspects of reproductive health. Previous studies have shown that limited reproductive health knowledge and persistent misconceptions are associated with poorer reproductive health literacy. Limited reproductive health literacy has been associated with teen pregnancy (Dongarwar & Salihu, 2019), increased risk of unintended pregnancy (Ghavami et al., 2024), and poorer sexually transmitted infection prevention behaviors (Wahyuningsih et al., 2024). These findings highlight the importance of accurately identifying students' misconceptions as a prerequisite for developing effective instructional strategies that promote both conceptual understanding and reproductive health literacy.

Despite growing recognition of the importance of accurate diagnosis of misconceptions, existing studies on biology misconceptions have largely relied on conventional diagnostic approaches such as interviews, open-ended questions, and standard multiple-choice tests (Borovicza & Szarka, 2023; Soeharto et al., 2019). While these methods offer valuable insights into students' understanding, they are often limited in distinguishing learners who genuinely hold misconceptions from those who lack knowledge or arrive at correct answers by guessing (Mulyani et al., 2021; Resbiantoro & Setiani, 2022). To address these limitations, science education researchers have increasingly adopted the three-tier diagnostic test (Yang & Sianturi, 2019), which combines content knowledge questions with reasoning justifications and confidence-level indicators (Istiyono, 2022). By simultaneously examining students' answers, explanations, and levels of certainty, this approach enables more precise identification of misconceptions and provides richer information about students' conceptual understanding.

The three-tier diagnostic test is widely recognized as a comprehensive instrument for assessing students' conceptual understanding and identifying misconceptions. In its standard form, the first tier presents a content question requiring students to select an answer, the second tier asks students to choose or provide a justification for their first-tier response, and the third tier requires students to indicate their level of confidence in their preceding answers (Pacala, 2024). This

structure enables teachers to evaluate not only whether students answer correctly but also the reasoning behind their responses and the certainty with which those responses are given. By analyzing responses across all three tiers, teachers can classify students into distinct conceptual categories, including scientific understanding, misconceptions, and a lack of knowledge. Consequently, the three-tier diagnostic test has become an increasingly valuable tool for investigating students' conceptual understanding and misconceptions in science education.

Although the three-tier diagnostic test has gained increasing attention in science education research, its application to the human reproductive system remains relatively limited, particularly at the high school level. Existing studies have frequently focused on instrument development rather than providing comprehensive analyses of students' misconception patterns. Moreover, many studies investigating misconceptions in the reproductive system have relied on the Certainty of Response Index (CRI), which provides less insight into students' underlying reasoning than a three-tier diagnostic test. Furthermore, empirical evidence on misconceptions about reproductive-system concepts among Indonesian high school students remains scarce. Therefore, this study aims to assess high school students' misconceptions regarding the human reproductive system using a three-tier diagnostic test and to identify the concepts most susceptible to misunderstanding.

RESEARCH METHODS

Study Design

This study employed a descriptive quantitative method to identify and describe students' misconceptions regarding the reproductive system. The study examined the distribution of students' conceptions across reproductive system subtopics using a three-tier diagnostic test. The descriptive quantitative approach was selected because it enables the systematic measurement and classification of students' conceptual understanding, misconceptions, and lack of knowledge based on their responses to diagnostic assessment items.

Selection of Participants

This study was conducted at a public senior high school in Parepare, South Sulawesi, Indonesia. The school was selected for its accessibility and the availability of twelfth-grade students who had completed instruction on the reproductive system. The study involved 57 twelfth-grade students selected through convenience sampling. The class was chosen based on practical accessibility and availability at the time of the study. To ensure the sample was appropriate for the research purpose, the selected class was

confirmed to have already completed instruction on the reproductive system topic, so that students' responses would reflect post-instructional conceptions rather than a complete absence of prior learning.

Procedure

The research procedure consisted of three main stages. The first stage involved instrument development, in which a three-tier diagnostic test was constructed to cover six subtopics of the reproductive system: reproductive organs, gametogenesis, fertilization and gestation, reproductive hormone regulation, reproductive system disorders, and modern reproductive technology. Each item consisted of three tiers: the first tier presented a content question with multiple-choice answer options, the second tier asked students to select the most appropriate reason for their first-tier answer from a set of provided multiple-choice options, and the third tier asked students to state their level of confidence in their combined first- and second-tier responses.

The second stage involved instrument validation and reliability testing. Content validity was established through expert judgment by two biology education experts, who reviewed each item for accuracy, clarity, and alignment with the learning objectives. The instrument was subsequently revised based on the feedback and recommendations provided by both experts. Following the revision, a pilot test was administered to 20 students outside the main sample. The pilot test data were analyzed using the Anates 4.0 application to determine the empirical validity and reliability of each item.

Analysis of validity revealed item-total correlation values ranging from 0.45 to 0.69, indicating that all items met the validity criteria. The reliability coefficient was 0.88, indicating high internal consistency of the instrument. Based on these results, all 20 items were declared valid and reliable. The third stage involved administering the validated instrument to the 57 selected participants during scheduled class sessions. Students completed the test individually under standard supervised conditions.

Data Collection

Data were collected using a three-tier diagnostic test. The instrument generated quantitative data from students’ responses to each tier of the test. The first tier assessed students’ content knowledge, the second tier evaluated the reasoning underlying their answers, and the third tier measured students’ confidence in their responses. The combination of these three tiers enabled the identification of students’ conceptual status, including scientific understanding (SU), misconception (Mi), and lack of knowledge (LoK).

Table 1. Instrument specifications of the three-tier diagnostic test

Subtopic	Indicator	Number of Items
Reproductive Organs	Identify the structure and function of male and female reproductive organs	4
Gametogenesis	Determine the stages of spermatogenesis and oogenesis	3
Fertilization and Gestation	Identify the sequence of fertilization, implantation, and embryonic development	3
Reproductive Hormone Regulation	Determine the functions and interactions of reproductive hormones in reproductive processes.	4
Reproductive System Disorders	Identify reproductive disorders and their causes.	3
Modern Reproductive Technology	Identify the principles and applications of modern reproductive technologies	3
Total		20

Table 2. A sample item from the three-tier diagnostic test instrument

Tier	Item
Tier 1 (Content Question)	A married couple who have been unable to conceive decides to undergo in vitro fertilization (IVF). One stage of the IVF procedure involves transferring the fertilized egg into the mother's uterus. Before embryo transfer, the uterus must be prepared to support implantation. Which of the following interventions is most appropriate to prepare the uterus for implantation? A. Administration of follicle-stimulating hormone (FSH) B. Administration of progesterone C. Consumption of folic acid D. Induction of ovulation
Tier 2 (Reasoning)	What is the reason for your answer? A. Progesterone stimulates thickening of the uterine lining to support implantation. B. FSH stimulates the maturation of ovarian follicles before ovulation. C. Ovulation must occur before the embryo can attach to the uterus. D. Folic acid directly stimulates the implantation of the embryo.
Tier 3 (Confidence Level)	Are you sure about your answer? A. Sure B. Not sure

The test consisted of 20 items covering six reproductive system subtopics: reproductive organs, gametogenesis, fertilization and gestation, reproductive hormone regulation, reproductive system disorders, and modern reproductive technology. The distribution of items and specifications is presented in Table 1. To illustrate the instrument's structure, an example of a three-tier diagnostic test item is presented in Table 2.

Data Analysis

Data were analyzed using descriptive statistics. Each student's response to every item was classified into one of three conception categories based on the combination of answer patterns across the three tiers, as adapted from Arslan et al. (2012), as shown in Table 3. The percentage of each category per subtopic was calculated using the following formula below.

$$P = \frac{f}{N} \times 100\%$$

Table 3. Answer pattern classification for the three-tier diagnostic test

Tier 1 (Answer)	Tier 2 (Reason)	Tier 3 (Confidence)	Category
Correct	Correct	Sure	Scientific understanding (SU)
Correct	Wrong	Sure	Misconception (Mi)
Wrong	Correct	Sure	Misconception (Mi)
Wrong	Wrong	Sure	Misconception (Mi)
Correct	Correct	Not Sure	Lack of knowledge (LoK)
Correct	Wrong	Not Sure	Lack of knowledge (LoK)
Wrong	Correct	Not Sure	Lack of knowledge (LoK)
Wrong	Wrong	Not Sure	Lack of knowledge (LoK)

where P is the percentage of a given conception category, f is the frequency of students classified under that category, and N is the total number of students. The results were then interpreted descriptively to determine the distribution of misconceptions, scientific understanding, and lack of knowledge across the six reproductive system subtopics.

RESULTS AND DISCUSSION

Students' Conceptions of the Reproductive System

The findings of this study indicate that misconceptions and conceptual difficulties remain prevalent among senior high school students despite having completed instruction on the reproductive system. Figure 1 illustrates the overall conception profile of students on reproductive system concepts. Only 36.26% of students demonstrated scientific understanding (SU), while 29.82% were categorized as having misconceptions (Mi) and 33.92% as lacking knowledge (LoK).

Although scientific understanding was the largest single category, the combined percentage of misconceptions and lack of knowledge reached 63.74%, indicating that nearly two-thirds of students still experienced difficulties understanding reproductive system concepts. This finding suggests that exposure to formal instruction alone does not necessarily guarantee meaningful conceptual understanding and that substantial conceptual challenges persist even after classroom learning.

The persistence of these conceptual difficulties highlights the complexity of reproductive system concepts. This interpretation is supported by previous studies indicating that the reproductive system is among the biological topics most susceptible to persistent misconceptions and conceptual gaps at the secondary school level (Andariana et al., 2020; Hasyim et al., 2018; Hayssen, 2020).

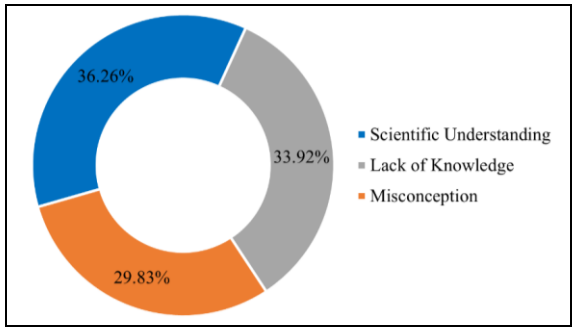

Figure 1. Distribution of students' conceptions on the reproductive system

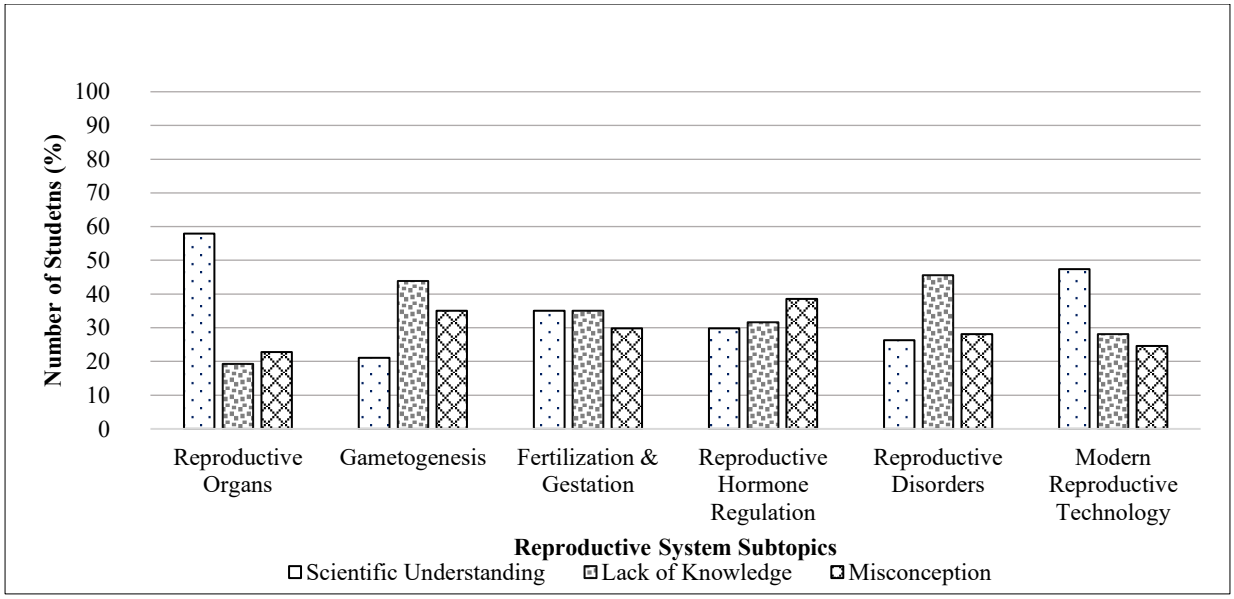

Figure 2. Students' Conceptions Across Reproductive System Subtopics

The substantial proportion of students classified as lacking knowledge is particularly noteworthy. Unlike misconceptions, which involve firmly held but incorrect explanations, a lack of knowledge indicates that students may lack the essential conceptual framework needed to interpret and integrate new biological information (Nehm, 2019). Consequently, this finding suggests that instructional challenges in reproductive system learning extend beyond misconception correction and also involve strengthening students' foundational understanding of key concepts.

The distribution of conceptions across six subtopics revealed notable differences in students' understanding. As shown in Figure 2, reproductive organs showed the highest percentage of scientific understanding (57.89%), whereas reproductive hormone regulation exhibited the highest percentage of misconceptions (38.60%). Gametogenesis also showed a high rate of misconceptions (35.09%) and a high proportion of lack of knowledge (43.86%). Meanwhile, reproductive disorders showed the greatest percentage of lack of knowledge (45.61%). Overall, these results indicate substantial variation in students' conceptual understanding across reproductive system subtopics, with misconceptions occurring more frequently in concepts involving complex physiological processes, such as reproductive hormone regulation and gametogenesis, than in those related to observable anatomical structures, such as reproductive organs.

These findings suggest that students tend to understand concrete, observable concepts more readily than abstract concepts involving physiological mechanisms and dynamic biological processes. This pattern

can be interpreted through theories of cognitive learning and scientific representation. According to Johnstone (1991), meaningful understanding in science often requires learners to coordinate knowledge across different representational levels. In the context of the human reproductive system, students must relate observable anatomical structures to invisible physiological processes, such as hormonal regulation, gametogenesis, fertilization, and embryonic development. Integrating these multiple levels of representation increases conceptual complexity and places greater demands on learners' cognitive processing. From the perspective of cognitive load theory, such concepts impose a higher intrinsic cognitive load because students must mentally organize numerous interacting elements that are not directly observable (Sweller, 2011). In contrast, concrete anatomical structures can be more readily linked to students' prior experiences and visual representations, facilitating conceptual construction and reducing the likelihood of misconceptions.

Reproductive organs demonstrated the most favorable conception profile among all subtopics, characterized by the highest percentage of scientific understanding and the lowest percentage of lack of knowledge. This pattern is consistent with previous studies showing that anatomical concepts are generally easier for students to understand than abstract and dynamic biological processes (Baharuddin et al., 2023; Lodang et al., 2022). The concrete, observable nature of reproductive organs provides students with clearer references for learning, making it easier for them to develop an accurate conceptual understanding and reducing the likelihood of misconceptions. Nevertheless, the finding that 42.11% of students did not demonstrate scientific understanding indicates that misconceptions and knowledge gaps persist even for relatively concrete concepts. Previous studies suggest that several factors may contribute to this pattern, including students' unfamiliarity with anatomical terminology (Lieu et al., 2018) and the persistence of prior misconceptions (Astiti et al., 2020).

In contrast, gametogenesis exhibited one of the weakest conception profiles among the six subtopics, with only 21.05% of students demonstrating scientific understanding, 35.09% holding misconceptions, and 43.86% classified as lacking knowledge. The high LoK rate suggests that many students have not developed a sufficient conceptual framework for understanding spermatogenesis and oogenesis. This topic requires students to understand meiotic division and the sequential stages of gamete formation, processes that occur at the cellular level and cannot be directly

observed. Previous studies have also identified misconceptions related to gametogenesis in biology textbooks, suggesting that instructional materials may contribute to students' alternative conceptions (Tenzer et al., 2022). This finding highlights the importance of ensuring the scientific accuracy of learning resources used in reproductive system instruction.

The findings related to fertilization and gestation revealed relatively balanced proportions of scientific understanding (35.09%) and lack of knowledge (35.09%), with misconceptions accounting for 29.82%. This pattern suggests that students possess a partial understanding of reproductive development but often fail to integrate individual concepts into a coherent scientific explanation. Although the misconception rate observed in the present study was considerably lower, previous research using concept mapping reported that up to 92% of students held misconceptions about fertilization and gestation (Kusumawardani et al., 2025). Such variation highlights that misconceptions are shaped by a complex interplay of factors, including the diagnostic approach used to identify them, the accuracy of textbooks and other instructional resources, students' exposure to misinformation, and the effectiveness of learning experiences provided in the classroom (Guerra-Reyes et al., 2024; Rahayu et al., 2024; Suprapto, 2020).

Reproductive Hormone Regulation recorded the highest misconception rate of all six subtopics (38.60%). Understanding reproductive hormones requires students to comprehend complex interactions among endocrine glands, hormones, target organs, and feedback mechanisms. Such processes are invisible and occur dynamically over time, making them difficult to visualize and conceptualize. Research has consistently identified hormonal regulation as one of the most challenging concepts in biology education, not only within the reproductive system but also across other human body systems involving endocrine control and physiological regulation (Fauzi et al., 2021; Salleh et al., 2021). Similar to gametogenesis, reproductive hormone regulation involves abstract and non-observable biological processes that require students to mentally represent dynamic mechanisms occurring at the microscopic and physiological levels (Gilissen et al., 2021). These shared characteristics may explain the high prevalence of misconceptions observed in both subtopics.

Among all six subtopics, Reproductive System Disorders recorded the highest proportion of students classified as lacking knowledge (45.61%). Unlike hormonal regulation and gametogenesis, where misconceptions were prominent,

reproductive disorders appeared to be characterized primarily by insufficient knowledge. This result may indicate that reproductive health topics receive less instructional emphasis than anatomy and physiology concepts. Previous studies have similarly reported that reproductive health topics tend to receive less instructional emphasis compared to anatomy and physiology content, partly due to cultural and religious sensitivities that constrain open classroom discussion of reproductive diseases and disorders (Cense et al., 2018; Tohit & Haque, 2024). As a result, students are often exposed to insufficient instructional input on these topics, limiting their opportunity to develop the foundational knowledge necessary for a comprehensive understanding of reproductive disorders.

Modern reproductive technology showed the second most favorable conception profile after reproductive organs, with scientific understanding reaching 47.37%, while misconception and lack of knowledge accounted for 24.56% and 28.07%, respectively. Compared with hormonal regulation and gametogenesis, students appeared to experience fewer conceptual difficulties in this subtopic. This finding further supports the pattern observed in the present study: concepts linked to observable applications and real-world contexts tend to be more accessible to students than abstract biological processes occurring at the microscopic or physiological level.

Although the characteristics of biological concepts provide an important explanation for observed patterns of misconceptions, these misconceptions are also likely influenced by multiple factors. Previous studies suggest that misconceptions may arise from students' everyday experiences, informal sources of information, oversimplified textbook explanations, and ineffective instructional practices (Chew & Cerbin, 2021; Dellantonio & Pastore, 2021). In addition, pre-existing conceptions that are not explicitly addressed during instruction may interfere with the acquisition of scientifically accepted knowledge (Vosniadou, 2019), while simplified visual representations and memorization-oriented teaching approaches may hinder the development of accurate conceptual understanding (Guerra-Reyes et al., 2024; Royani et al., 2025). Therefore, the misconception patterns observed in this study are likely to reflect not only the complexity of reproductive-system concepts but also the influence of students' learning experiences and instructional contexts.

Taken together, the findings reveal three important patterns. First, students experienced the greatest conceptual difficulties with subtopics involving abstract and dynamically regulated biological

processes, such as gametogenesis and reproductive hormone regulation. In contrast, understanding was stronger for more concrete, observable concepts such as reproductive organs. Second, the balance between misconception and lack of knowledge varied across subtopics, suggesting that different instructional approaches may be needed depending on the nature of students' conceptual difficulties. Third, the relatively low overall percentage of scientific understanding (36.26%) indicates that conceptual challenges are widespread rather than confined to specific subtopics. It is also important to recognize that misconceptions likely reflect not only the inherent characteristics of the concepts but also broader instructional and contextual factors. These findings highlight the need for targeted instructional strategies that facilitate conceptual change among students with misconceptions while simultaneously building foundational understanding in subtopics characterized by high levels of lack of knowledge.

Instructional Strategies to Address Misconceptions

Given the prevalence of misconceptions and conceptual gaps across several reproductive system subtopics, instructional interventions should focus not only on knowledge acquisition but also on facilitating meaningful conceptual change. According to the conceptual change model proposed by Posner et al. (1982), students are unlikely to replace misconceptions unless they become dissatisfied with their existing explanations and perceive scientific explanations as more plausible and useful. Teachers can facilitate this process by first identifying students' prior conceptions through diagnostic assessments and then presenting evidence, demonstrations, or conceptual conflict situations that challenge inaccurate beliefs (Allen, 2025; Makhrus & Busyairi, 2022). Such approaches can help students reconstruct their understanding in accordance with scientific conceptions.

Visualization-based and model-based learning strategies are particularly relevant for addressing misconceptions in reproductive hormone regulation and gametogenesis. Because reproductive hormone regulation and gametogenesis involve abstract, dynamic, and non-observable biological processes, visualization-based learning strategies such as animations and interactive multimedia may help make these concepts more accessible and comprehensible. Visual representations, such as comics, can also enhance students' understanding of reproductive system concepts and support learning about reproductive health (Aruan et al., 2025). Previous research has demonstrated that both visualization and modeling approaches can improve students' understanding of abstract biological

concepts by promoting deeper cognitive engagement and supporting the development of scientifically accurate mental models (Jenkinson, 2018). As students identify and refine inconsistencies in their thinking, meaningful conceptual change becomes more likely.

Several instructional strategies have been developed to facilitate conceptual change in learners. Refutational text (Amiruddin et al., 2025), Predict–Observe–Explain (POE) (Wati et al., 2025), concept mapping (Abbas et al., 2018), and argumentation-based instruction (Li et al., 2022) are among the approaches that are effective in supporting conceptual change in science education. These strategies directly engage students' prior conceptions and create opportunities for cognitive conflict and conceptual restructuring, prompting learners to revise their existing conceptions in light of new evidence and scientific explanations. Therefore, integrating these strategies into reproductive system instruction may help promote deeper conceptual understanding and reduce the persistence of misconceptions.

Addressing students' misconceptions requires more than delivering correct information; it demands pedagogical approaches that actively confront prior conceptions, engage students in meaningful cognitive restructuring, and support the construction of scientifically accurate understanding.

By combining conceptual change-oriented strategies with visualization-based and model-based learning, educators may be better positioned to bridge the gap between students' intuitive beliefs and scientific knowledge, ultimately fostering more robust and lasting conceptual understanding of reproductive biology. Such approaches are particularly important for reproductive system topics characterized by high levels of misconceptions and conceptual difficulties, including gametogenesis and the regulation of reproductive hormones. Consequently, integrating targeted instructional interventions into reproductive system instruction may improve conceptual understanding and reduce the persistence of misconceptions among students.

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in a single public senior high school and involved a relatively small sample of students selected through convenience sampling. Consequently, the identified misconception patterns may primarily reflect the characteristics of the participating students, including their instructional experiences, school context, and academic background, rather than those of high school students more broadly. In addition, the descriptive quantitative design enabled the

identification of misconceptions but did not investigate their cognitive origins. Future studies should therefore involve larger, more diverse samples, employ qualitative methods, such as interviews, to explore students' reasoning in greater depth, and evaluate the effectiveness of specific instructional interventions in reducing misconceptions about reproductive system concepts. Such investigations would provide a more comprehensive understanding of students' conceptual difficulties and contribute to the development of evidence-based instructional practices in biology education.

CONCLUSION

This study found that misconceptions and conceptual difficulties remain common among senior high school students when learning about the reproductive system. However, scientific understanding was the largest category of conceptions; nearly two-thirds of students were classified as having either misconceptions or a lack of knowledge. The greatest conceptual difficulties were observed in reproductive hormone regulation and gametogenesis, while reproductive organs demonstrated the strongest conceptual understanding. The three-tier diagnostic test used in this study provided a more comprehensive identification of students' conceptual profiles by distinguishing among scientific understanding, misconceptions, and lack of knowledge based on response accuracy, reasoning, and confidence levels. This diagnostic precision provides educators with a stronger basis for designing targeted instructional interventions that address specific conceptual problems and facilitate meaningful conceptual change, particularly for abstract and non-observable biological processes such as reproductive hormone regulation and gametogenesis.

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