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# Socio-Scientific Issues Eating Disorder Module: An Innovation to Improve Students' Critical Thinking and Collaboration

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**Abstract**

Health-related social issues in the community often spark controversy due to the ethical, social, and environmental implications of scientific and technological advancements. To develop an SSI (Socio-Scientific Issues) module on eating disorders within the digestive system curriculum that is valid, practical, and effective in enhancing the critical thinking and collaboration skills of Phase F students. This was a development study utilizing the ADDIE model, conducted from January to December 2025 at Public High School 1 Sradakan, Indonesia. Research subjects included media and instructional material experts, content experts, biology teachers, and students. Data on validity and practicality were collected using product assessment sheets; critical thinking skills were assessed via essay questions, and collaboration skills were evaluated using self-assessment sheets. Data were analyzed using descriptive quantitative methods and ANCOVA. The SSI module on eating disorders was found to be valid and practical as a teaching resource for the digestive system topic. The module effectively enhanced critical thinking and collaboration skills, yielding a significance value of 0.00 ($p < 0.05$). The SSI module is valid, practical, and effective as an instructional resource that fosters critical thinking and collaboration skills among Phase F students.

**Keywords:** Development of teaching materials; Digestive system; Health issues; Social issues; Socio-scientific issues

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## INTRODUCTION

Life in the 21st century is characterized by rapid technological advancements, globalization, and easy access to information, all of which influence various aspects of human life (Cebrero, 2025). In this era, technology and information are advancing at a rapid pace, so students need to be able to adapt, think critically, and solve problems effectively (Rahmawati & Cintamulya, 2025). These skills are known as 21st-century skills, which include critical thinking, collaboration, creativity, communication, and technological proficiency (Imam et al., 2023). It is important to equip students with 21st-century skills so they can solve complex problems, adapt to new ideas, and thrive in an ever-evolving job market (Gündüz, 2023). According to Karaca-Atik et al. (2023) and Mahmud & Wong (2022) learning should focus on developing the 21st-century skills and competencies needed in life. Leite (2022) and Lin et al. (2023) added that integrating 21st-century skills into learning has become a global educational goal, given that students must be prepared to face future changes, including preparing themselves for the future workforce.

21st-century skills consist of several competencies, one of which is critical thinking. Critical thinking is the ability to think in accordance with reasoning and logic, but it also refers to the ability to apply these skills to real-life problems (Raj et al., 2022). In the learning process, particularly in biology, critical thinking skills are essential for students' problem-solving and decision-making (Listiana et al., 2023). Zulyusri et al. (2023) added that in the science learning

process, students must also possess critical thinking skills, as these skills help them make decisions and understand scientific concepts and procedures. More broadly, the development of critical thinking skills is not only beneficial to students in their learning. In the future, equipping them with critical thinking skills will help prepare them to actively participate in society through more informed decision-making, thereby increasing their engagement in public affairs (Gonzalez-Mohino et al., 2023).

In addition to critical thinking skills, collaboration skills are also one of the key 21st-century competencies that students need to develop (Thornhill-Miller et al., 2023; Xu et al., 2023). Collaborative skills in learning enable students to exchange ideas, information, and knowledge with their peers. In addition, collaboration can boost students' self-confidence, thereby helping them better understand the material (Listiana et al., 2023). Students with poor collaboration skills tend to have difficulty participating in group learning and show little respect for differing opinions. As a result, these students tend to be closed-minded, less able to accommodate others' perspectives, and reluctant to share roles and responsibilities in collaboratively solving problems during learning activities (Nahar et al., 2022). Therefore, in addition to critical thinking, collaboration is one of the important skills students need to support the achievement of their learning outcomes.

Despite the importance of critical thinking and collaboration skills for students, several findings from previous research indicate that students' critical thinking and collaboration skills in Indonesia still need to be improved. For example, the results of a study (Asrowi et al., 2025) that the critical thinking skills of vocational students in Surakarta are relatively low. The results of a literature review conducted by Z. Arifin et al. (2025) An analysis of publications on critical thinking skills from 2000 to 2024 indicates that Indonesian students' critical thinking skills in science education remain relatively low. The results of a study by Sari et al. (2025) shows that high school students' critical thinking skills in biology classes in Magetan Regency fall into the moderate category. Findings by Kumalasari et al. (2025) that the critical thinking skills of students at one of the Public High Schools in Yogyakarta City are also relatively low. Based on various previous studies, it can be concluded that the critical thinking skills of students in Indonesia ranging from high school students to college students remain at a relatively low level.

Next, the research findings Ernawati & Sari (2022) that the collaboration skills of biology education students at one of the universities in South Sulawesi are also relatively low. In addition to the students, the research findings Listiana et al. (2023) that the collaboration skills of high school students at one of the schools in Lamongan Regency are relatively low. Sari et al. (2025) also found that high school students' collaboration skills in biology classes in Magetan Regency fell into the moderate category, with an achievement rate of 67%. The results of a study by Haisani & Wijayanti (2025) that collaboration skills at one of the public junior high schools in Yogyakarta City are also relatively low. Based on several findings from previous studies, it can be concluded that the collaboration skills of students from junior high school through college in Indonesia still need to be optimized.

In line with the results of previous research, the situation at Public High School 1 Srandakan, Bantul, Yogyakarta particularly in biology lessons on the human digestive system indicates that students' critical thinking abilities and collaboration skills still need to be optimized. A survey conducted on critical thinking skills among Phase F students at Public High School 1 Srandakan regarding the human digestive system revealed that 64% of students scored in the low category, 20% in the moderate category, and 16% in the high category. These survey findings align with the results of interviews with biology teachers, who noted that when studying the human body including the digestive system students still struggle to analyze the relationships between organs and the physiological processes involved, interpret problems related to digestive disorders, and connect concepts of the digestive system to phenomena encountered in daily life. In addition to critical thinking skills, the survey results on students' collaboration skills showed that 50% were in the moderate category, 26% in the low category, and 24% in the high category. These findings align with observations made during biology

lessons, which indicate that students still demonstrate limitations in effectively collaborating within groups. Some students tend to be passive during discussions, do not actively participate in sharing ideas or opinions, and are not yet able to distribute tasks and responsibilities evenly. Furthermore, communication among group members is not yet optimal, so the task completion process is often dominated by only a few students particularly the top-performing students in the class. The biology teacher also noted that when covering the human body systems unit, only active students tended to engage in the learning process such as by asking questions, answering the teacher's questions, or sharing their opinions during discussions.

The material on the human body's systems including the digestive system—is among the most complex topics in 11th-grade biology because it involves various interrelated concepts, such as organ structure and function, physiological mechanisms, biochemical processes, and the relationships between organs in maintaining the body's balance (Dwi et al., 2025). The complexity of this material requires students to analyze information, evaluate cause-and-effect relationships, and work together to discuss solutions to a problem (M. F. Arifin et al., 2022). However, students' underdeveloped critical thinking and collaboration skills can hinder their conceptual understanding and even lead to misconceptions about the learning material (Yolviansyah et al., 2022). There are several factors that contribute to students' suboptimal critical thinking and collaboration skills. For example, research findings Fahruddin et al. (2025) and Sumardi et al. (2024) that the use of instructional materials in the learning process is one of the key factors determining the quality of the learning process and its outcomes. Findings by Nurwina et al. (2025) that the factor contributing to students' low collaboration skills in physics learning is the use of instructional materials that do not sufficiently enable students to practice the indicators of collaboration skills. In addition to instructional materials, students' low critical thinking skills may also be attributed to the instructional models used by teachers (Fikriyati et al., 2022). In his research Nahar et al. (2022) also found that students' low collaboration skills are also due to classroom teaching methods that do not sufficiently develop students' collaboration skills.

The results of previous research are consistent with the findings of interviews with biology teachers at Public High School 1 Sradakan. Based on the interview results, it was found that instruction on the digestive system still relies on teaching materials from publishers. The use of these teaching materials is maintained because the school is still in the process of adapting to and implementing the Merdeka Curriculum. Teachers also noted that instruction on the digestive system is still dominated by the lecture method because students struggle to understand the scientific concepts of the digestive system on their own. Representatives of several 11th-grade students at Public High School 1 Sradakan also noted that instruction on the digestive system is still dominated by the lecture method and the use of teaching materials from publishers. According to the students, learning about the human body's systems sometimes makes it difficult for them to grasp the scientific concepts involved because the material presented tends to be theoretical and relies heavily on memorization particularly regarding the anatomy and physiology of the human body. Therefore, teaching materials are needed that not only focus on mastering concepts but also develop students' critical thinking and collaboration skills during the learning process on the human body. One such resource is the Socio-Scientific Issues (SSI) module.

A module is a type of instructional material that is comprehensively and methodically organized, provides a selection of planned learning resources, and is designed to help students master learning objectives. The use of modules in instruction provides teachers with an alternative method for delivering educational resources (Safitri & Adinugraha, 2022). In addition, the modules can be used for self-directed learning, allowing students to study on their own and making the teaching and learning process more effective and varied (Susanti et al., 2020). Although they have a positive impact on learning, modules are essentially instructional materials with characteristics similar to those of general instructional materials, such as textbooks. Therefore, appropriate teaching methods or approaches are needed to optimize the

use of modules so that they not only serve as a source of information but also encourage active student engagement, particularly in developing critical thinking and collaboration skills. One approach that can be applied is Socio-Scientific Issues (SSI) (Husniyyah et al., 2023).

SSI is a teaching method that integrates social contexts with scientific concepts, so that science education focuses not only on laboratory activities but also on real-world problems faced by society (Högström et al., 2025). SSI addresses controversial social issues related to science that have no straightforward solutions and require consideration of various factors such as moral, ethical, cultural, traditional, economic, political, and environmental considerations and that require both scientific understanding and public consensus to be resolved (Kumar et al., 2024). Thus, integrating SSI into learning enables students to study science by developing an awareness of the interconnections between social, political, and scientific perspectives while learning scientific content and practices (Smit et al., 2025). Siew & Arifin (2025) incorporating SSI into learning can foster collaborative discussion and enable students to explore science within a social and cultural framework, thereby making their understanding of scientific concepts more meaningful and contextual. Therefore, engaging students in SSI-based contextual learning allows them to connect with broader social and global issues (Kumar et al., 2024), so that it can help students improve their critical thinking skills (Lubis et al., 2022; Suwono et al., 2023) and students' collaboration skills (Mellyzar et al., 2025; Tullah et al., 2025).

Based on various research findings, the use of modules and SSI in teaching has been shown to have a positive impact on learning. However, the success of SSI implementation depends not only on the use of this approach but also on teachers' ability to determine appropriate SSI content, particularly in selecting the scientific cases and topics to be used in instruction. According to (Högström et al., 2025) The selection of SSI content is a crucial aspect because it can influence students' engagement and interest during the learning process. Therefore, selecting appropriate case studies and scientific topics is a key factor in optimizing the effectiveness of SSI-based learning.

One issue that can be used as SSI content in lessons on the human digestive system is eating disorders. This issue is relevant to students' lives because it relates to eating patterns, body image, the influence of social media, and the physical and mental health of adolescents (Convertino & Mendoza, 2023; Selian et al., 2024). Through discussions of these issues, students not only learn about the structure and function of the digestive system and the impact of eating disorders on physical health, but are also encouraged to analyze the social and cultural factors that influence a person's eating behavior. The SSI-based learning process enables students to discuss, exchange opinions, and evaluate various perspectives based on scientific evidence (Kolong et al., 2023, 2025).

Nevertheless, research that specifically develops SSI-based modules addressing eating disorders within the context of the human digestive system and focuses on fostering students' critical thinking and collaboration skills remains limited. Previous studies have primarily addressed the application of SSI to develop critical thinking skills or the use of health-related issues as a learning context, whereas the integration of eating disorder issues into SSI modules that explicitly facilitate both of these skills has not been extensively explored. This situation highlights a gap between the potential of eating disorder issues as an SSI context and the availability of instructional materials that systematically integrate the development of critical thinking and collaboration.

Learning about eating disorders in the context of SSI can be further developed through instructional materials that not only present information and concepts but also provide learning experiences through activities such as issue analysis, evidence evaluation, discussion, presenting arguments, and collaborative decision-making. These activities foster the development of critical thinking skills through the process of identifying problems, analyzing information, evaluating various perspectives, and drawing conclusions based on evidence, while collaboration skills are developed through task-sharing, communication, exchanging

opinions, and reaching consensus within a group. Thus, integrating eating disorders into the SSI module can serve as an alternative teaching resource that connects the study of the digestive system with health issues relevant to students' lives while facilitating the development of critical thinking and collaboration skills. Therefore, this study aims to develop an SSI module on eating disorders to enhance the critical thinking and collaboration skills of Phase F students in the human digestive system curriculum at Public High School 1 Sradakan.

## METHOD

### Type of Research

This study employed a development research design based on the Analysis, Design, Development, Implementation, and Evaluation (ADDIE) model (Figure 1). The objective of this study was to develop a SSI module on eating disorders that is appropriate, practical, and effective in enhancing the critical thinking and collaboration skills of Phase F students regarding the digestive system. The study was conducted from January to December 2025. The study was conducted at Public High School 1 Sradakan, Bantul, Special Region of Yogyakarta, Indonesia.

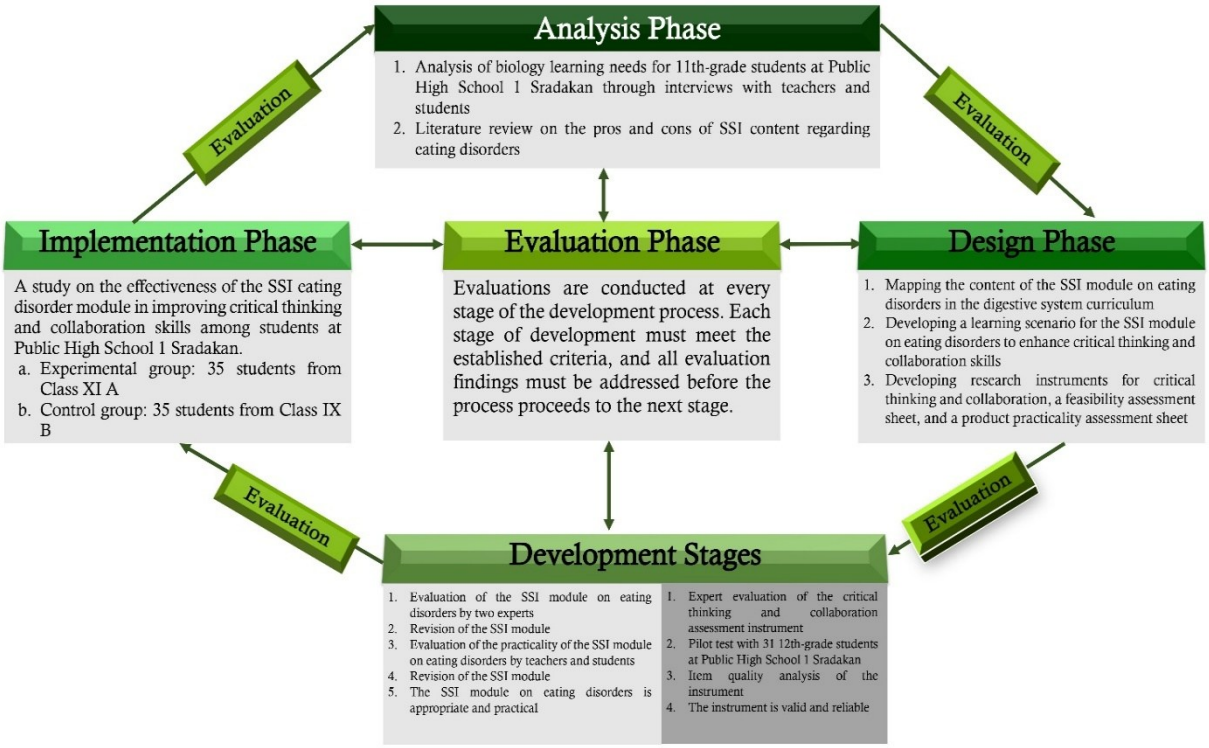



**Figure 1.** The ADDIE research design in the development of the SSI eating disorder module
*Source*: Branch (2010)

### Research Subject

The subjects involved in the development of the SSI eating disorder module in this study were divided into three groups: feasibility test subjects, practicality test subjects, and effectiveness test subjects for the use of the SSI eating disorder module in improving the critical thinking and collaboration skills of Phase F students. The feasibility test subjects in this study were experts from Yogyakarta State University. The experts were divided into two fields: media and instructional materials experts, and subject matter experts. Experts were selected based on their competencies and areas of expertise relevant to the aspects being evaluated (Table 1). Specifically, for the development of the SSI module on the topic of eating disorders, subject matter experts were selected based on criteria established in the study and possessed competencies relevant to the substance of the material being developed. The selection of subject matter experts considered the alignment of their fields of expertise with the eating disorder issues addressed in the module (Table 1). This consideration was based on the nature

of eating disorders as a sensitive health issue, necessitating evaluation by experts with competencies in relevant fields to ensure the accuracy and reliability of the information presented. Finally, the practicality test subjects in this study involved practitioners, specifically biology teachers and high school students. The practitioners were from Public High School 1 Sradakan.

**Table 1**. Research Subject

| Subjects | | Criteria | Expert/Practitioner | Total |
|---|---|---|---|---|
| Feasibility study | Media and instructional materials expert | 1) Minimum educational requirement: Ph.D. in the field of Education<br>2) Field of study: media and instructional materials<br>3) Preference will also be given to candidates with a field of study in SSI | Lecturer in Biology Education, Faculty of Mathematics and Natural Sciences, Yogyakarta State University | 1 lecturer |
| | Subject matter expert | 1) Minimum educational requirement: Ph.D. in Biology or a related field<br>2) Field of study: human anatomy and physiology or biomedical sciences<br>3) Preference will be given to candidates with additional expertise in SSI | Lecturer in Biology, Faculty of Mathematics and Natural Sciences, Yogyakarta State University | 1 lecturer |
| Practicality Test | Teachers | 1) Minimum education requirement: Bachelor's degree in Biology Education and Professional Teacher Education, or Master's degree in Biology Education<br>2) Minimum of 5 years of teaching experience<br>3) Minimum of 5 years of experience teaching 11th grade | Biology Teacher at Public High School 1 Sradakan | 2 teachers |
| | Students | The students have already studied the digestive system. | 12th-grade students at Public High School 1 Sradakan | 30 students |
| Efficacy Test | Students | Students have not yet covered the material on the digestive system | 11th-grade students at Public High School 1 Sradakan | 1) Experimental group: 35 students<br>2) Control group: 35 students |

A study examining the effect of using the SSI eating disorder module on improving students' critical thinking and collaboration skills involved 11th-grade students at Public High School 1 Sradakan. This study involved two groups: an experimental group of 35 students from Class 11A and a control group of 35 students from Class 11B. The sampling technique used in this study was purposive sampling. The selection of the control and experimental classes was based on subject teachers' recommendations, taking into account characteristics relevant to the

study's objectives. The criteria used for sampling in this study were: a nearly equal number of students; the Biology class schedule for 11th-grade Class A and Class B was held during the first period, although on different days (to ensure equal learning conditions); relatively similar levels of student engagement as observed by the teacher; and the students had never previously received instruction using the SSI eating disorder module. The experimental design used in this study was a nonequivalent (pretest-posttest) control group design (Table 2).

**Table 2.** A Design for a Pilot Study on the use of the SSI Eating Disorder Module to Improve Critical Thinking and Collaboration Skills

| Group | Pre-test | Treatment | Post-test |
|---|---|---|---|
| Experiment | Critical Thinking and Collaboration Skills | Lesson using the SSI module on eating disorders | Critical Thinking and Collaboration Skills |
| Control | Critical Thinking and Collaboration Skills | Lesson using teaching materials feasible for the school | Critical Thinking and Collaboration Skills |

*Source*: Creswell & Clark (2007)

This study on the implementation of an SSI module focused on eating disorders involved 11th-grade high school students (Phase F). Therefore, the study was conducted in accordance with the ethical principles governing research involving children as participants. The ethical aspects of the study were based on the guidelines established by Oliver (2010). The first step before the study was conducted was for the researchers to obtain permission from the school. Second, information regarding the study's objectives, procedures, benefits, and implementation was conveyed to the students directly through an information session led by the researchers and facilitated by a teacher. Since the study addressed the sensitive issue of eating disorders a topic viewed from various perspectives in society the research process began with a carefully conducted information session for the students. The information session was led by the teacher, with the researcher present to provide an initial understanding of the research objectives and plan. The teacher and researcher conveyed the information using language appropriate for the students' age group and emphasized that discussing eating disorders in this research was intended to develop the students' critical thinking and collaboration skills. Teachers and researchers also provided guidance to prevent misconceptions regarding the discussed issues, given that eating disorders are a health issue that can elicit both supportive and critical viewpoints.

Third, after the information session, student consent to participate was obtained by having them fill out a Google Form containing a parental/guardian consent form and a student consent form, which the teacher shared via a WhatsApp group. It should be noted that the research was conducted in accordance with the Biology curriculum schedule for the digestive system unit. Thus, the research activities were not conducted as additional activities outside of class but were integrated into the regular learning process. Finally, throughout the research process from implementation to the publication of the results the researchers ensured the confidentiality of the students' identities and personal data. The data collected was used solely for research purposes and reported in aggregate form so as not to reveal the identities of individual students.

**Data Collection Techniques and Data Collection Instruments**

The data collected in this development study included data on the feasibility, practicality, and impact of using the SSI eating disorder module to enhance the critical thinking and collaboration skills of Phase F students. Feasibility data were collected using non-test methods, through assessments by experts in media and instructional materials as well as subject matter experts (Table 3). Practicality data were collected using non-test methods, through practicality assessments by teachers and students (Table 3). Critical thinking ability data were collected using test methods, while collaboration ability data were collected using non-test methods (Table 3).

**Table 3.** Data Collection Techniques and Instruments

| Data Type | Data Collection Techniques | Data Collection Instruments |
|---|---|---|
| Feasibility of the SSI module on eating disorders | Non-test | Product feasibility assessment sheet using a 1–5 Likert scale |
| Practicality of the SSI module on eating disorders | Non-test | Product practicality assessment sheet using a 1–5 Likert scale |
| Critical thinking skills | Test | Essay questions (9 items) using a 0–4 scoring rubric |
| Collaboration skills | Non-test | Self-assessment sheet (25 items) using a 1–5 Likert scale |

The critical thinking skills instrument used in this study is based on indicators developed by Ennis (1962). The critical thinking instrument used in this study was developed by the researcher; therefore, it had to undergo validation and pilot testing before being used in the study. The validation of the critical thinking instrument was conducted by two experts lecturers in biology education from the Faculty of Mathematics and Natural Sciences at Yogyakarta State University. The experts involved in evaluating the critical thinking instrument included one expert in the field of learning assessment and one subject matter expert in human biology. The expert evaluation sheet for the critical thinking instrument addressed the respective areas of expertise of each expert: the construct aspect consisted of 8 items, the language aspect consisted of 5 items, and the assessment rubric aspect consisted of 3 items. For the subject matter expert, the content appropriateness aspect consists of 3 items, the content accuracy aspect consists of 3 items, and the content depth aspect consists of 3 items. The rating scale used on the critical thinking instrument validation sheet employs a 1–5 scale, ranging from a score of 1 (very poor) to a score of 5 (very good). Furthermore, the minimum expert assessment results for each aspect must fall within the score range of 72–85 or be categorized as "good." (Wardany & Anjarwati, 2020). In general, the expert evaluation of the critical thinking skills instrument yielded good results (Table 4), indicating that the instrument is suitable for pilot testing. However, there are several aspects of the critical thinking skills instrument that the researcher must revise before it can be used in the pilot test. After the researcher revises the instrument, the critical thinking skills instrument will undergo pilot testing.

**Table 4.** Results of the Critical Thinking Instrument Assessment by Experts

| Expert | Aspects | Average Rating | Interpretation |
|---|---|---|---|
| Learning Assessment | Concept | 87.5 | Very good |
| | Language | 88 | Very good |
| | Assessment rubric | 80 | Good |
| Average scores from expert evaluators | | 85.16 | Good |
| Matter | Relevance of the material | 80 | Good |
| | Accuracy of the material | 80 | Good |
| | Depth of the material | 86 | Very good |
| Average expert assessment scores for the subject matter | | 81.16 | Good |

The pilot test involved 31 twelfth-grade students at Public High School 1 Sradakan. Following the pilot test, the results were used to conduct item validity and reliability tests on the instrument. The instrument validity test utilized the Pearson product-moment correlation test, with the decision criterion being that if the calculated R value is greater than the table R value, the item is valid; whereas if the calculated R value is less than the table R value, the item is invalid (Sari et al., 2024). The table R value in this study is 0.296 (N=31-1=30). Reliability was tested using Cronbach's alpha, with a decision criterion that the alpha value must be at least 0.70 for the data to be used in the study (Sari et al., 2024). Item quality analysis in this study was conducted using IBM SPSS 27. The results of the instrument's item validity test showed that, out of 10 items, one item assessing critical thinking skills was invalid (Table 5). The invalid item was not used in the study. Furthermore, the reliability test for the critical

thinking skills instrument yielded a value of 0.752. Therefore, a total of 9 items from the critical thinking skills instrument were used in this study.

**Table 5.** Validity of Research Instruments for Critical Thinking Skills

| Indicators of critical thinking skills | Item | R value | Results |
|---|---|---|---|
| Ability to provide simple explanations | Item 1 | 0.439 | Valid |
| | Item 2 | 0.678 | Valid |
| Building basic skills | Item 3 | 0.417 | Valid |
| | Item 4 | 0.557 | Valid |
| Drawing conclusions | Item 5 | 0.510 | Valid |
| | Item 6 | 0.510 | Valid |
| Providing further explanations | Item 7 | 0.388 | Valid |
| | Item 8 | 0.678 | Valid |
| Developing strategies and tactics | Item 9 | 0.398 | Valid |
| | Item 10 | 0.284 | Invalid |

Just like the critical thinking assessment tool, the collaboration assessment tool was also developed by researchers. The indicators of collaboration skills refer to Greenstein (2012). The validation of the collaboration skills instrument was conducted by two experts lecturers in biology education from the Faculty of Mathematics and Natural Sciences at Yogyakarta State University. Unlike the experts involved in the validation process for the critical thinking skills instrument, the validation of the collaboration skills instrument was carried out by two lecturers specializing in learning assessment. The validation process for the collaboration instrument did not involve subject matter experts, as the instrument used was a non-test, self-assessment tool designed to measure students' collaboration skills, not their mastery of the learning material. The expert evaluation sheet for the collaboration instrument, developed by the learning evaluation experts, was based on a construct scale consisting of 8 items, a language aspect consisting of 5 items, and an assessment rubric aspect consisting of 3 items. The rating scale on the critical thinking instrument validation sheet uses a 1–5 scale, ranging from a score of 1 (very poor) to a score of 5 (very good). Furthermore, the minimum expert assessment score for each aspect must fall within the range of 72–85 or be categorized as "good" (Wardany & Anjarwati, 2020). In general, the expert evaluation of the collaboration instrument yielded a "good" rating (Table 6), indicating that the instrument is suitable for pilot testing. However, there are several aspects of the collaboration instrument that the researcher must revise before it can be used in the pilot test. After the researcher revises the instrument, the collaboration instrument will undergo pilot testing.

**Table 6.** Results of the Assessment of Collaboration Tools by Experts

| Experts | Aspects | Average expert 1 | Average expert 2 | Average Rating | Interpretation |
|---|---|---|---|---|---|
| Learning Assessment | Concept | 87.5 | 85 | 86.25 | Very good |
| | Language | 80 | 84 | 82 | Good |
| | Assessment rubric | 80 | 80 | 80 | Good |
| Average scores from expert evaluators | | 82.5 | 83 | 82.75 | Good |

The pilot test was conducted on 31 twelfth-grade students at Public High School 1 Sradakan. Following the pilot test, the results were used to conduct item validity and reliability tests on the instrument. The R-table value in this study was 0.296. The results of the item validity test for the collaboration instrument showed that, out of 30 items, 5 were invalid (Table 7). The invalid items were not used in this study. Furthermore, the reliability test for the collaboration instrument yielded a value of 0.881. Therefore, the number of items in the collaboration instrument used in this study totaled 25 item.

**Table 7.** Validity of the Research Instrument Measuring Collaboration Skills

| Indicators of collaboration skills | Item | R value | Results |
|---|---|---|---|
| Contribute actively | Item 1 | 0.518 | Valid |
| | Item 2 | 0.399 | Valid |
| | Item 3 | 0.423 | Valid |
| | Item 4 | 0.643 | Valid |
| | Item 5 | 0.509 | Valid |
| | Item 6 | 0.426 | Valid |
| Working Productively | Item 7 | 0.380 | Valid |
| | Item 8 | 0.518 | Valid |
| | Item 9 | 0.548 | Valid |
| | Item 10 | 0.660 | Valid |
| | Item 11 | 0.476 | Valid |
| Demonstrating a sense of responsibility | Item 12 | 0.387 | Valid |
| | Item 13 | 0.660 | Valid |
| | Item 14 | 0.524 | Valid |
| | Item 15 | -0.127 | Invalid |
| | Item 16 | 0.133 | Invalid |
| | Item 17 | 0.550 | Valid |
| Demonstrating flexibility and a willingness to compromise | Item 18 | 0.643 | Valid |
| | Item 19 | 0.660 | Valid |
| | Item 20 | 0.362 | Valid |
| | Item 21 | 0.511 | Valid |
| | Item 22 | 0.222 | Invalid |
| | Item 23 | 0.419 | Valid |
| Showing mutual respect | Item 25 | 0.099 | Invalid |
| | Item 26 | 0.428 | Valid |
| | Item 27 | 0.057 | Invalid |
| | Item 28 | 0.518 | Valid |
| | Item 29 | 0.518 | Valid |
| | Item 30 | 0.565 | Valid |

## Data Analysis Techniques

The feasibility and practicality data in this study were analyzed using quantitative descriptive techniques to obtain average scores for each evaluation aspect, namely the feasibility aspect as assessed by subject matter experts, media experts, and instructional material experts, as well as the practicality aspect as assessed by practitioners (teachers) and students. The assessment results for each aspect were deemed acceptable if they received a rating of at least "fair" (Table 8). In addition, all suggestions and feedback provided by experts and practitioners must be addressed and improved before the study proceeds to the next stage.

**Table 8.** Criteria for the Suitability and Practicality of the SSI Eating Disorder Module

| Assessment Results (%) | Qualifications | Feasibility Statement | Practical Statement |
|---|---|---|---|
| 81-100 | Excellent | Very feasible | Very practical |
| 61-80 | Good | Feasible | Practical |
| 41-60 | Fair | Somewhat feasible | Fairly practical |
| 21-40 | Poor | Not very feasible | Not very practical |
| 0-20 | Very Poor | Very not feasible | Very impractical |

Pre-test and post-test data on critical thinking and collaboration skills in the experimental and control groups were analyzed using quantitative descriptive statistics to obtain an overview of the scores for each skill in both groups. Next, the pre-test and post-test data were analyzed using inferential statistics. The statistical test used was the Analysis of Covariance (ANCOVA). This test was used to determine differences in critical thinking and collaboration skills between the experimental group, which used the SSI learning module based on eating disorders, and the control group after controlling for students' initial abilities based on pre-test

scores. In the ANCOVA analysis, the pre-test scores were used as the covariate, while the post-test scores were used as the dependent variable and the learning group as the independent variable. In ANCOVA, if the significance value is < 0.05, H0 is rejected and Ha is accepted. If the significance value is > 0.05, H0 is accepted and Ha is rejected (Table 9).

The ANCOVA test is a parametric statistical test; therefore, there are several prerequisite assumptions that must be met, namely that the data are univariate normally distributed and homogeneous. In this study, the Shapiro–Wilk test was used to assess normality because the sample size was less than 50 respondents. The data are considered normally distributed if the p-value is > 0.05; conversely, if the p-value is < 0.05, the data are not normally distributed. The homogeneity of variances test was conducted using Levene's test. The data are considered to have homogeneous variances if the p-value is > 0.05. Conversely, if the p-value is < 0.05, the variances of the data are considered heterogeneous. Next, a test for homogeneity of regression slopes was conducted (by testing the interaction between the group variable and the covariate, namely Class × Pre). The assumption of homogeneity of regression slopes is met if the significance value of the interaction is > 0.05, indicating that there is no significant interaction between the group and the covariate. If the significance value is ≤ 0.05, then the assumption of homogeneity of regression slopes is not met. Data analysis in this study was performed using IBM SPSS 27.

**Table 9**. Research Hypothesis

| Dependent variable | $H_0$ | $H_a$ |
|---|---|---|
| Critical thinking skills | There was no difference in the critical thinking skills of Phase F students who used the SSI module based on eating disorders in their learning compared to students in the control group who studied the digestive system, after controlling for initial critical thinking skills. | There was a difference in the critical thinking skills of Phase F students who used the SSI module based on eating disorders in their learning compared to students in the control group who studied the digestive system, after controlling for initial critical thinking skills. |
| Collaboration | There was no difference in the collaboration skills of Phase F students who used the SSI module based on eating disorders in their learning compared to students in the control group who studied the digestive system, after controlling for initial collaboration skills. | There was a difference in the collaboration skills of Phase F students who used the SSI module based on eating disorders in their learning compared to students in the control group who studied the digestive system, after controlling for initial collaboration skills. |

## RESULTS AND DISCUSSION

### SSI Eating Disorder Module to Enhance Critical Thinking and Collaboration Skills Among Phase F Students

The product developed in this study is an SSI module based on eating disorder issues designed to enhance the critical thinking and collaboration skills of Phase F students regarding the digestive system. The product was developed in the form of printed instructional materials in Indonesian. The topic was broken down into two issues presenting both pro and con perspectives (Table 10) and was used as learning material over the course of four sessions. The eating disorder issue was identified through a literature review and a search of relevant health news articles. The results of this search were then analyzed and selected by the researcher based on their relevance to the learning material, learning objectives, and alignment with the characteristics of socio-scientific issues. The selected issues were subsequently developed into SSI content that presents differing perspectives so that students can explore information, consider various viewpoints, and discuss issues based on available evidence.

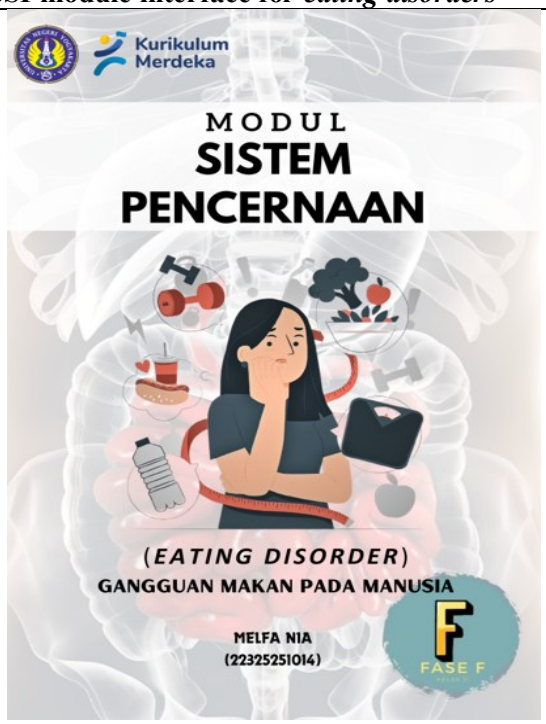
**Table 10.** The Pros and Cons of Social Issues Related to Eating Disorders

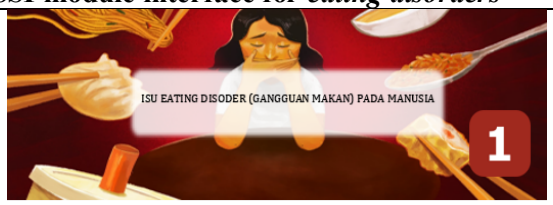
| Issues | Pros | Cons |
|---|---|---|
| Should social media be held responsible for the rise in cases of eating disorders among teenagers? | Social media and unrealistic beauty standards can push people to go on extreme diets. | Not everyone exposed to social media or beauty standards develops an eating disorder. |
| | Social pressure to have an "ideal" body can lower self-esteem and trigger eating disorders. | Genetic and biological factors also contribute to the development of eating disorders |
| | Exposure to content promoting strict diets and weight loss can influence adolescents' eating behaviors. | Psychological conditions such as anxiety, depression, and perfectionism are often major contributing factors. |
| | Education about a healthy body image can help reduce the risk of eating disorders. | Education alone is not always enough without feasible medical and psychological treatment. |
| | Restricting content that promotes unhealthy body images can protect vulnerable groups. | Content restrictions can be seen as limiting freedom of expression and may not necessarily be effective. |
| Is a strict diet to achieve an ideal body worth it, even if it risks disrupting the health of the digestive system? | Restricting food intake can help obese individuals lose weight | Excessive dietary restrictions can lead to a deficiency in the nutrients needed for the digestive system to function normally |
| | A balanced diet can reduce the risk of diseases caused by being overweight. | Eating disorders such as anorexia can cause stomach problems, constipation, and a slowdown in the digestive process |
| | Maintaining a healthy weight can improve overall health. | Bulimia, which is characterized by self-induced vomiting, can damage the esophagus, stomach, and teeth due to repeated exposure to stomach acid. |
| | Certain diets can raise a person's awareness of healthy eating habits. | Extreme diets are often not based on the body's physiological needs and can interfere with nutrient absorption. |
| | Some people view strict diets as a quick way to reach their weight goals. | The long-term effects of eating disorders can lead to malnutrition, metabolic disorders, and damage to the digestive organs. |

The SSI module on eating disorders in this study was designed using the Canva application to create a visually appealing, systematic, and user-friendly interface for both students and teachers. The developed module includes several key components: a table of contents, instructions for teachers and students, material on the digestive system, student worksheets, and practice questions to assess student understanding (Table 11). The SSI-based digestive system material in the module is designed for students to study independently outside of class hours. To facilitate independent learning, students are asked to study the material available in the module and then answer several questions presented after the learning material. Students' answers to these questions serve as indicators of their independent learning progress and are subsequently discussed together in the next session to reinforce their understanding of the concepts studied. In classroom instruction, learning activities focus on the use of

worksheets included in the SSI module. The worksheets are designed around the issue of eating disorders and include activities that encourage students to analyze problems, identify relevant scientific facts, evaluate various perspectives, and construct arguments based on scientific evidence. Through these activities, students not only develop a conceptual understanding of the digestive system, but also hone their critical thinking and collaboration skills through group discussions and working together to complete assignments.

**Table 11.** Design of an SSI Eating Disorder Module to Foster Students' Critical Thinking and Collaboration Skills

<table>
<tr><th>SSI module interface for eating disorders</th><th>SSI module interface for eating disorders</th></tr>
<tr><td>


</td><td>


TUJUAN PEMBELAJARAN<br>
Setelah pembelajaran 1 siswa diharapkan mampu:<br>
1. Siswa mampu menjelaskan eating disorder pada manusia<br>
2. Siswa mampu menjelaskan organ-organ yang menyusun sistem pencernaan dan fungsinya<br>
3. Siswa mampu menjelaskan proses pencernaan manusia<br>
PENDAHULUAN<br>

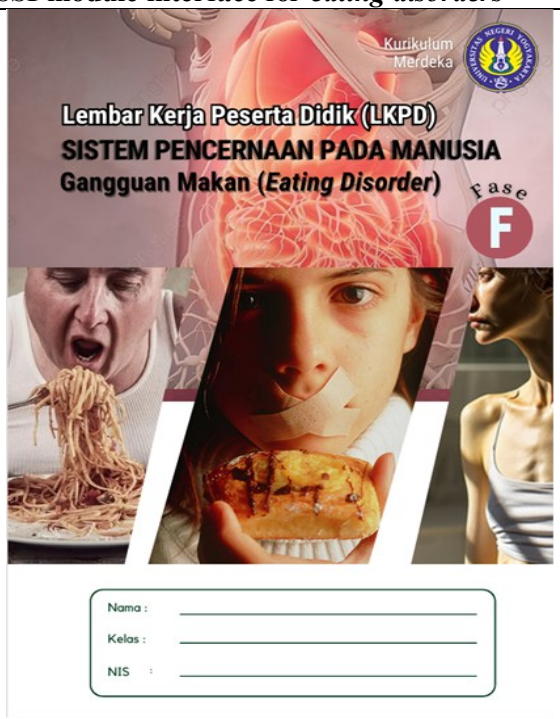
. Saat ini kita telah banyak mendengarkan berita tentang diet, mulai dari influencer media sosial yang memberi informasi tentang diet yang mereka lakukan. Faktanya, diet sudah menjadi hal yang lumrah sehingga kebanyakan orang pasti pernah mencoba satu atau dua diet di suatu waktu dalam hidup mereka. Definisi diet adalah mengatur pola makan sehari-hari dengan tujuan menyeimbangkan berat badan (Oktrisia et al., 2021).<br>
Diet sudah menjadi hal yang lumrah sehingga bagi sebagian besar dari kita, diet dianggap tidak berbahaya. Salah satu diet yang membahayakan kesehatan adalah diet ketat seperti makan hanya sekali sehari tanpa berkonsultasi dengan dokter atau ahli gizi. Diet super ketat yang dilakukan oleh remaja akan berdampak pada hilangnya perasaan lapar sehingga pada akhirnya akan memunculkan gangguan makan (Safitri et al., 2020).<br>
Kenapa diet dapat menyebabkan gangguan makan?<br>
Gangguan makan diperparah oleh perilaku makan yang ditandai dengan pembatasan makanan yang ketat dan olahraga berlebihan. Kegiatan ini dapat menyebabkan individu mengalami peningkatan berat badan dan mendorong mereka untuk melakukan diet atau mengubah kebiasaan makan mereka. Akibatnya, mereka mungkin tidak langsung makan ketika lapar, namun tetap mengalami perasaan lapar yang persisten. Gangguan makan diperparah oleh perilaku makan yang sering melibatkan pembatasan makanan yang parah dan olahraga berlebihan. Seseorang yang merasa seolah-olah baru saja makan mungkin merasa bangga, bahagia, atau bahkan kenyang (Puspita et al., 2024).
</td></tr>
<tr><td>
Mari Menganalisis (KELOMPOK)!<br>
1. Media sosial dan industri hiburan sering kali menampilkan standar bentuk tubuh yang tidak realistis sehingga memicu eating disorder pada remaja sekolah.<br>
Pertanyaan: Sebagai siswa yang mempelajari sistem pencernaan manusia, solusi nyata apa yang bisa kamu tawarkan di lingkungan sekolah untuk mengampanyekan pentingnya menjaga kesehatan organ pencernaan dalam (seperti lambung dan usus) daripada sekadar mengejar penampilan fisik luar (six-pack)?<br>
B. Faktor Yang Mempengaruhi Eating Disorder<br>
Eating disorder dapat terjadi pada semua orang. Ada beberapa faktor yang bisa meningkatkan risiko terjadinya gangguan makan yaitu:<br>
<table>
<tr><th>NO</th><th>Faktor / Isu Sosial</th><th>Mekanisme Sains / Biologis</th></tr>
<tr><td>1.</td><td>Budaya Diet & Standar Kecantikan Media Sosial<br>(Tekanan sosial untuk memiliki tubuh kurus/ideal yang memicu restriksi makanan ekstrem).<br>Westmoreland et al. (2016) - Journal of Eating Disorders</td><td>Kelaparan kronis menurunkan motilitas (gerakan dinding) saluran cerna secara drastis serta menurunkan produksi tujuan pencernaan.</td></tr>
<tr><td>2.</td><td>Stigma Berat Badan & Body Shaming<br>(Perundungan sosial terkait bentuk tubuh yang memicu pelarian stres ke makanan/makan kompulsif).<br>Mehler & Brown (2015) - International Journal of Eating Disorders</td><td>Peregangan fisik lambung yang berulang melebihi kapasitas normal memicu desensitisasi saraf lambung dan mengganggu hormon kenyang (leptin/kolesistokinin).</td></tr>
<tr><td>3.</td><td>Ketakutan Sosial akan Penolakan & Kegemukan<br>(Kecemasan sosial tinggi yang memicu perilaku kompensasi ekstrem seperti memuntahkan makanan).<br>Mehler & Brown (2015) - International Journal of Eating Disorders</td><td>Paparan asam klorida (HCl) lambung yang pekat secara berulang-ulang pada jaringan non-lambung (esofagus dan mulut).</td></tr>
<tr><td>4.</td><td>Kecemasan Sosial & Perfeksionisme Akademik/Kerja</td><td>Stres kronis mengaktifkan poros HPA (Hypothalamic-Pituitary-Adrenal) yang menghentikan aliran</td></tr>
</table>
</td><td>


TUJUAN PEMBELAJARAN<br>
Setelah pembelajaran 2 siswa diharapkan mampu:<br>
1. Menjelaskan jenis-jenis Eating disorder<br>
2. Menganalisis gangguan sistem pencernaan akibat Eating Disorder<br>
3. Penanganan penderita eating disorder<br>
PENDAHULUAN<br>

Masalah Gangguan Makan di Dunia Semakin Meningkat<br>
Gangguan makan (eating disorder) menjadi masalah kesehatan yang makin sering dibahas dalam 20 tahun terakhir. Di seluruh dunia, jumlah orang yang mengalami gangguan makan terus melonjak tajam:<br>
• Secara Global: Pada tahun 2000–2006, rata-rata penderita gangguan makan di dunia hanya sekitar 3,5%. Namun, angka ini melonjak drastis menjadi 7,8% pada tahun 2013–2018 (Galmiche Dechelotte, Lambert, & Tavolacci., 2019.<br>
• Di Amerika Serikat: Penelitian terhadap 260.000 mahasiswa menunjukkan kenaikan yang luar biasa. Penderita gangguan makan melonjak dari 15% pada tahun 2013 menjadi 28% pada tahun 2020 (Daly&Costigan, 2022)..<br>
Bagaimana Situasinya di Asia dan Indonesia?<br>

Ternyata, masalah ini tidak hanya terjadi di negara barat, tetapi juga sudah sangat parah di Asia, termasuk Indonesia.<br>
• Tingkat ASEAN: Dari penelitian terhadap ribuan mahasiswa di lima negara ASEAN, sebanyak 11,5% di antaranya mengalami gangguan makan. Khusus untuk Indonesia, angka penderitanya mencapai 7,4% (Pengpid & Peltzer, 2018).<br>
• Kasus di Daerah (Contoh: Gorontalo): Studi pada mahasiswa di Gorontalo bahkan menemukan bahwa 43,3% mahasiswa memiliki kecenderungan gangguan makan. Gangguan makan yang paling banyak ditemukan adalah:<br>
o Bulimia nervosa (makan banyak lalu dimuntahkan): 23,1%<br>
o Binge-eating disorder (makan berlebihan tanpa kontrol): 15,38%<br>
o Anorexia nervosa (takut gemuk ekstrem hingga mogok makan): 7,7%<br>
o Gejala gangguan makan lainnya: 53,85% (Goi, Anasiru & Tumenggung.,
</td></tr>
</table>

**SSI module interface for *eating disorders***




**SSI module interface for *eating disorders***



KEGIATAN 1

ANTARA

Gadis remaja di China tewas akibat diet ketat

Beijing (ANTARA) - Seorang gadis remaja berusia 15 tahun di Provinsi Guangdong, China, tewas setelah melakukan diet ketat hingga mengalami penyakit anoreksia nervosa. Kisah dokumenter yang diunggah di media sosial China pada Rabu (24/5) menuliskan bahwa gadis tersebut memiliki tinggi badan 165 centimeter namun berat badannya hanya 24,8 kilometer, lebih ringan daripada berat badan anak TK pada umumnya.

Dia sempat dilarikan ke rumah sakit di Kota Shenzhen pada Maret setelah mengalami malnutrisi, kegagalan pernapasan, gangguan elektrolit, dan ukuran otak yang menyusut. Tapi setelah lebih dari 20 hari dirawat di ICU, korban tak tertolong nyawanya, tulis media setempat, Kamis.Korban melakukan diet sejak kelas VI sekolah dasar karena ingin seperti temannya yang memiliki tubuh ramping. Pada saat itu tinggi dan berat badannya masih proporsional, 52 kilogram. Namun setelah melakukan diet ketat, dia diagnosis anoreksia nervosa atau gangguan makan akut karena takut kelebihan berat badan dengan tingkat kematian yang sangat tinggi.

Orang tua korban telah beberapa kali membawanya ke rumah sakit. Namun penanganan medis sudah sangat terlambat sehingga nyawa gadis tersebut tak bisa diselamatkan. Tragedi tersebut memantik keprihatinan warganet China di Weibo dengan menyatakan duka cita yang mendalam atas kematian seorang gadis belia yang seharusnya menikmati masa mudanya. Sejumlah warganet juga menyerukan pola hidup sehat dengan tidak merusak diri sendiri sampai kurus dan pucat karena tidak percaya diri dengan ukuran tubuhnya.

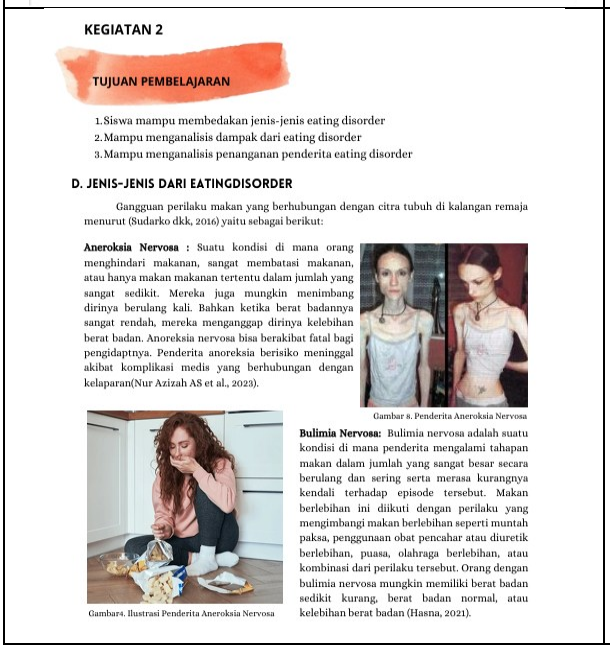
Sumber: https://www.antaranews.com/berita/3556374/gadis-remaja-di-china-tewas-akibat-diet-ketat

POLEMIK

Diskusikan pernyataan-pernyataan di bawah ini bersama kelompokmu. Tentukan apakah kelompok kalian **SETUJU** atau **TIDAK SETUJU** dengan pernyataan tersebut. Berikan alasan kritis yang kuat, serta solusi atau alternatif pemikiran jika kalian memilih tidak setuju!

1. Artikel menyebutkan bahwa penanganan medis berakhir "sudah sangat terlambat". Penderita eating disorder sering kali menyembunyikan pola makannya yang ekstrem dari orang tua dan guru karena rasa takut yang mendalam.

Pertanyaan: Apakah kalian SETUJU atau TIDAK SETUJU jika sekolah mengadakan pemeriksaan fisik dan berat badan secara berkala, lalu berhak mengintervensi atau memanggil psikolog secara paksa jika ada siswa yang berat badannya turun drastis, meskipun siswa tersebut menganggapnya sebagai privasi? Berikan argumen kelompok yang kuat!



KEGIATAN 2

TUJUAN PEMBELAJARAN

1. Siswa mampu membedakan jenis-jenis eating disorder
2. Mampu menganalisis dampak dari eating disorder
3. Mampu menganalisis penanganan penderita eating disorder

D. JENIS-JENIS DARI EATINGDISORDER

Gangguan perilaku makan yang berhubungan dengan citra tubuh di kalangan remaja menurut (Sudarko dkk, 2016) yaitu sebagai berikut:

**Aneroksia Nervosa :** Suatu kondisi di mana orang menghindari makanan, sangat membatasi makanan, atau hanya makan makanan tertentu dalam jumlah yang sangat sedikit. Mereka juga mungkin menimbang dirinya berulang kali. Bahkan ketika berat badannya sangat rendah, mereka menganggap dirinya kelebihan berat badan. Anoreksia nervosa bisa berakibat fatal bagi pengidaptnya. Penderita anoreksia berisiko meninggal akibat komplikasi medis yang berhubungan dengan kelaparan(Nur Azizah AS et al., 2023).

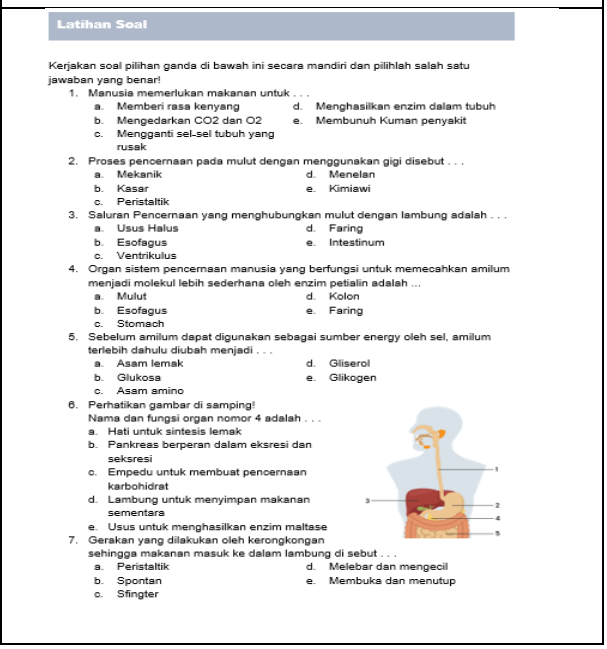


Gambar 8. Penderita Aneroksia Nervosa



Gambar4. Ilustrasi Penderita Aneroksia Nervosa

**Bulimia Nervosa:** Bulimia nervosa adalah suatu kondisi di mana penderita mengalami tahapan makan dalam jumlah yang sangat besar secara berulang dan sering serta merasa kurangnya kendali terhadap episode tersebut. Makan berlebihan ini diikuti dengan perilaku yang mengimbangi makan berlebihan seperti muntah paksa, penggunaan obat pencahar atau diuretik berlebihan, puasa, olahraga berlebihan, atau kombinasi dari perilaku tersebut. Orang dengan bulimia nervosa mungkin memiliki berat badan sedikit kurang, berat badan normal, atau kelebihan berat badan (Hasna, 2021).



Latihan Soal

Kerjakan soal pilihan ganda di bawah ini secara mandiri dan pilihlah salah satu jawaban yang benar!

1. Manusia memerlukan makanan untuk . . .
   a. Memberi rasa kenyang
   b. Mengedarkan CO2 dan O2
   c. Mengganti sel-sel tubuh yang rusak
   d. Menghasilkan enzim dalam tubuh
   e. Membunuh Kuman penyakit
2. Proses pencernaan pada mulut dengan menggunakan gigi disebut . . .
   a. Mekanik
   b. Kasar
   c. Peristaltik
   d. Menelan
   e. Kimiawi
3. Saluran Pencernaan yang menghubungkan mulut dengan lambung adalah . . .
   a. Usus Halus
   b. Esofagus
   c. Ventrikulus
   d. Faring
   e. Intestinum
4. Organ sistem pencernaan manusia yang berfungsi untuk memecahkan amilum menjadi molekul lebih sederhana oleh enzim petialin adalah ...
   a. Mulut
   b. Esofagus
   c. Stomach
   d. Kolon
   e. Faring
5. Sebelum amilum dapat digunakan sebagai sumber energy oleh sel, amilum terlebih dahulu diubah menjadi . . .
   a. Asam lemak
   b. Glukosa
   c. Asam amino
   d. Gliserol
   e. Glikogen
6. Perhatikan gambar di samping!
   Nama dan fungsi organ nomor 4 adalah . . .
   a. Hati untuk sintesis lemak
   b. Pankreas berperan dalam eksresi dan seksresi
   c. Empedu untuk membuat pencernaan karbohidrat
   d. Lambung untuk menyimpan makanan sementara
   e. Usus untuk menghasilkan enzim maltase
7. Gerakan yang dilakukan oleh kerongkongan sehingga makanan masuk ke dalam lambung di sebut . . .
   a. Peristaltik
   b. Spontan
   c. Sfingter
   d. Melebar dan mengecil
   e. Membuka dan menutup

**The Feasibility of of the SSI eating disorder module for enhancing critical thinking and collaboration skills among students in Phase F**

The results of the feasibility assessment of the media and instructional materials in the SSI module on eating disorders showed average ratings of “feasible” and “very feasible” for each aspect (Table 12). These results indicate that the SSI module materials on eating disorders that were developed meet the criteria for the feasibility of media and instructional materials in learning.

**Table 12.** Results of the Feasibility Assessment by Media and Instructional Materials Experts on the SSI Eating Disorder Module Regarding Students’ Critical Thinking and Collaboration Skills

| Assessment criteria | Results (%) | Description |
|---|---|---|
| Graphics | 96% | Very feasible |
| Worksheet Design | 100% | Very feasible |
| Language | 80% | Feasible |

| Assessment criteria | Results (%) | Description |
|---|---|---|
| Usage | 100% | Very feasible |
| Average | 93% | Very feasible |

The results of the content validity assessment by subject matter experts indicate that all aspects of the SSI materials and content in the module were rated as "feasible" (Table 13). These findings suggest that the presented materials do not contain misconceptions and are appropriate for the students' developmental level. Additionally, the developed SSI content was deemed relevant to the learning materials. Regarding the topic of eating disorders, the SSI content addresses sensitive health issues related to eating behaviors, health conditions, and psychosocial factors that can affect individuals. Therefore, the presentation of these issues in the module is structured in an educational and balanced manner, with careful attention to the accuracy of the information and its alignment with the learning objectives.

**Table 13.** Results of the Feasibility Assessment of the Material in the SSI Eating Disorder Module Regarding Students' Critical Thinking and Collaboration Skills

| Assessment criteria | Results (%) | Description |
|---|---|---|
| Contents | 78% | Feasible |
| Language | 75% | Feasible |
| Presentation | 75% | Feasible |
| SSI | 71% | Feasible |
| Average | 75% | Feasible |

Despite the experts' assessment results which placed the module in the "feasible" and "very feasible" categories the experts offered several suggestions for improving the module before proceeding to the next phase. These improvements are as follows (Table 14).

**Table 14.** Revisions to the SSI Module Based on Expert Assessment

| Expert comments and suggestions | Corrective Actions |
|---|---|
| – Summarize the theoretical section on the digestive system to focus on the key points relevant to the issue. | – Researchers summarize theories on the digestive system to focus on the key points relevant to the issue. |
| – Add an in-depth analysis of the relationship between physiology and society | – Researchers re-examine the relationship between physiology and social factors.<br>– For example: How do extreme diets affect enzymes and the stomach? |
| – Use shorter, more concise, and more communicative sentences. | – The researcher revised the sentences used |
| – Include more visual aids such as infographics, diagrams, and summary tables. | – The author included more visual elements such as infographics, diagrams, and summary tables |
| – Add reflective questions that require students to propose solutions | – Researchers ask reflective questions that require students to propose solutions.<br>– For example: How can schools prevent cases of anorexia? |
| – Encourage students to build arguments using data | – The researcher included comparative data on eating disorders from both Indonesia and other countries with the aim of encouraging students to develop arguments based on the data provided. |
| – Integrate moral aspects | – The researchers added: "Integrate moral aspects (empathy for those suffering, criticism of excessive beauty standards)." |
| – Emphasize character development | The researchers added an emphasis on character development (awareness of healthy living, a critical perspective on diet culture). |

The research results in Tables 12 and 13 show that the SSI module on eating disorders is feasible as teaching material for developing students' critical thinking and collaboration skills, as assessed from the perspectives of experts in media and instructional materials as well as subject matter experts. These findings are consistent with the results of previous research Amalia et al (2024) and Nirwana & Octavia (2025) that the use of SSI-based teaching materials is feasible as a means of improving high school students' critical thinking skills. In addition to critical thinking, the results of the study Rasyidi et al. (2024) that SSI-based instructional materials are also suitable for fostering students' collaboration skills. In the process of developing instructional materials, the expert review process is a crucial stage. According to Sistyarini & Nurtjahyani (2017) expert evaluation aims to produce high-quality, relevant instructional materials grounded in theory and to determine whether such materials are suitable for use in the learning process. Yanthi et al. (2022) added that in the development of instructional materials, it is important to seek input from subject matter experts to ensure that both the instructional content and the materials presented in the instructional resources are feasible for the students' developmental stage, so that learning objectives can be achieved.

From the perspective of media and instructional materials, the SSI module was evaluated based on several key components: graphics, worksheet design, language, and usability. In terms of graphics, the module was found to have an attractive, well-proportioned layout that supports readability and a comfortable learning experience for students. This is achieved by incorporating various images into the SSI module, ensuring that it is not limited to text alone. Regarding worksheet design, the learning activities in the module were found to be organized systematically, contextually, and in line with the SSI approach, thereby facilitating students in developing critical and collaborative thinking skills. Worksheets in the module are available for learning activities 1 through 4. Furthermore, regarding language, the module is assessed as using language that is communicative, easy to understand, and feasible for the cognitive development level of high school students, thereby making it easier for students to understand both the material and activity instructions. Meanwhile, regarding usability, the module is assessed as functioning well as instructional material because it can be used for both out-of-class and in-class learning and supports the achievement of the established learning objectives. Classroom learning focuses on utilizing the worksheets included in the SSI module, while for out-of-class learning, students are required to study the material before coming to class (Table 11). This is evidenced by students completing several questions provided in the SSI module on eating disorders.

The health issues addressed in the SSI eating disorder module were identified through a literature review and a search of relevant health news articles. This search was conducted to identify information and health issues related to eating disorders, including their causes, characteristics, impacts, and prevention strategies. The information obtained was then analyzed and selected by the researchers, taking into account the relevance of the issues to the learning materials and learning objectives. The selected issues were subsequently developed into SSI content within the module. The results of the content validity assessment by subject matter experts indicated that all aspects of the SSI materials and content in the module were categorized as "feasible" (Table 13). These findings indicate that the presented material does not contain misconceptions and is appropriate for the students' developmental level. Furthermore, the developed SSI content was deemed relevant to the learning material and based on health issues sourced from relevant literature and health news. Thus, the material and SSI content on eating disorders are deemed suitable for use as instructional materials to support learning that fosters students' critical thinking and collaboration skills.

In addition to media and instructional material experts, the research results in Table 13 indicate that the SSI eating disorder module received satisfactory ratings from subject matter experts. From a content perspective, the SSI eating disorder module presents material on the digestive system that aligns with the learning outcomes, conveys concepts accurately, and has a clear connection to the topic of eating disorders. The material is also organized sequentially,

from learning activity 1 through learning activity 4, making it easier for students to understand the concepts being studied. From a linguistic perspective, the SSI module uses language that is communicative, easy to understand, and feasible for the students' developmental level. Additionally, the use of scientific terms has been adapted to the context of the material and is supported by a glossary. From a presentation perspective, the module is systematically organized, starting from the introduction, through the presentation of material, learning activities, to evaluation. The structured presentation of material, supported by illustrations and learning activities, enhances student engagement in the learning process (Table 11). From the perspective of SSI content, the eating disorder issue addressed is relevant to students' lives and closely related to the digestive system curriculum (Table 10). The presentation of this issue encourages students to analyze problems from various perspectives, connect scientific concepts with social phenomena, and develop their critical thinking and collaboration skills.

**The practicality of the SSI eating disorder module in enhancing critical thinking and collaboration skills among Phase F students**

The results of the SSI module's practicality assessment were based on evaluations by biology teachers and students. The practicality assessment of the SSI module by two biology teachers yielded an average rating of "very practical" across all aspects (Table 15). These findings indicate that, when used in the classroom, the SSI module is easy to understand, easy to use, and effective in supporting teachers in conducting the learning process. In addition, the presentation of the material, usage instructions, and learning activities contained in the SSI module were assessed as clear and systematic, thereby making it easier for teachers to manage the learning process and foster students' critical thinking and collaboration skills.

**Table 15.** Results of the Practicality Assessment (Teachers) of the SSI Eating Disorder Module Regarding Students' Critical Thinking and Collaboration Skills

| Assessment criteria | Results (%) | | Average | Description |
|---|---|---|---|---|
| | Teacher 1 | Taecher 2 | | |
| Presentation | 100% | 90% | 95% | Very practical |
| Language Appropriateness | 83% | 80% | 81.5% | Very practical |
| Content Appropriateness | 88% | 85% | 86.5% | Very practical |
| Content Accuracy | 100% | 95% | 97.5% | Very practical |
| Practicality | 86% | 80% | 81.5% | Very practical |
| Average | | | 88.4% | Very practical |

In addition to assessing practicality from the teachers' perspective, students also evaluated practicality. The average results of the practicality assessment by 30 students across all aspects fell into the "practical" category (Table 16). These findings indicate that when used by students, the SSI module is fairly easy to understand and use in the learning process. The material presented, activity instructions, and assignments included in the module help students follow the lessons in a more focused manner.

**Table 16.** Results of the Practicality Assessment (Students) of the SSI Eating Disorder Module Regarding Students' Critical Thinking and Collaboration Skills

| Assessment criteria | Average score (%) | Description |
|---|---|---|
| Interesting | 75% | Practical |
| Practicality | 80% | Practical |
| Effectiveness | 66% | Practical |
| Learning objectives | 67% | Practical |
| Average | 72% | Practical |

Regardless of the results of the practicality assessment, there are several areas for improvement based on practitioners' feedback. These improvements are as follows (Table 17).

**Table 17.** Revisions to the SSI Module based on Practitioners' Assessments

| Expert comments and suggestions | Improvements |
|---|---|
| Add a glossary for foreign terms | Add foreign terms to the glossary |
| Include more visual images | Add some images to support the presentation of the material in the module |

In addition to the SSI eating disorder module being deemed practical, the module was also evaluated by practitioners, namely the students' teachers. The results of the practicality assessment of the SSI eating disorder module, presented in Tables 15 and 16, indicate that the module is practical for use as teaching material on the digestive system to facilitate students' critical thinking and collaboration skills. These findings are consistent with the research results Amalia et al. (2024) and Nirwana & Octavia (2025) that SSI-based teaching materials are practical for developing students' critical thinking skills. In addition to critical thinking, findings by Rasyidi et al. (2024) SSI-based instructional materials can also foster students' collaboration skills. Overall, these findings indicate that the SSI module on eating disorders is easy to use in the learning process. This ease of use is evident in the clarity of the module's instructions, worksheets that are easy for students to understand and complete, and the presentation of SSI content that aligns with the characteristics and developmental level of 11th-grade high school students. Furthermore, the learning activities presented in the SSI module help students understand the digestive system while encouraging them to discuss, collaborate, and analyze issues related to eating disorders, thereby fostering students' critical thinking and collaboration skills.

**The Effect of the SSI Eating Disorder Module on Improving Critical Thinking and Collaboration Skills Among Students in Phase F**

To determine the effect of using the SSI eating disorder module on critical thinking and collaboration skills, instruction in the experimental group utilized the SSI module focused on eating disorders developed in this study. The SSI learning module focused on eating disorders in this study was implemented over four class sessions by integrating the SSI stages into the flow of student learning activities. Each stage in the module is oriented toward the SSI steps as a guide for student learning. Additionally, the SSI module was designed to facilitate the development of indicators of students' critical thinking and collaboration skills in each learning activity (Table 18). The learning process was conducted in groups to encourage students to actively engage in discussions, arguments, and decision-making based on the issues being discussed. In the experimental class, students were divided into 6 groups 3 "pro" groups and 3 "con" groups regarding the given eating disorder issue (Table 10). Grouping students based on differing positions aims to help them construct arguments, evaluate evidence, analyze various perspectives, and refute the opinions of other groups. During the learning activity, each group worked together to find relevant information, discuss scientific facts supporting their group's position, and compile the results of their discussion for presentation.

**Table 18.** Mapping of Indicators Of Students' Critical Thinking and Collaboration Skills in the SSI Eating Disorder Module

| Learning | SSI Stages | SSI issues | Indicators of critical thinking | Indicators of collaboration |
|---|---|---|---|---|
| 1 | Involvement | Should social media be held | The ability to provide simple explanations | Contribute actively |
| | Exploration | responsible for the rise in cases of eating disorders among teenagers? | 1. Building Basic Skills<br>2. Developing Strategies and Tactics | Work productively |
| 2 | Explanation | | Provide further explanation | 1. Demonstrating flexibility and a |

| Learning | SSI Stages | SSI issues | Indicators of critical thinking | Indicators of collaboration |
|---|---|---|---|---|
| | | | | willingness to compromise<br>2. Demonstrating mutual respect |
| | Evaluation | | Drawing conclusions | Demonstrating a sense of responsibility |
| 3 | Involvement | Is a strict diet to achieve an ideal body worth it, even if it risks disrupting the health of the digestive system? | The ability to provide simple explanations | Contribute actively |
| | Exploration | | 1. Building Basic Skills<br>2. Developing Strategies and Tactics | Work productively |
| 4 | Explanation | | Provide further explanation | 1. Demonstrating flexibility and a willingness to compromise<br>2. Demonstrating mutual respect |
| | Evaluation | | Drawing conclusions | Demonstrating a sense of responsibility |

Meanwhile, instruction in the control group used conventional teaching materials in the form of textbooks commonly used by teachers in schools. The topic studied in the control group was the digestive system. The lesson was conducted following the standard school curriculum, in which the teacher presented the material on the digestive system through a lecture, followed by a discussion. Students studied the material using the textbook as their primary learning resource and participated in learning activities guided by the teacher.

The difference in the implementation of instruction between the two groups lay in the instructional materials and the stages of learning activities used. The experimental group studied the digestive system using an SSI module based on eating disorders by following the SSI stages, while the control group studied the digestive system using textbooks through conventional instruction involving lectures and discussions. Thus, both groups covered the same core material but used different instructional materials and learning approaches.

Based on the results of the descriptive test, the critical thinking skills of students in the experimental and control groups improved after the learning process (Table 19). The results of the descriptive test of critical thinking skills in the experimental group showed a pre-test average score of 63.62, which increased to 84.82 (post-test) after participating in the SSI eating disorder module (Table 19). Furthermore, in the control group, the pre-test average for critical thinking skills was 63.00, which then increased to 74.85 (post-test). Although there was an improvement in critical thinking skills in both groups, the improvement in the experimental group was greater than that in the control group. Overall, these descriptive data indicate that the use of the SSI eating disorder module has the potential to improve students' critical thinking skills regarding the digestive system compared to the learning method used in the control group.

**Table 19.** Results of the Descriptive Test of Students' Critical Thinking Skills

| Group | Data | N | Range | Min | Max | Mean | SE | SD |
|---|---|---|---|---|---|---|---|---|
| Experimental | Pre | 35 | 8.00 | 60.00 | 68.00 | 63.6286 | .37815 | 2.23720 |
| | Post | 35 | 7.00 | 82.00 | 89.00 | 84.8286 | .31352 | 1.85481 |
| Control | Pre | 35 | 11.00 | 58.00 | 69.00 | 63.0000 | .40996 | 2.42536 |
| | Post | 35 | 9.00 | 70.00 | 79.00 | 74.8571 | .42829 | 2.53381 |

In addition to critical thinking skills, the results of the descriptive test of students' collaboration skills also showed an increase before and after the learning activities in each treatment group (Table 20). The results of the descriptive test of collaboration skills in the experimental group showed a pre-test average score of 63.88, which then increased after participating in the SSI eating disorder module to 85.22 (post-test) (Table 20). Furthermore, in the control group, the average pre-test score for students' collaboration skills was 62.97, which then increased to 74.80 (post-test). Although there was an improvement in collaboration skills in both groups, the improvement in the experimental group was greater than that in the control group. Overall, these descriptive data indicate that the use of the SSI eating disorder module has the potential to improve the collaboration skills of Phase F students on the digestive system material compared to the learning method used in the control group.

**Table 20.** Results of the Descriptive Test of Students' Collaboration Skills

| Group | Data | N | Range | Min | Max | Mean | SE | SD |
|---|---|---|---|---|---|---|---|---|
| Experimental | Pre | 35 | 9.00 | 60.00 | 69.00 | 63.8857 | .42361 | 2.50613 |
| | Post | 35 | 10.00 | 80.00 | 90.00 | 85.2286 | .40394 | 2.38975 |
| Control | Pre | 35 | 9.00 | 59.00 | 68.00 | 62.9714 | .36087 | 2.13494 |
| | Post | 35 | 8.00 | 71.00 | 79.00 | 74.8000 | .36392 | 2.15297 |

After conducting a quantitative descriptive analysis of the pre-test and post-test data, the next step was to perform an ANCOVA test, beginning with a prerequisite test. The results of the Shapiro-Wilk normality test in Table 21 showed that the critical values for the pre-test critical thinking ability data of the experimental group yielded a significance value of > 0.116, while the post-test data yielded a significance value of > 0.131. These results indicate that the pre-test and post-test data on critical thinking ability in the experimental group are normally distributed. Furthermore, the pre-test data on critical thinking ability in the control group yielded a significance value of > 0.266, and the post-test data yielded a value of 0.128. These results indicate that the pre-test and post-test data on critical thinking ability in the control group are normally distributed.

**Table 21.** Results of the Normality Test for Critical Thinking Skills

| Data | Group | Statistic | df | Sig. |
|---|---|---|---|---|
| Pre-test | Experimental | .950 | 35 | .116 |
| | Control | .962 | 35 | .266 |
| Post-test | Experimental | .952 | 35 | .131 |
| | Control | .959 | 35 | .218 |

The results of the test for homogeneity of variances using Levene's test indicate that the critical thinking ability data exhibit homogeneous variances. For the pre-test data, a significance value of 0.761 > 0.05 was obtained, while for the post-test data, a significance value of 0.079 > 0.05 was obtained. Therefore, it can be concluded that the variances of the pre-test and post-test data on critical thinking skills are homogeneous, meaning there are no significant differences in variance between the groups (Table 22).

**Table 22.** Results of the Homogeneity of Variance Test for the Pre-Test and Post-Test of Critical Thinking Skills

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Pre-test | Based on Mean | .093 | 1 | 68 | .761 |
| | Based on Median | .050 | 1 | 68 | .823 |
| | Based on Median & with adj. df | .050 | 1 | 64.613 | .823 |
| | Based on trimmed mean | .092 | 1 | 68 | .763 |
| Post-test | Based on Mean | 3.184 | 1 | 68 | .079 |
| | Based on Median | 3.031 | 1 | 68 | .086 |
| | Based on Median & with adj. df | 3.031 | 1 | 62.529 | .087 |
| | Based on trimmed mean | 3.082 | 1 | 68 | .084 |

The results of the homogeneity of regression slopes test for critical thinking skills indicate that the interaction between group and initial critical thinking skills (Group × pre-test critical thinking skills) yielded an F-value of F(1,66) = 0.176 with a significance level of 0.676 > 0.05 (Table 23). These results indicate that the interaction between group and students' pre-test critical thinking ability is not significant. Thus, the assumption of homogeneity of regression slopes is met, indicating that the relationship between initial critical thinking ability and final critical thinking ability has homogeneous regression slopes in both the experimental and control groups.

**Table 23.** Homogeneity of Regression Slopes Critical Thinking Skills

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Corrected Model | 1748.696[a] | 3 | 582.899 | 117.802 | .000 |
| Intercept | 460.310 | 1 | 460.310 | 93.027 | .000 |
| Group | 5.892 | 1 | 5.892 | 1.191 | .279 |
| Pre-test | 7.347 | 1 | 7.347 | 1.485 | .227 |
| Group * Pre-test | .871 | 1 | .871 | .176 | .676 |
| Error | 326.575 | 66 | 4.948 | | |
| Total | 448317.000 | 70 | | | |
| Corrected Total | 2075.271 | 69 | | | |

Based on the results of the prerequisite tests conducted earlier, it can be concluded that the critical thinking ability data meet the prerequisites for univariate parametric analysis. Therefore, data analysis can proceed using the ANCOVA test. The ANCOVA results in Table 24 show that there is a significant difference in post-test critical thinking skills between the experimental group using the SSI eating disorder module and the control group after controlling for initial (pre-test) critical thinking skills, with an F-value of F(1,67) = 343.131 and a p-value of 0.00 < 0.05. Furthermore, initial critical thinking ability did not show a significant effect on post-test scores, with an F-value of F(1,67) = 1.598 and a significance level of 0.211 > 0.05. The partial eta-squared value of 0.837 indicates that the learning group had a very large effect size on post-test critical thinking ability after controlling for initial ability.

**Table 24.** ANCOVA Test Results for Critical Thinking Skills

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1747.825[a] | 2 | 873.913 | 178.815 | .000 | .842 |
| Intercept | 460.256 | 1 | 460.256 | 94.175 | .000 | .584 |
| Pre-test | 7.811 | 1 | 7.811 | 1.598 | .211 | .023 |
| Group | 1676.971 | 1 | 1676.971 | 343.131 | .000 | .837 |
| Error | 327.446 | 67 | 4.887 | | | |
| Total | 448317.000 | 70 | | | | |
| Corrected Total | 2075.271 | 69 | | | | |

Based on the estimated results in Table 25, the average post-test critical thinking ability score was 84.783 for the experimental group and 74.903 for the control group. Thus, the experimental group's average post-test critical thinking ability was higher than that of the control group after controlling for initial ability. These results indicate that, after controlling for initial critical thinking ability, the group that used the SSI eating disorder module had a higher average final critical thinking ability score than the control group.

**Table 25.** Estimated Marginal Means for Critical Thinking Skills

| Group | Mean | Std. Error | Lower Bound | Upper Bound |
|---|---|---|---|---|
| Experiment | 84.783[a] | .375 | 84.034 | 85.532 |
| Control | 74.903[a] | .375 | 74.153 | 75.652 |

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 63.3143.

The results of pairwise comparisons of critical thinking skills showed a significant difference between the experimental group and the control group. The experimental group, which used the SSI eating disorder module, had significantly higher post-test critical thinking scores than the control group, with a mean difference of 9.880 points (MD = 9.880) and a p-value of 0.00 < 0.05 (Table 26).

**Table 26.** Results of Pairwise Comparisons of Critical Thinking Skills

| (I) Group | (J) Group | Mean Diff. (I-J) | SE | Sig.[b] | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Experimental | Control | 9.880* | .533 | .000 | 8.816 | 10.945 |
| Control | Experiment | -9.880* | .533 | .000 | -10.945 | -8.816 |

Next is the statistical test for the collaboration ability variable. The results of the normality test using the Shapiro-Wilk test on the pre-test data of the experimental group yielded a significance value of 0.071 > 0.05, and the post-test data yielded a significance value of 0.754 > 0.05. These results indicate that the pre-test and post-test data on collaboration ability in the experimental group are normally distributed. Furthermore, the results of the normality test for the collaboration ability data in the control group showed a significance value of 0.144 > 0.05 for the pre-test and 0.118 for the post-test (Table 27).

**Table 27.** Results of the Normality Test for Collaboration Ability

| Data | Group | Statistic | df | Sig. |
|---|---|---|---|---|
| Pre-test | Experimental | .943 | 35 | .071 |
| | Control | .953 | 35 | .144 |
| Post-test | Experimental | .980 | 35 | .754 |
| | Control | .951 | 35 | .118 |

The results of the test for homogeneity of variances using Levene's test indicate that the data on collaboration skills exhibit homogeneous variances (Table 28). For the pre-test data, a significance value of 0.290 > 0.05 was obtained, while for the post-test data, a significance value of 0.531 > 0.05 was obtained. Therefore, it can be concluded that the variances of the pre-test and post-test data on collaboration skills are homogeneous, meaning there are no significant differences in variance between the groups.

**Table 28.** Results of the Homogeneity of Variance Test for Pre- and Post-Test Collaboration Skills

| | | Levene Statistic | df1 | df2 | Sig. |
|---|---|---|---|---|---|
| Pre-test | Based on Mean | 1.137 | 1 | 68 | .290 |
| | Based on Median | .745 | 1 | 68 | .391 |
| | Based on Median & with adj. df | .745 | 1 | 60.134 | .391 |
| | Based on trimmed mean | 1.095 | 1 | 68 | .299 |
| Post-test | Based on Mean | .396 | 1 | 68 | .531 |
| | Based on Median | .363 | 1 | 68 | .549 |
| | Based on Median & with adj. df | .363 | 1 | 67.435 | .549 |
| | Based on trimmed mean | .398 | 1 | 68 | .530 |

The results of the homogeneity of regression slopes test for collaboration skills indicate that the interaction between group and initial collaboration skills (Group × pre-test collaboration skills) yielded an F-value of F(1,66) = 0.00 with a significance level of 0.997 > 0.05 (Table 23). These results indicate that the interaction between group and students' pre-test collaboration ability is not significant. Thus, the assumption of homogeneity of regression slopes is met, indicating that the relationship between initial collaboration ability and final collaboration ability has homogeneous regression slopes in both the experimental and control groups.

**Table 29.** Homogeneity of Regression Slopes Collaborative Ability

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1903.215[a] | 3 | 634.405 | 119.028 | .000 | .844 |
| Intercept | 572.936 | 1 | 572.936 | 107.495 | .000 | .620 |
| Group | 2.404 | 1 | 2.404 | .451 | .504 | .007 |
| Pre-test | .000 | 1 | .000 | .000 | .994 | .000 |
| Group * Pre-test | 7.100E-5 | 1 | 7.100 | .000 | .997 | .000 |
| Error | 351.771 | 66 | 5.330 | | | |
| Total | 450415.000 | 70 | | | | |
| Corrected Total | 2254.986 | 69 | | | | |

a. R Squared = .844 (Adjusted R Squared = .837)

Based on the results of the prerequisite tests conducted earlier, it can be concluded that the collaboration ability data meet the assumptions required for univariate parametric analysis. Therefore, data analysis can proceed using the ANCOVA test. The ANCOVA results in Table 30 show a p-value of 0.000 < 0.05. This finding indicates that there is a significant difference in post-test collaboration ability between the experimental and control groups after controlling for initial collaboration ability. Furthermore, initial collaboration ability did not show a significant effect on post-test scores, with a significance value of 0.995 > 0.05. Finally, the partial eta-squared value of 0.839 indicates that the effect of the group factor on post-test collaboration ability is very large.

**Table 30.** ANCOVA Test Results for Collaboration Skills

| Source | Type III Sum of Squares | df | Mean Square | F | Sig. | Partial Eta Squared |
|---|---|---|---|---|---|---|
| Corrected Model | 1903.215[a] | 2 | 951.607 | 181.248 | .000 | .844 |
| Intercept | 586.388 | 1 | 586.388 | 111.686 | .000 | .625 |
| Pre-test | .000 | 1 | .000 | .000 | .995 | .000 |
| Group | 1830.798 | 1 | 1830.798 | 348.702 | .000 | .839 |
| Error | 351.771 | 67 | 5.250 | | | |
| Total | 450415.000 | 70 | | | | |
| Corrected Total | 2254.986 | 69 | | | | |

a. R Squared = .844 (Adjusted R Squared = .839)

Based on the estimated marginal means in Table 31, the average estimated collaboration ability was 85.229 in the experimental group and 74.800 in the control group. Thus, the experimental group's average collaboration ability was higher than that of the control group after controlling for initial ability. These results indicate that, after controlling for initial collaboration ability, students who learned using the SSI eating disorder module had a higher average final collaboration ability than the control group.

**Table 31.** Estimated Marginal Means for Collaboration Ability

| Group | Mean | Std. Error | 95% CI | |
|---|---|---|---|---|
| | | | Lower | Upper |
| Experiment | 85.229[a] | .391 | 84.448 | 86.010 |
| Control | 74.800[a] | .391 | 74.019 | 75.580 |

a. Covariates appearing in the model are evaluated at the following values: Pre-test = 63.4286.

Based on the results of the pairwise comparisons in Table 32, the mean difference in collaboration skills between the experimental group and the control group was found to be 10.429 points. The significance value of 0.000 < 0.05 indicates that there is a significant difference in collaboration skills between the experimental group and the control group after controlling for initial ability. Thus, the collaboration skills of students who learned using the SSI eating disorder module were significantly higher than those of the control group after controlling for initial ability.

**Table 32.** Results of Pairwise Comparisons of Collaboration Skills

| (I) Group | (J) Group | Mean Diff. (I-J) | SE | Sig.[b] | 95% CI | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| Experimental | Control | 10.429* | .559 | .000 | 9.315 | 11.544 |
| Control | Experimental | -10.429* | .559 | .000 | -11.544 | -9.315 |

The results of the ANCOVA analysis in Table 24 generally indicate that the use of the SSI eating disorder module has an effect on improving the critical thinking skills of Phase F students in the digestive system curriculum. Research results by Rohali & Hamimi (2024) also found that SSI-based teaching materials that address controversial environmental issues are effective in improving students' critical thinking skills. These are the findings of a study by Nirwana & Octavia (2025) that incorporating SSI-based instructional materials can also enhance students' critical thinking skills regarding the reproductive system. Therefore, the findings of this study contribute to the understanding that using the SSI eating disorder module helps improve the critical thinking skills of students in Phase F.

Each learning activity in the SSI eating disorder module is designed to enhance critical thinking skills (Table 18). By addressing the issue of eating disorders, students are confronted with real-world problems related to health, social issues, and psychology, thereby encouraging them to think critically in order to understand the causes, impacts, and prevention strategies. Students do not merely receive information; they also analyze facts, evaluate various perspectives, identify relevant scientific evidence, and formulate logical solutions based on the results of their discussions. For example, in the first learning activity during the "engagement stage," students are presented with the question, "Should social media be held responsible for the rise in eating disorder cases among adolescents?" In this activity, students are divided into "pro" and "con" groups to discuss and present arguments based on their respective viewpoints. This activity develops the critical thinking indicator of the ability to "provide a simple explanation," as students are required to identify the main issue, explain the relationship between social media use and eating disorders, and present an initial opinion supported by relevant facts or information (Table 18). In addition, students also learn to distinguish between facts and opinions and to provide logical reasons to support the arguments they present.

According to Kusumaningsih et al. (2025) and Liu & Tu (2024) Incorporating SSI topics into learning modules makes the material more relevant to students' daily lives, thereby encouraging them to think critically and make decisions based on scientific evidence. (Rahmanto et al., 2026) It adds that SSI provides students with the opportunity to consider various perspectives when facing problems that do not have a single correct answer, thereby stimulating their critical thinking skills. SSI-based learning provides a meaningful learning experience because students not only understand scientific concepts but also relate them to real-world social issues (Gul & Akcay, 2020). According to Dusturi et al. (2024) Involving social issues related to science encourages students to actively engage in learning through various activities and deep reflection, enabling them to make informed decisions that take moral, ethical, and social aspects into account. In this module, the SSI topic addressed is eating disorders, a health issue increasingly prevalent among adolescents and closely linked to the influence of social media, body image, eating patterns, and mental health (Table 10). This topic was chosen because it is relevant to students' lives, thereby enhancing their engagement in the learning process. Through discussions of this issue, students are encouraged to analyze the causes and effects of eating disorders, evaluate information circulating in the media, and formulate solutions and make decisions based on scientific evidence. Thus, the context of eating disorders not only strengthens students' understanding of biological concepts but also facilitates the development of critical thinking skills through analysis, evaluation, and argumentation regarding issues relevant to their lives.

In addition to helping improve critical thinking skills, the use of the SSI eating disorder module also helped improve the collaboration skills of Phase F students in the excretory system

unit (Table 30). The findings of this study are consistent with previous research Mellyzar et al. (2025) and Revinda, Sukarmin, et al. (2025) that incorporating SSI into effective learning enhances students' collaboration skills. Research findings by (Tullah et al., 2025) The study also found that incorporating SSI-based instructional materials into effective learning helps improve students' collaboration skills. Therefore, the findings of this study contribute to the understanding that using the SSI eating disorder module helps improve students' collaboration skills in Phase F.

The modules in this study were developed using SSI (Table 10), and the learning activities within the SSI modules were designed to improve indicators of student collaboration from Learning Sessions 1 through 4 (Table 18). Incorporating SSI into learning activities positions students as active participants engaged in discussions, information analysis, and the evaluation of various perspectives on a specific issue (Alves et al., 2025; Rahmanto et al., 2026). According to Dusturi et al. (2024) and Ni'mah et al. (2025) controversial issues emerging in society have proven effective as contexts for science and biology instruction, encouraging students to actively engage in discussions and present arguments grounded in scientific evidence. In this study, the SSI issue presented in the module was eating disorders. During the learning process using the SSI eating disorder module, students were divided into "pro groups" and "con groups" (Table 18). The pro groups were tasked with developing arguments supporting the statements on the given issue, while the con groups developed arguments opposing those statements. During the discussion process, students were required to seek information from various sources, evaluate the accuracy of the information, connect it to biological concepts they had learned, and consider health, social, psychological, and ethical aspects. Each group member had the opportunity to express their opinions, provide input, and determine the best arguments to present. These interactions train students to actively contribute to discussions, work productively, demonstrate responsibility, flexibility, and a willingness to compromise, and show mutual respect (Table 10). Thus, the SSI eating disorder module not only contributes to students' mastery of digestive system concepts but also facilitates the development of their collaborative skills.

## CONCLUSION

The SSI eating disorder module in this study is appropriate, practical, and effective as teaching material on the human digestive system, facilitating the development of critical thinking and collaboration skills among Phase F students. The appropriateness of the SSI eating disorder module was assessed by one expert in media and teaching materials, who gave it an average score of 93%, and one subject matter expert, who gave it an average score of 75%. The practicality of the SSI eating disorder module was assessed by practitioners, namely 2 biology teachers and 30 students. The average teacher rating was 88.4%, and the average student rating was 72%. Based on the results of the ANCOVA test, the use of the SSI eating disorder module had a significant effect on students' critical thinking skills, with a significance value of $0.000 < 0.05$. The results of the estimated marginal means and pairwise comparisons also showed that the experimental group using the SSI eating disorder module had higher final critical thinking skills compared to the control group. In addition, the results of the ANCOVA test on collaboration skills also yielded a significance value of $0.000 < 0.05$. Furthermore, the results of the estimated marginal means and pairwise comparisons also showed that the experimental group using the SSI eating disorder module had higher collaboration skills than the control group. Thus, the use of the SSI eating disorder module can support the improvement of critical thinking or collaboration skills among Phase F students in the subject of the human digestive system.

In general, the research results indicate that SSI-based module learning can serve as a means to enhance students' critical thinking and collaboration skills. These findings have important implications for the learning process in schools, namely the need for teachers to integrate contextual issues related to social life, health, and inequality into learning activities.

Thus, students not only understand concepts theoretically but are also able to analyze real-world problems more deeply, evaluate various sources of information, and work together to solve problems. Therefore, the development and implementation of SSI modules can serve as a relevant educational innovation to support the strengthening of 21st-century skills.

## RECOMMENDATION

Regardless of the results obtained, this development study has several limitations. First, the resulting product consists of instructional materials in the form of printed modules, so their use is still limited to conventional learning media. Therefore, future development is expected to integrate digital technology so that the instructional materials become more interactive and accessible. Second, the module feasibility assessment process involved one media expert and one subject matter expert from each respective field of expertise. The limited number of validators is one of the limitations of this study because the module feasibility assessment was based on only one evaluation from each field of expertise. Nevertheless, the experts involved were selected based on their competencies and fields of expertise, which aligned with the characteristics of the modules and the aspects being evaluated. Thus, the assessments remain relevant to the validation objectives and the characteristics of the developed product. Third, the product trial was conducted at only one school, so the scope of its implementation remains limited. Therefore, future research should involve more schools with diverse characteristics to obtain a broader picture of the product's effectiveness. Fourth, the collaborative assessment conducted through self-assessment has the potential to introduce bias because it is subjective. Nevertheless, during the study, the researchers asked students to respond based on their actual experiences during the learning process. Therefore, in future research, the assessment of collaboration should be combined with direct observation to ensure that the results are more objective and accurate in depicting students' collaborative abilities. Fifth, the materials developed in this study focused solely on the digestive system, with SSI issues centered on eating disorders. Thus, future research is expected to develop instructional materials on different SSI topics and issues, thereby enriching the variety of learning contexts and enhancing the relevance of learning to various real-life problems. Sixth, the control group in this study still used the teaching methods typically employed by teachers in schools, namely conventional instruction using textbook materials along with lectures and discussions. This condition constitutes one of the limitations in comparing the effectiveness of the SSI module more specifically. Therefore, future research examining the effectiveness of the SSI module could use a comparison group employing a relevant learning model or approach with comparable learning characteristics. Consequently, a comparison of the SSI module's effectiveness could provide a more comprehensive picture of how its use contributes to improving students' critical thinking and collaboration skills.

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**AUTHOR CONTRIBUTIONS STATEMENT**

| Name of Author | C | M | So | Va | Fo | I | R | D | O | E | Vi | Su | P | Fu |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Melfa Nia | ✓ | ✓ | ✓ | | ✓ | ✓ | ✓ | | ✓ | | ✓ | | ✓ | ✓ |
| Evy Yulianti | | | | ✓ | | | | ✓ | | ✓ | | ✓ | ✓ | |

**CONFLICT OF INTEREST STATEMENT**

The author has no conflict of interest.

**DATA AVAILABILITY**

The research data are open and available from the corresponding author upon request.

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