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CULTIVATING HIGHER ORDER THINKING AND ASSESSMENT DESIGN THROUGH THE SISSCA MODEL WITH E-MODULE INTEGRATION

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ABSTRACT

The demands of twenty-first-century education require prospective biology teachers to demonstrate not only mastery of Higher-Order Thinking Skills (HOTS) but also the capacity to cultivate a learning and assessment culture grounded in critical inquiry, reflective practice, and systematic evaluation. Preliminary findings reveal that students' competence in designing assessment instruments—particularly within the cognitive and affective domains remains insufficient, indicating a limited culture of higher-order assessment practices. This study investigates the effectiveness of the SISSCA model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, and Appraising), supported by e-modules, in fostering a constructivist learning culture while enhancing HOTS and assessment design skills. Employing a Plomp-based developmental framework encompassing preliminary research, prototyping, and assessment phases, the study demonstrates that integrating the SISSCA model with digital modules significantly improves analytical thinking and promotes systematic instrument construction. The findings contribute to the theoretical literature on constructivist pedagogy and offer practical implications for strengthening professional competencies aligned with the Merdeka Curriculum.

KEYWORDS: Higher-Order Thinking Skills (HOTS), assessment instruments, e-modules, SISSCA model, innovative learning.

1. INTRODUCTION

The advancement of twenty-first-century education requires prospective teachers to develop Higher-Order Thinking Skills (HOTS), encompassing analysis, evaluation, and creation. These competencies are essential not only for solving complex problems but also for designing assessment instruments aligned with the Merdeka Curriculum, which emphasizes comprehensive evaluation of attitudes, knowledge, and skills while promoting critical, creative, collaborative, and communicative thinking (1);(2). However, empirical evidence indicates that prospective biology teachers still demonstrate limited competence in constructing HOTS-based assessment instruments. Difficulties persist in formulating analytical rubrics, developing higher-order test items, and integrating assessment principles into instructional practice. Such limitations reflect an underdeveloped culture of higher-order assessment, compounded by insufficient structured and innovative learning resources in evaluation-related courses (3); (4).

To address these challenges, this study proposes the SISSCA model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, and Appraising), assisted by interactive e-modules. The model integrates Project-Based Learning and structured drill methods to provide meaningful, practice-oriented learning experiences. Project-based activities engage students in authentic tasks that foster analytical and creative thinking, while systematic drills reinforce conceptual and procedural mastery. The integration of e-modules ensures flexible, interactive, and independent learning, supporting both classroom and self-directed study (5). Grounded in constructivist principles, the SISSCA model facilitates active knowledge construction, collaboration, and reflective evaluation. Consequently, it offers a relevant instructional innovation for strengthening HOTS and cultivating a sustainable assessment design culture among prospective biology teachers in the digital era.

2. RELATED WORK

The integration of constructivist approaches and active learning has been widely recognized as a significant factor in improving the quality of higher education (6); (7). Contemporary research emphasizes that student-centered instructional models foster deeper engagement, thereby strengthening Higher-Order Thinking Skills (HOTS), including analysis, evaluation, and creation (8). In addition, inclusive assessment practices and innovative science curricula are critical in promoting

HOTS-oriented instruction and enhancing overall teaching effectiveness (9); (3). These findings underscore the necessity of pedagogical innovations that integrate theory, practice, and technology to prepare prospective teachers for complex educational contexts.

The SISSCA model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, and Appraising), assisted by e-modules, represents such an innovation. Conceptually, it combines Project-Based Learning (PjBL) with structured drill exercises. PjBL engages students in authentic, meaningful projects that produce tangible outputs, encouraging creativity and critical inquiry. Meanwhile, drill activities reinforce conceptual understanding and procedural mastery through systematic practice. The incorporation of e-modules extends learning beyond classroom boundaries by providing structured, interactive, and flexible digital resources (5); (10).

E-modules coherently support the six stages of SISSCA. In the Stimulating stage, multimedia content and contextual cases spark curiosity and connect theory with real-world challenges. During Identifying Problems, digital guidance helps students recognize authentic issues in biology assessment practices. The Solving Problems phase provides simulations and scaffolded exercises to enhance analytical and evaluative reasoning. In Strategizing, interactive tools enable collaborative planning and critical decision-making. The Creating Instruments stage provides templates and digital rubrics to facilitate the development of valid, reliable HOTS-based assessments. Finally, the Appraising stage integrates self-assessment and peer-feedback features to cultivate reflective and metacognitive skills.

This integrated framework operationalizes constructivist principles by engaging students in active knowledge construction, collaboration, and reflection. Empirical studies confirm that PjBL enhances creativity and learning outcomes (11); (12), while e-modules promote independence, motivation, and academic performance (13); (4)

Consequently, the SISSCA model, assisted by e-modules, contributes to two primary outcomes: enhancing HOTS and developing applied competencies in assessment design. Together, these competencies prepare prospective teachers to become critical, innovative, and adaptive professionals capable of responding effectively to twenty-first-century educational demands.

3. RESEARCH METHODOLOGY

3.1 Sample and Research Design

The participants of this study were undergraduate students enrolled in the Biology Education Study Program at Universitas PGRI Sumatera Barat, specifically those taking the Evaluation of Biology Teaching and Learning Processes and Outcomes course in the even semester of the academic year. Purposive sampling was employed because these students were directly engaged with assessment-related coursework relevant to the research objectives. The sample consisted of two groups: an experimental group that received instruction through the SISSCA model assisted by e-modules, and a control group that experienced conventional teaching methods.

3.2 Data Collection and Analysis

The study followed Plomp's R&D model, encompassing preliminary research, prototyping, and assessment phases. Initial data were gathered through needs analysis, diagnostic tests, and interviews to identify students' baseline HOTS and assessment design skills. During the prototyping phase, the SISSCA model and e-modules were developed and validated by experts. In the assessment phase, posttests, performance rubrics, questionnaires, observations, and interviews were administered. Quantitative data were analyzed using validity, practicality, gain scores, and independent-samples t-tests, while qualitative data were examined through thematic analysis. The model was considered successful if it met validity, practicality, and effectiveness criteria (14).

4. RESULT AND DISCUSSION

4.1 Need Analysis

The needs analysis was conducted in February 2022 through interviews, document analysis, and preliminary testing, involving the lecturer and students of the Evaluation of Biology Teaching and Learning Processes and Outcomes course in the Biology Education Study Program at Universitas PGRI Sumatera Barat. The findings revealed that prospective biology teachers still experience substantial difficulties in designing and developing assessment instruments across the domains of attitudes, knowledge, and skills. Furthermore, structured and systematic learning resources to guide students in constructing such instruments were not yet available. Existing instructional materials were limited to PowerPoint slides, guided

discovery-based handouts, and printed textbooks, many of which lacked practical guidance and were not fully accessible to students.

Quantitative data from the preliminary study indicated that students' ability to design assessment instruments varied across domains. The percentage for attitude assessment was 67.82% (fair), knowledge assessment 50.5% (fair), and skills assessment 74.84% (high). Although the skills domain showed relatively better performance, the knowledge domain demonstrated notably low achievement, suggesting gaps in conceptual understanding and application of evaluation principles.

The analysis of Higher-Order Thinking Skills (HOTS), encompassing C4 (analysing), C5 (evaluating), and C6 (creating) of Bloom's Revised Taxonomy, further highlighted critical concerns. The average HOTS score was only 46.42, indicating a generally low level of higher-order thinking. Only 5.3% of students were categorized as very high or high, 11.1% as moderate, 27.9% as low, and 55.7% as very low. These findings demonstrate that the majority of students were not yet adequately trained to think critically, analytically, and creatively.

Interview data reinforced these quantitative results. Students reported three primary challenges: (1) difficulty in understanding course materials, particularly in designing rubrics and constructing valid assessment instruments; (2) textbooks that were perceived as unsystematic and lacking step-by-step practical guidance; and (3) learning processes that did not optimally stimulate active engagement and critical reflection. These conditions align with Freeman et al. (2014), who emphasized that passive instructional approaches are less effective in fostering deep learning and higher-order thinking.

The findings are also consistent with Ramadhan et al. (2020), who argued that HOTS-based instruments are essential not only for measuring competencies but also for elevating students' cognitive levels. Similarly, Mitani (2021) highlighted that the limited use of innovative learning models contributes to low HOTS achievement.

The needs analysis indicates a significant gap between curriculum expectations, particularly those of the Merdeka Curriculum, which emphasizes HOTS-oriented assessment, and the actual competencies of prospective biology teachers. This condition underscores the urgency of implementing innovative instructional models, such as the SISSCA model supported by e-modules, to enhance higher-order thinking skills and strengthen students' competence in designing valid and reliable assessment instruments.

4.2 Curriculum Analysis

The curriculum analysis was conducted on the Evaluation of Biology Learning Processes and Outcomes course within the Biology Education Study Program, Faculty of Science and Technology, Universitas PGRI Sumatera Barat. The analysis examined course learning outcomes (CLOs), instructional materials, content structure, and the evaluation system to ensure alignment between the proposed instructional model and curriculum expectations, particularly in strengthening Higher-Order Thinking Skills (HOTS).

The findings indicate that the curriculum explicitly emphasizes students' competence in designing and analysing assessment instruments grounded in Anderson's revised Bloom's Taxonomy. This emphasis is reflected in CLO 3 and CLO 4. CLO 3 requires students to construct, process, and analyse assessment instruments for affective, cognitive, and psychomotor domains. CLO 4 further specifies the ability to develop HOTS-based instruments focusing on higher cognitive levels (C4-C6: analysing, evaluating, and creating). These outcomes highlight the expectation that learning activities should cultivate analytical, evaluative, and creative capacities through classical, cooperative, and independent learning formats.

To operationalize these CLOs, the SISSCA model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, and Appraising), assisted by e-modules, is considered highly relevant. Each stage of the model corresponds systematically to the curriculum demands. In the Stimulating phase, students are exposed to authentic assessment cases to contextualize learning. During Identifying Problems, they critically examine weaknesses in existing instruments. The Solving Problems and Strategizing stages guide students in aligning assessment design with the revised Bloom's Taxonomy and learning objectives. In Creating Instruments, students develop prototypes of assessment tools covering affective, cognitive, and psychomotor aspects, including HOTS-based items. Finally, the Appraising stage emphasizes peer review and self-evaluation to ensure validity and reliability.

Complementing the curriculum analysis, interviews, and preliminary studies revealed persistent challenges. Lecturer interviews indicated that students' ability to design assessment instruments remains limited, particularly in the attitude and knowledge domains. Learning resources are largely confined to PowerPoint slides, guided discovery handouts, and printed textbooks

that lack a systematic structure and are not accessible. Students also reported difficulties understanding evaluation concepts, constructing rubrics, and actively engaging in the learning process.

Quantitative findings show that skills assessment design reached 74.84% (high), while attitude (67.82%) and knowledge (50.5%) assessments were categorized as fair. Moreover, the average HOTS score was only 46.42%, with 55.56% of students in the very low category and only 5.26% in the high category. These results underscore a substantial gap between curriculum expectations and actual student competence.

Consistent with Tamah et al. (2023), who emphasized the importance of validated HOTS-oriented frameworks in teacher education, the present findings confirm the urgency of integrating innovative models. Overall, the analysis demonstrates that limited systematic resources, insufficient HOTS training, and less interactive instructional processes hinder curriculum achievement. Therefore, implementing the SISSCA model supported by e-modules represents a strategic response to align instructional practice with curriculum standards and enhance prospective biology teachers' professional competence.

4.3. Result of Concept Analysis

The concept analysis stage was conducted to obtain a comprehensive understanding of the objectives, scope, and structure of the Evaluation of Learning Processes and Outcomes in Biology course. This stage involved identifying key concepts, organizing them systematically, and mapping their relationships to the Course Learning Outcomes (CLOs). The purpose was to ensure that the instructional model to be developed is conceptually grounded and aligned with curriculum demands, particularly in strengthening Higher-Order Thinking Skills (HOTS) among prospective biology teachers.

The course encompasses fundamental concepts of measurement, assessment, and evaluation; the scope and techniques of assessing learning outcomes; and the design, analysis, and processing of assessment instruments across affective, cognitive, and psychomotor domains. The four CLOs progressively guide students from conceptual understanding to applied competence. CLO 1 emphasizes explaining and analysing basic evaluation concepts, requiring analytical skills (C4) to distinguish measurement, assessment, and evaluation. CLO 2 focuses on understanding assessment scope and techniques, engaging both analytical (C4) and evaluative (C5) thinking to determine appropriate methods for

different learning objectives.

CLO 3 advances toward the development, processing, and analysis of assessment instruments in affective, cognitive, and skills domains. At this level, students must evaluate instrument quality based on validity and reliability (C5) and create assessment tools aligned with curriculum standards (C6). CLO 4 further concentrates on designing HOTS-based instruments that target higher cognitive levels—analysis, evaluation, and creation (C4–C6). This progression demonstrates that the course is systematically structured to cultivate increasingly complex cognitive competencies.

The mapping of CLOs, study materials, and HOTS competencies confirms that theoretical knowledge alone is insufficient. Students are expected not only to comprehend evaluation principles but also to construct and critically appraise authentic assessment instruments. Literature supports this alignment. Nitko & Brookhart (2011) emphasize that strong conceptual foundations are essential for producing valid and reliable assessments (15). Similarly, Ramadhan et al. (2020) and Pratama & Retnawati (2018) highlight the necessity of HOTS mastery in designing curriculum-relevant instruments (4); (16). Zohar & Barzilai (2015) and Dori et al. (2018) argue that HOTS-oriented assessments enhance critical thinking and innovative capacity in 21st-century education (17); (18).

The concept analysis reveals that the course learning outcomes are coherently designed to integrate analysis, evaluation, and creation within assessment practice. However, achieving these outcomes requires an instructional approach that bridges theory and application. Therefore, the development of the SISSCA model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, Appraising), supported by e-modules, is highly relevant. This model facilitates active engagement, structured practice, and reflective evaluation, ensuring that prospective biology teachers are systematically trained to design HOTS-based assessment instruments aligned with contemporary curriculum demands and constructivist learning principles.

4.4 Result of The Literature Review

The literature review in this study analyzed theories and concepts that form the foundation for developing the SISSCA learning model (Stimulating, Identifying Problems, Solving Problems, Strategizing, Creating Instruments, Appraising), supported by an e-module. This analysis aimed to identify relevant theoretical aspects that support the

enhancement of Higher-Order Thinking Skills (HOTS) among prospective biology teachers, particularly in the course Evaluation of Learning Processes and Outcomes in Biology. Based on the review, three main theoretical categories were identified as the foundation for this model, summarized in Table 1.

Table 1: Supporting Aspects for the Development of the SISSCA Learning Model with E-Module Integration.

Aspect	Supporting Theories	References
Model Construction	Syntax, Social system, Principles of reaction, Support system, Instructional and nurturant effects	Joyce, W., & Calhoun (2015). (19)
Stages of Model Development	Preliminary research, Prototyping phase, Assessment phase	Plomp (2013) (20)
Theoretical Foundations	Cognitive Constructivism (Piaget), Social Constructivism (Vygotsky), Meaningful Learning Theory (Ausubel), Discovery Learning Theory (Bruner), Connectivism Theory (Siemens)	Shuell (1986) ; Slavin (1994) (21); Schunk (2011); Zhou & Brown (2015) (7); Siemens (2005, 2008); Boyraz & Ocak (2021) (10)

The SISSCA learning model, developed with the support of an e-module, is the result of integrating various educational theories oriented toward strengthening Higher-Order Thinking Skills (HOTS). This model is designed for implementation in the Evaluation of Learning Processes and Outcomes in Biology course to enhance students' ability to analyze, evaluate, and create assessment instruments.

4.5. Discussion

The findings of this study demonstrate that the SISSCA model, supported by e-modules, functions not merely as an instructional strategy but as a structured pedagogical system capable of cultivating Higher-Order Thinking Skills (HOTS) and systematic assessment design competencies among pre-service biology teachers. These results extend broader systemic perspectives in education, which emphasize that innovation does not automatically yield transformation unless supported by a coherent conceptual and structural framework that mediates between curriculum demands and classroom practice.

The educational theories examined in this study provide a comprehensive conceptual foundation for developing the SISSCA model supported by e-modules. Cognitive Constructivism (Piaget) emphasizes that learners actively construct knowledge through internal cognitive processes shaped by experience. This perspective underscores the importance of engaging prospective biology teachers in authentic tasks that help them meaningfully internalize evaluation concepts. Complementing this view, Social Constructivism (Vygotsky) stresses the role of social interaction and collaboration in knowledge construction, supporting the inclusion of peer discussion, feedback, and cooperative problem-solving within the SISSCA stages. Meaningful Learning theory (Ausubel) further strengthens this framework by emphasizing the linkage between new information and existing cognitive structures, ensuring that assessment literacy develops conceptually rather than superficially. Discovery Learning (Bruner) reinforces students' active role in exploring and formulating concepts independently, particularly during the problem-identification and problem-solving phases. Meanwhile, Connectivism (Siemens) situates learning within digital networks, making it especially relevant to the integration of e-modules as interactive technological support systems that promote flexible, self-directed, and networked learning in the digital era. Together, these perspectives integrate cognitive, social, and technological dimensions into a multidimensional pedagogical base.

Discovery Learning (Bruner) reinforces students' active role in exploring and formulating concepts independently, aligning with the problem-identification and problem-solving stages of SISSCA. Meanwhile, Connectivism (Siemens) situates learning within digital networks, making it particularly relevant to the integration of e-modules as interactive, technology-based resources that support flexible and self-directed learning in the digital era. Together, these theories establish a multidimensional pedagogical base that integrates cognitive, social, and technological dimensions of learning.

The structural design of the SISSCA model is further informed by the instructional framework proposed by Joyce, Weil, and Calhoun (2015), which outlines essential components of effective models, including syntax, social system, principles of reaction, support systems, and instructional and nurturant effects. This framework ensures that each stage of SISSCA (Stimulating, Identifying Problems,

Solving Problems, Strategizing, Creating Instruments, and Appraising) is systematically organized to foster both immediate learning outcomes and long-term professional dispositions. In addition, the developmental procedures follow Plomp's (2013) model, consisting of preliminary research, prototyping, and assessment phases. This methodological structure guarantees that the model is rigorously designed, validated, and evaluated before implementation.

Curriculum analysis of the Evaluation of Learning Processes and Outcomes in Biology course reveals a strong emphasis on developing Higher-Order Thinking Skills (HOTS), particularly in CLO 3 and CLO 4, which require students to design and analyse HOTS-based assessment instruments grounded in Anderson's revised Bloom's taxonomy. However, findings indicate that students' competencies remain limited, especially in designing knowledge- and attitude-based assessments, and that their average HOTS achievement is low. These challenges are compounded by limited systematic learning resources and insufficient active engagement during instruction.

The SISSCA model supported by e-modules is therefore proposed as a strategic solution. By integrating constructivist principles with structured digital resources, the model enables students to progressively develop analytical, evaluative, and creative skills while practicing authentic instrument design. Empirical evidence supports this direction: active learning improves learning outcomes (1), and interactive e-modules enhance motivation and critical thinking (12).

Conceptually, this study extends systemic educational models by positioning instructional design as the micro-level mediator between curriculum mandates and competency outcomes. The integrative pathway can thus be articulated as Curriculum Demand → Instructional Design (SISSCA + E-Module) → Reflective Learning Culture → HOTS and Assessment Competence (22).

The synthesis of classical constructivist theories, contemporary digital learning perspectives, and systematic instructional design establishes a robust pedagogical framework for strengthening HOTS and assessment design competence. The SISSCA model, supported by e-modules, represents an innovative, theoretically grounded approach to preparing prospective biology teachers for the demands of 21st-century education and the Merdeka Curriculum.

5. CONCLUSION

This study indicates that pre-service biology

teachers' ability to design assessment instruments remains relatively low, particularly in the knowledge and attitude domains, and their Higher-Order Thinking Skills (HOTS) are insufficiently developed. Findings from the needs analysis, curriculum review, conceptual analysis, and literature study underscore the urgency of instructional innovation. The SISSCA model supported by e-modules offers a relevant solution by integrating cognitive constructivism, social constructivism, connectivism, and active learning principles. Its structured stages, stimulating, identifying problems, solving problems, strategizing,

creating instruments, and appraising, provide systematic learning experiences that simultaneously foster HOTS and assessment design competence.

The implications are significant: lecturers can apply the model to systematically train students in developing valid and reliable HOTS-based instruments; pre-service teachers can strengthen critical and creative thinking skills; researchers can further test its effectiveness across disciplines; and institutions can enhance graduate quality in response to 21st-century educational demands.

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