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Research Artikel

MARZANO'S INSTRUCTIONAL STRATEGIES: FOSTERING INFORMATION ANALYSIS AND PROCESSING SKILLS OF PLANT ANATOMY IN TEACHER EDUCATION

Anna Fitri Hindriana[1*], Behailu Merdekios Gello[2], Ina Setiawati[3], Handayani[4], Alin Rizki Pratami[5]
[1,3,4,5] Universitas Kuningan, Kuningan, Indonesia
[2]Arba Minch University, Department of Public Health Ethiopia
anna@uniku.ac.id[1*]

Abstract
This study proposes a design for a Plant Anatomy course by adapting Marzano's instructional framework to develop students' information analysis and processing skills. The focus of the Plant Anatomy course is determined because it requires complex cognitive processing to integrate knowledge about plant tissue structure with changes in plant structure based on adaptation strategies in their habitat. This study employs a quantitative method, utilising information analysis ability tests and process skills tests as its instruments. The data were analysed descriptively using an assessment rubric. The design is then tested on 106 undergraduate students in Biology Education taking the Plant Anatomy course during data collection at a university in West Java, Indonesia. The results showed that the Marzano-based plant anatomy course design could facilitate students' information analysis and processing skills due to a conducive learning environment, the utilisation of prior knowledge, the development of thinking potential, the delivery of meaningful information, contextual learning, and cooperative learning. This study further proposes using this design when studying materials with a high concept interconnection.

Keywords: *Cognitive load; concept mastery; information analysis skill; marzano instructional framework; plant anatomy learning.*

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*Corresponding author
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INTRODUCTION

The Plant Anatomy course is one of the most challenging classes for undergraduate students because it covers complex and interrelated concepts. Students need to master various structures derived from a single plant organ and relate them to the plant's adaptation strategy within a habitat; hence, students require complex thinking skills to master the topic. Unfortunately, the education program in universities in Indonesia inadequately provides support for the development of complex thinking skills. (Puspitawati et al., 2018). Specifically in the Biology Education Program, the lack of pre-teacher students' thinking skills is shown by inadequate analysis (IA) and information processing (IP) skills. (Hujjatusnaini et al., 2022). The real problem that arises is the high level of interconnectedness between concepts, for example, changes in tissue structure in response to different environments (such as leaf adaptation to dry or wet environments). The inadequate thinking skill is attributed to the low ability to process highly complex information from learning activities in the classroom and textbook materials. Consequently, the underdeveloped information analysis skills of pre-service teachers correlate with a limited mastery of plant anatomy concepts, as evidenced by their difficulties in identifying plant structures within the Plant Anatomy course. (Setiono et al., 2017). This problem was further evident during on-site teaching practice, where pre-service teachers struggled to articulate the relationship between plant structure and function when delivering plant biology lessons in secondary school settings. This resulted in a superficial treatment of the subject matter.

To enhance the pre-teacher students' ability to analyse information and perform higher-order processing skills as well as master complex concepts, the system of cognitive processing should be first understood (Lintz & Johnson, 2021; Rönnberg et al., 2021). The theory of cognitive processing explains that in dealing with information, the human cognitive system utilizes two parts of the brain's memory: working memory and long-term memory. (Kerzel & Andres, 2020). Working memory is a part of the brain's memory responsible for receiving and processing newly acquired information before storing it in long-term memory for future use. (Strunk et al., 2019). Due to the tremendous amount of information that can be dealt with at a time, the working memory has a limited capacity, as well as a limited duration for information storage, to prevent overcapacity, leading to an overexhausted brain. (Hanfstingl et al., 2019; Manglos-Weber & Avelis, 2019; Weber et al., 2024). It is likely for working memory to be overloaded when the amount and complexity of information surpass its capacity. This means that learning materials with a high level of concept interconnection, such as Plant Anatomy, are challenging to process.

Based on the cognitive information processing theory, Marzano (1988) published an instructional framework to guide teaching practices. The instructional framework consists of five learning dimensions and a thinking taxonomy. The learning dimension (Marzano, 1992). Consists of five dimensions: attitude, perception, acquisition and integrated knowledge, extension and refined knowledge, using knowledge meaningfully, and habits of mind. Meanwhile, Marzano’s taxonomy categorises thinking processes into three systems that interact with knowledge arranged in four different domains. The three interconnected thinking processes are the self-system that controls the metacognitive system which also controls the cognitive system. Each component also operates on the content achievement of three knowledge domains: domain of information, mental procedures, and psychomotor procedures.

The domain and taxonomy in Marzano's instructional framework show the natural interaction of the cognitive system with the different types of information or knowledge, highlighting the process of thinking when learning. The thinking processes are closely related to the activity of working memory, that is, the entire cognitive process that occurs intentionally, which can only handle a limited number of possibilities and have very limited elements, no more than two or three novels of element interaction (Amadieu et al., 2009; Paas & van Merriënboer, 2020; Sweller et al., 2019). Working memory determines the capacity of cognitive processes during the learning process. Considering this, this study adapts

Marzano's instructional framework to design course activities for teaching Plant Anatomy in the Teacher Education Program. It builds on Marzano's learning dimensions that have been applied in many schools and colleges in facilitating students to be actively involved in the thought process during learning (Almekhlafi et al., 2020; Dubas & Toledo, 2016; Kadarusman et al., 2020). The use of the Marzano instructional framework that highlights the thinking process would guide the process of integrating plant structure characteristics and relating them with plant habitat to facilitate pre-teacher students in creating an information scheme while learning plant anatomy concepts.

METHOD

In adapting the Marzano Instructional Framework to Plant Anatomy course design, This study employed a quantitative method using a quasi-experimental design with a one-group posttest-only design (Bolondi et al., 2018). The Plant Anatomy course design, assessment rubric and knowledge construction test are the three instruments for quantitatively measuring the effectiveness of adapting Marzano's instructional framework to enhance information analysis (IA) and information processing (IP) skills. A preliminary needs assessment was conducted to identify the learning objectives and to observe the challenges faced by students in the classroom while learning Plant Anatomy. The instruments were subsequently evaluated by experts to ascertain the content validity and feasibility of the design prior to implementation. The instrument for assessing information analysis ability demonstrated a validity coefficient of 0.77 and a reliability coefficient of 0.72. Meanwhile, the instrument for assessing process skills showed a validity coefficient of 0.72 and a reliability coefficient of 0.83. Accordingly, both the information analysis ability test and the process skills test instruments can be considered valid, as their correlation coefficients exceed the critical value of $\alpha = 0.05$ (df = 22), which is 0.413. Furthermore, both instruments exhibit high reliability, with correlation coefficients equal to or greater than 0.70 (Asrul et al., 2015). The methodology is outlined in Figure 1.

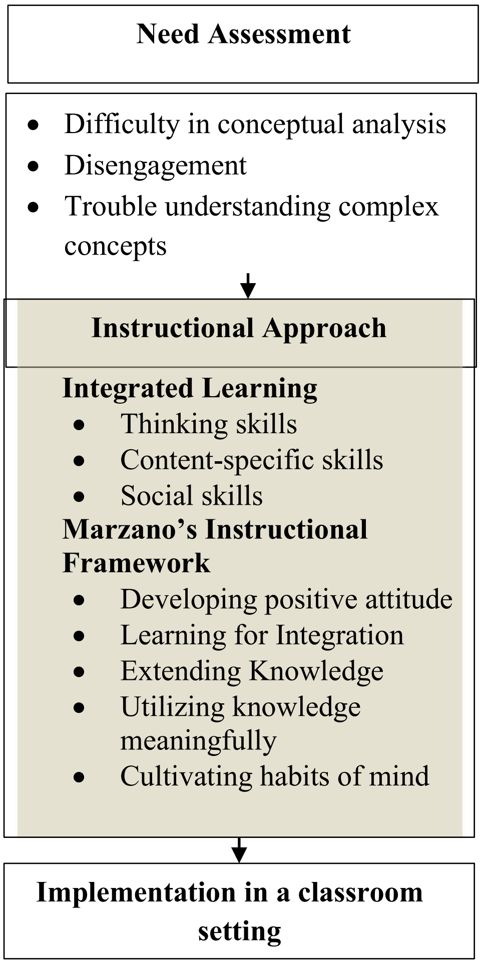

Figure 1 The Outline of Adapting Marzano in Plant Anatomy Course Design

The design of the Marzano instructional framework-based plant anatomy course involves four stages and one additional session following Marzano's dimensions of learning (Marzano, 1992). The first dimension of learning, which is developing positive perception is translated into the first step of the sequence named information delivery which aims to create a supportive learning environment and introduce the meaning of learning plant anatomy about daily context for motivating students. The second step is the simulation of prior knowledge aiming to activate the students' prior knowledge related to characteristics of plant tissue for facilitating students to make the relation between plant tissue and plant habitat. The third step is knowledge analysis and transformation which aims to determine the principles of the relation between plant tissue structure and plant habitat and develop a cognitive scheme using graphs. The fourth step is knowledge internalization aiming to apply the principle of plant tissue structure and plant habitat for designing a school experiment which is an important competency for professional Biology teachers. While the last dimension in Marzano's learning dimension is the habit of mind, in the design, the last dimension is not included into the learning syntax, instead, it is applied in the after-learning stage. The syntax of the Plant anatomy course design is shown in Table 1.

Table 1. Stages in Plant Anatomy Course based on Marzano's Instructional Framework

Stages / syntax	Strategy – activity	Marzano's Framework
Presenting Contextual information	Introducing phenomena related to characteristics of plant tissue in different living conditions	Developing attitude and positive perception
Stimulating prior knowledge	Utilizing prior knowledge about plant tissue characteristics (using animation) Conducting focused discussion to identify the tissue of plant organ Making a hypothesis about the relation of change in tissue and plant organ	Learning for attainment and integration of knowledge
Analyzing and transforming knowledge	Displaying pictures of varied structures of a plant organ based on the plant's respective living conditions. Processing data by conducting discussions and contextually solving related problems Formulating the principles of tissue change in a specific environment and plant organ development Communicating the result of formulation along with its reason.	Extending and refining of knowledge
Internalizing knowledge	Designing a school experiment by apply the principle of plant tissue structure and plant habitat	Using knowledge meaningfully
After class activity	Measuring intrinsic load to ensure the effectiveness of managing cognitive load (done by lecture as evaluation and reflection of the course)	Habits of mind

The Plant Anatomy Course design was subsequently implemented with 106 pre-service teachers enrolled in the Plant Anatomy course within the Biology Education program at Kuningan University, West Java, Indonesia. To evaluate the effectiveness of the Plant Anatomy Course Design on pre-service teachers' information analysis (IA) skills, the learning process was observed using an assessment rubric. This rubric assessed four key skills aligned with the course's learning objectives; tissue identification, tissue analysis, principle implementation, and knowledge organisation.

Meanwhile, Information processing (IP) skills were assessed at the conclusion of the course using a knowledge construction test. This test evaluated four levels of processing skills, grounded in Marzano's instructional framewor, namely; generalisation, specification, decision-making, problem-solving and experimentation. The collected data on IA and IP skills were then subjected to quantitative analysis, employing regression and correlation tests to determine the contribution and correlation between the measured variables. Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS) for Windows.

RESULTS AND DISCUSSIONS

Implementation of the Plant Anatomy course based on yielded data on students' information analysis (IA) and information processing (IP) skills. In regards to IA skills, the four skill indicators tissue identification, tissue analysis, principle implementation, and knowledge organization were analyzed in relation to the course's learning objectives. Individual indicator scores and the overall average are presented in Table 2.

Table 2. Result of Information Analysis Skills

No	Indicator	Score	Category
1	Tissue identification	3.8 ± 0.45	Advanced
2	Tissue analysis	3.2 ± 0.52	Effective
3	Adaptation Principles implementation	3.2 ± 0.34	Effective
4	Knowledge organization	2.8 ± 0.31	Effective
Average		3.2 ± 0.41	Effective

The data shows a high average score of 3.2 out of a maximum of 4 across the four IA skill indicators, with the indicator of relevant tissue identification attaining the highest average score. This result might be attributed to the simplicity of the task, which only requires students to identify the tissue of one plant organ. Meanwhile, the indicator of tissue analysis based on the living environment, along with the indicator of principal implementation, obtained decent scores. Likewise, the indicator of knowledge organization showed a decent result, albeit the lowest among the indicators. Considering the high score of the four indicators, it can be implied that Marzano's instructional framework-based plant anatomy course has effectively developed students' IA skills.

Furthermore students' IP skills are analysed by referring to the taxonomy of processing by Marzano and Kendall (Dubas & Toledo, 2016). The knowledge construction test used in this study measures IP at a high-order thinking level; therefore, the questions are on the analysis and knowledge utilization levels which are the two highest levels in Marzano's processing taxonomy. The result of students' IP skills is shown in Table 3.

Table 3. Average Percentage of Processing Information Skills

No	Level of processing	Indicator	Score	Category
1	Generalization	Students can organize principles and draw a conclusion	63 ± 14.1	Good
2	Specification	Students can logically identify consequences and predict	58 ± 14.7	Fair
3	Decision making	Students can utilize information to make a decision or propose alternatives	61 ± 20.5	Good
4	Problem-solving	Students can utilize information to solve the problem	73 ± 13.5	Excellent
5	Experimentation	Students can hypothesize	71 ± 8.4	Excellent
Average			65 ± 15.9	Good

The average ability to analyze information is included in the good category because it exceeds 60% (Bao et al., 2009). The data shows that the ability to utilize information for problem-solving attains the biggest development. This result aligns with several experts stating that learners who actively and regularly elaborate a newly learned information tend to achieve higher than learners who only passively receive information (Murphy et al., 2021; Ouyang et al., 2022). This implies that Marzano's instructional framework-based plant anatomy learning can facilitate IP skills. It is due to the learning process that starts by developing a positive attitude and perception of the learning activity. As a result, the students are well-prepared to learn a concept and know the benefits of studying the topic. Consequently, it lowers the difficulties in understanding concepts, although the learning process integrates several skills, including thinking and content-specific skills.

Furthermore, following the notion that IA skill influences IP skills, the correlation analysis on IA and IP skills is then tested using regression test. The result showed a significant correlation (p = 0.00*<0.01) with a correlation coefficient of 0.921 and r=0.85. This implies that IA skills highly support the development of IP skills. This is exemplified by how pre-teacher students' high performance in making decisions on deciding specific plants and tools in designing a school experiment is necessarily supported by their ability to identify and analyse plant tissue, implement plant adaptation principles and organise this knowledge. This is supported by Jokinen et al. (2020) and Kerzel and Andres (2020) stating that skill in implementing knowledge in novel situations is likely to increase provided that long-term memory attains a cognitive scheme. Students with a well-developed mental scheme are likely to better utilize stored information in long-term memory to organize steps to produce solutions (Jokinen et al., 2020; Kerzel & Andres, 2020). The discussion on how Marzano's instructional framework in Plant Anatomy course design enhances the IA and IP is detailed further on the next section.

CONCLUSION

This study shows that the adaptation of the Marzano instructional framework in designing plant anatomy subjects foster pre-teacher students' information analysis and information processing skills. This result is attributed to the emphasis of Marzano's instructional framework to realise a conducive learning environment, prior knowledge utilization, thinking potential development, meaningful information delivery, contextual learning, and cooperative learning. The applied strategy advances intrinsic processing due to information that is delivered meaningfully and results in the capability to overcome working memory limitations. This is achieved through utilizing prior knowledge or information stored in long-term memory to accommodate the information processing in working memory. Consequently, students not only achieve conceptual mastery but also extend their knowledge base to enhance their professional capabilities.

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