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Popular science book on the Ficus genus at Lambung Mangkurat University Campus: Its effectiveness in training students' critical thinking

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Abstract

There is no popular science book (PSB) on the genus Ficus, especially those that grow and develop specifically in the Lambung Mangkurat University Campus Area, Banjarmasin and Banjarbaru. Equipped with questions and invitations related to critical thinking, the PSB was compiled and then tested. The aim was to measure the effectiveness of the PSB to train students' critical thinking. The valid PSB was tested with a small group test involving 20 students and a field test involving 25 students. In three meetings, the first meeting was only as an exercise and was not assessed and meetings 2 and 3 were assessed by observers, students were asked to carry out practicums based on student worksheets and answer 10 questions. The values were analyzed so that from the small group test the expected effectiveness was obtained and from the field test the actual effectiveness was obtained. An increase in quantitative values occurred from meeting 2 to next meeting, both for expected effectiveness (from 69.10 to 84.60) and actual effectiveness (from 67.80 to 86.10). With an increase from quite good to very good in the two effectiveness, the PSB on the Ficus genus is effective in training students' critical thinking.

Abstrak. *Belum ada buku ilmu pengetahuan populer (BIP) tentang genus Ficus, apalagi yang tumbuh dan berkembang khusus di Area Kampus Universitas Lambung Mangkurat, Banjarmasin dan Banjarbaru. Dilengkapi dengan pertanyaan dan ajakan terkait dengan berpikir kritis, BIP tersebut disusun dan kemudian diuji. Tujuannya adalah untuk mengukur efektivitas BIP itu untuk melatihkan berpikir kritis mahasiswa. BIP yang sudah valid diuji dengan uji kelompok kecil yang melibatkan 20 mahasiswa dan uji lapangan yang melibatkan 25 mahasiswa. Dalam tiga pertemuan yang pertemuan pertamanya hanya sebagai latihan dan tidak dinilai serta Pertemuan-2 dan Pertemuan-3 dinilai oleh observer, mahasiswa diminta melaksanakan praktikum berdasarkan lembar kerja mahasiswa dan menjawab 10 pertanyaan. Nilai-nilainya dianalisis sehingga dari uji kelompok kecil diperoleh efektivitas harapan dan dari uji lapangan diperoleh efektivitas aktual. Peningkatan nilai kuantitatif terjadi dari Pertemuan-2 ke Pertemuan-3, baik untuk efektivitas harapan (dari 69,10 ke 84,60) maupun efektivitas aktual (dari 67,80 ke 86,10). Dengan peningkatan dari cukup baik ke sangat baik pada dua efektivitas tersebut, BIP tentang genus Ficus tersebut efektif untuk melatihkan berpikir kritis mahasiswa.*

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A. Introduction

Popular science books (PSB) are the result of simplification and translation or interpretation of science and research related to forms, symptoms or natural phenomena that can be captured with the five senses, both in the form of physical resources (for example in Haines, 2019; Rothschild, 2019) and biological resources consisting of plants (Mckenney et al., 2019; Stephen et al., 2013), animals (Allen, 2020; Phillipps, 2024), and even humans (Stephane et al., 2013). PSB provides information and tools for the public or general readers to understand the topic easily and then improve their knowledge, technology and insight. In the world of education, the feasibility of PSB is usually tested, as was done by Fajeriadi et al. (2024), Harlinson et al. (2023), Irianti & Mahrudin (2024), Junaidi et al. (2023); Khatimah et al. (2023), Mulkan et al. (2022), Rahayu et al. (2022), Rini et al. (2021), and Suga et al. (2022). Feasibility includes validity, practicality, and effectiveness.

From previous references, there are no PSBs containing the Ficus genus, especially those that grow and develop on both the Lambung Mangkurat University (LMU) Campus of Banjarmasin and Banjarbaru. This is an opportunity to present books about the Ficus genus to the public, especially students. This opportunity needs to be utilized as well as possible to minimize ignorance and indifference and at the same time increase insight, knowledge, and technology and build awareness for the preservation of the genus. Students often point to beringin or banyan (the common name in Indonesia for *Ficus benjamina*) only when asked about Ficus, even though there are many other Ficus species growing around them. Students often point to syconium when asked about Ficus fruit, but then answer very doubtfully when asked about the flowers. Students do not know the mechanism of pollination in Ficus flowers or the meeting between male and female flowers in Ficus.

The PSB that is prepared certainly does not just discuss Ficus. As a learning resource, the book is equipped with various questions and invitations for students to think critically. Critical thinking is a person's ability to always be critical, rational and objective towards ideas, thoughts or information so that people can sort, choose and make decisions well and correctly. Everyone needs to get used to and have this critical thinking because it can help people have the courage to face change, smoothly overcome obstacles and challenges, and have many alternatives in solving problems (Munawarah et al., 2018; Santi et al., 2018). With this completeness, the book becomes more valuable and has higher benefits. Books are not just for knowing something, but also for understanding a mechanism and explaining a reason. The question then is how effective can PSB on Ficus be used to train critical thinking?

To understand the statement and also answer the questions mentioned above, this research was carried out. The aim is to test the effectiveness of this PSB to train students' critical thinking, especially students. The results are used not only as input or consideration to improve this book, but also to awaken and improve students' critical thinking.

B. Material and method

Main Topics in PSB

PSB was developed based on the Educational Design Research (EDR) method. The main discussion of PSB, the front and back cover designs of which are presented in Figure 1, consists of five chapters, namely 1) introduction, 2) wetland environment which is one of the habitats or living places of Ficus and has become a leading science of LMU, 3) general characteristics of Ficus which include morphology, stature, and habitus, 4) special characteristics of 12 Ficus species that grow and develop on both the LMU Campus of Banjarmasin and Banjarbaru (Table 1) along with their distribution points on the two campuses, 5) closing. The closing section of PSB consists of references or bibliography, glossary, and a brief description of the authors.

PSB is equipped with questions that must be answered and statements that must be followed or understood in order to think critically. According to Facione & Gittens (2016), there are six cores or indicators of critical thinking, namely interpretation, analysis, evaluation, inference, explanation, and self-regulation. As a note, the ISBN of this book will be registered after a complete revision.

The PSB was evaluated formatively in accordance with Tessmer (1998). The evaluation stages consist of self-evaluation, expert review, one-on-one test, small group test, and field test (large group test). The first three stages are not discussed here, but the PSB has been declared valid. This valid PSB is then tested using small group tests and also field tests.

Data collection

The small group test involved 20 students who were grouped into 4 groups and assessed by 4 observers. meetings were held three times. The activities in the small group test are to examine the implementation of the Semester Lecture Plan including the implementation of interpretation, analysis, evaluation, inference, explanation, and self-regulation of students during learning activities using PSB. These observers are alumni of Biology Education LMU who graduated a maximum of 3 years ago.

Meeting-1 was held on the reasons that students did not know about PSB material, practicums, questions, and other matters related to critical thinking. To understand and be able to do something, the students study in a guided manner and then practice or carry out trials. This meeting focuses more on what needs to be known or understood and how to carry out activities to prove it. No judgment at all.

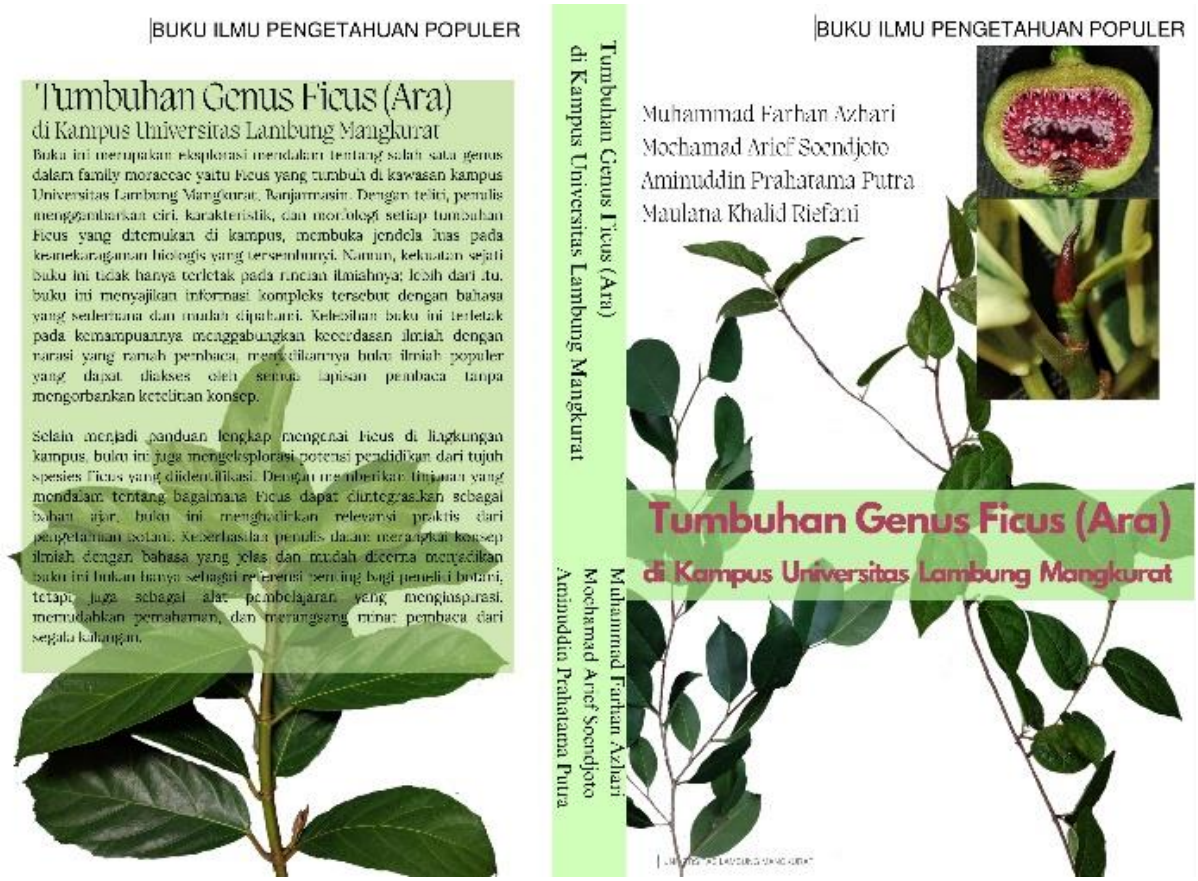

Figure 1 PSB front and back cover design (in Indonesian)

Table 1 Ficus that grows and develops on the LMU Campus

No.	Scientific name	Vernacular/local name	LMU Campus	
			Banjar-masin	Banjar-baru
1	*F. aurata*	Ara topog	-	V
2	*F. benjamina*	Beringin	V	V
3	*F. callosa*	Pangsor, ilat-ilatan	-	V
4	*F. hirta*	Gegedangan	-	V
5	*F. kurzii*	Beringin walik	V	V
6	*F. microcarpa*	Panggang	V	V
7	*F. elastica*	Karet kebo	V	V
8	*F. lyrata*	Ara daun-biola	-	V
9	*F. natalensis*	Beringin kupu-kupu	V	-
10	*F. fistulosa*	Kujajing	V *)	V
11	*F. trichocarpa*	Reket	V	-
12	*F. variegata*	Gondang hijau	-	V

Note: *) *F. fistulosa* here is a correction of *F. racemosa* in Azhari et al. (2024).

In meeting-2, students study independently. They carry out practicums whose procedures can be seen and studied in the student worksheet (LKM). They also work on other equally important tasks, namely answering 10 questions. The activities carried out by these students are assessed by observers.

In meeting-3, students also study independently and carry out the same activities. The tasks that must be done and the questions that must be answered by students are basically the same. It's just that the sequence numbers of the tasks and questions are changed randomly.

There are three alternatives for changing the grades obtained by students at meeting-2 and meeting-3. The alternatives are fixed, increased, or decreased grades. In general, this small group test produces expected effectiveness values.

The field test involved 25 students who were assessed by five observers. The meetings were held three times and the activities were also similar to those in the small group test. This field test produced actual effectiveness values.

The provisions that apply to the assessment of activities by observers are as follows. Observers observe student activities and add values in the form of scores on the rubric. The score range is between 0 (lowest value) and 10 (highest value)

Data analysis

The scores obtained each student, both from student worksheets and from the 10 questions asked are calculated and converted according to Formula 1. The scores obtained by all students are then averaged, both for expected effectiveness and actual effectiveness. The next provisions are presented in Table 2.

$$\text{Value} = \frac{\text{Number of scores obtained}}{\text{Maximum number of scores}} \times 100 \quad \ldots\ldots\ldots \text{Formula 1}$$

Table 2 Effectiveness values range and categories

Range of value	Category
80 < x ≤ 100	Very good
70 < x ≤ 80	Good
60 < x ≤ 70	Fairly good
40 < x ≤ 60	Less good
x < 40	Not good

The difference in value between meeting-2 and meeting-3 is calculated using n-gain (Formula 2). The differences in values obtained are categorized qualitatively as presented in Table 3.

$$g = \frac{\text{S posttest} - \text{S pretest}}{\text{S maximum} - \text{S pretest}}$$ ..... Formula 2

Description:
S posttest = critical thinking score at meeting-3
S pretest = critical thinking score at meeting-2

Table 3 N-gain range and categories (Hake, 1998)

Range of value	Category
g ≥ 0,7	High
0,3 ≤ g < 0,7	Moderate
g < 0,3	Low

C. Results and discussion

Overall results

Overall, this PSB on Ficus can generate and at the same time increase critical thinking from one meeting to the next, both on expected effectiveness and on actual effectiveness. In terms of expected effectiveness, critical thinking rose from a value of 69.1 or fairly good and increased to 84.6 or very good (Table 4), while actual effectiveness rose from a value of 67.8 or fairly good and increased to 86.1 or very good (Table 5).

Table 4 Results of the expected effectiveness test at meeting-2 and meeting-3

No.	The indicator of critical thinking	Meeting-2			Meeting-3		
		Student worksheet	Evaluation	Average	Student worksheet	Evaluation	Average
1	Interpretation	65,00	77,50	71,30	85,00	82,50	83,80
2	Analysis	67,50	68,75	68,10	82,50	83,75	83,10
3	Evaluation	70,00	73,75	71,90	85,00	86,25	85,60
4	Inference	60,00	75,00	67,50	90,00	88,75	89,40
5	Explanation	72,50	66,25	69,40	82,50	81,25	81,90
6	Self-regulation	62,50	70,00	66,30	85,00	82,50	83,80
Average each meeting		**Fairly good**		**69,10**	**Very good**		**84,60**

Table 5 Results of the actual effectiveness test at meeting-2 and meeting-3

No.	The indicator of critical thinking	Meeting-2			Meeting-3		
		Student worksheet	Evaluation	Average	Student worksheet	Evaluation	Average
1	Interpretation	60,00	69,00	64,50	83,00	83,00	83,00
2	Analysis	64,00	60,50	62,25	90,00	86,50	88,25
3	Evaluation	73,00	67,50	70,25	87,00	87,00	87,00
4	Inference	76,00	72,50	74,25	85,00	82,50	83,75
5	Explanation	65,00	74,50	69,75	91,00	87,50	89,25
6	Self-regulation	69,00	62,00	65,50	88,00	83,00	85,50
Average each meeting		Fairly good		67,80	Very good		86,10

Two notes can be drawn from the two meetings held and the two types of PSB effectiveness tests. The notes refer to the average quantitative value and also the qualitative category.

First, the average quantitative score increased from meeting-2 to meeting-3. The increase can occur because of the key activity in the form of revision. Revision is important and is the author's obligation to change or improve the PSB, both after the small group test and after the field test.The object of revision is the PSB content consisting of the display (pictures, photos, layout) and sentences (sequence, length, coherence, complexity). Sentence length and complexity affect fluency (Eraslan, 2018). Revision needs to be directed at understanding the topic, commitment to what is learned and understood by memory, and training in planning and writing answers to questions so that students can participate in class and also take exams (Wangdi & Zangmo, 2021). From the revised or improved book, students can understand the PSB content more easily and fluently than before.

The next key activity is repetition. Repetition is the process of repeating learning. Repetition is indeed held only once; in this case, meeting-3 which is basically a repetition of meeting-2. However, repetition allows students to store PSB content longer in memory. Repetition affects subsequent memory over time (Zhan et al., 2018). Repetition can increase the mechanism of object individualization and also memory storage capacity (Tagliabue et al., 2020).

Second, the same qualitative category between small group tests and field tests - in this case is quite good and also very good - shows that the results of the two tests are steady or consistent. In other sentences, consystency, both from small groups and from large groups, reflect the level of effectiveness of PSB on Ficus

which is relatively high. Consistency is the key in social behavior which in this case is at least maintaining trust (Nowak et al., 2023). The consistency must be prioritized, especially when designing a curriculum that should meet the needs of learners or students with a variety of backgrounds (McMullan et al., 2022).

The results of each indicator

Overall, the average N-gain of students' critical thinking, both in small group tests and field tests on PSB discussing Ficus, was 0.5 or classified as moderate. The range in the small group test is 0.3–0.5 or is classified as moderate–moderate, while the range in the field test is 0.4–0.7 or is classified as moderate–high. In detail, the N-gain of the four critical thinking indicators in the small group test is lower than in the field test, one indicator is the same, and one other indicator is higher (Figure 2).

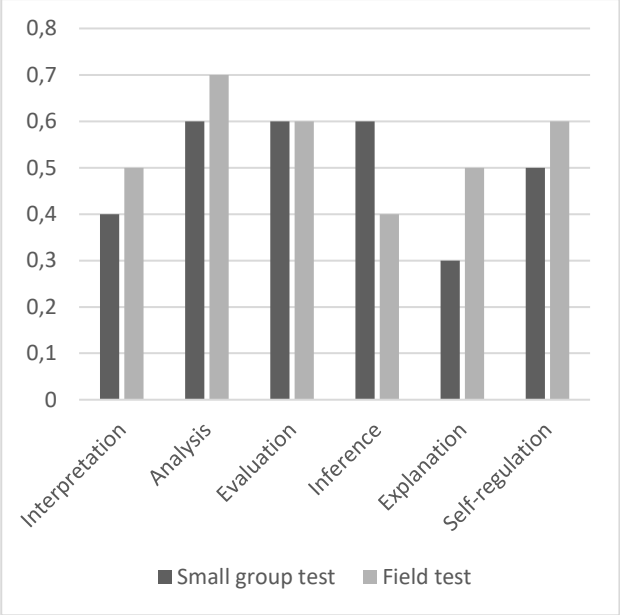

Figure 2
N-gain of each critical thinking indicator, both in small group tests and field tests

The first indicator of critical thinking is interpretation, the ability which basically requires a high level of concentration. Lin et al. (2018) argues that interpretation requires hearing and also understanding of the source language that is used as an introduction so that this indicator is included in a very complex verbal task.

Related to PSB in Ficus, the ability of interpretation is seen among others when students formulate problems with relatively complex content. Examples of problem formulations made by students are as follows. “How do Ficus adapt to the place of life?” “What are the morphological characteristics that differentiate between two different Ficus species or between a particular Ficus and plants of another species?”

The content or more precisely the questions in the PSB at meeting 2 and also meeting 3 are actually relatively the same. Only the order is changed randomly. However, the interpretation results show that the score at meeting 3 is better than the score at meeting 2. This condition is an indication that repetition, even if only carried out once, can improve the fluency and quality of students' interpretation of the contents of the book.

The next indicator of critical thinking is analysis. Analytical skills can be seen when students are trained to use available content and practical experiences to answer questions or to find alternative answers to problem formulations. Words of invitation to see, examine, and study in depth lead students to be able to analyze, among others, the benefits of Ficus on the LMU Campus, the contents or organs in the syconium body, and how Ficus lives and thrives in natural environments and also disturbed environments.

The third indicator is evaluation. Evaluation is not to apply or test a particular model (as mentioned by Anh, 2018; Purba & Maulana, 2023; Warju, 2016), but rather focuses on honing or measuring students' abilities to 1) compare statements in discourse with observation results, 2) assess statements or opinions, both those that develop from themselves and those that come from others, and 3) formulate the right answers. Several statements are offered to students to implement, as follows. "Compare the statements conveyed in this discourse with the results of your observations in the field!" "Compare the results of your observations with the results of your friends' observations!" "Try to explain in more detail the differences or similarities of these answers!"

As mentioned, the N-gain in both the small group test and the field test was the same; the quantitative value was 0.6. This condition can occur because students have not mastered problem solving so that the answers given are not in accordance with expectations. According to Mardhatilah et al. (2022), students are less skilled at assessing problems. According to Pardjono & Wardaya (2009), students find it difficult to associate certain concepts with other concepts and they are used to learning in conditions that tend to simply receive information.

The fourth indicator is inference. This ability can be seen when students attract the right conclusions from the formulation of the problem or the right solution from alternative answers. Inference is related to interpretation in the form of problem formulation. After making observations, students then try to make a hypothesis. The hypothesis is an answer (temporary) of the problem formulation made by students themselves or made after students discuss with fellow students, friends, or team members. For example, if the formulation of the problem "Does the morphological characteristics affect the identification of Ficus plant species?", then the inference that can be drawn by students is "Morphological characteristics affect the

identification of Ficus species" or "Different morphology between certain species and other species facilitate Ficus species identified."

In this study, inference is the only indicator whose N-gain in actual effectiveness is lower than the expected effectiveness. This can happen because students focus on answer keys that are limited in scope. On the other hand, students' critical thinking abilities and skills are diverse and different between certain individuals and other individuals. Therefore, the strategy needs to be developed to make good PSB and revise it to be more feasible and comprehensive.

The first strategy is to place a solid and concise answer key in the conclusion section. The conclusion is generally located at the end of a book. Its contents are the essence of various statements that have been conveyed previously. Its contents can also be answers to questions that are stated directly and explicitly in the book or questions that arise later in the minds of students when reading the book. From this section, students should be able to draw conclusions clearly.

The second strategy is to enrich the illustrations or improve their quality. This can be a solution or best practice for students who prefer illustrations (such as pictures or even videos which are dynamic illustrations) rather than reading with many words or sentences (static media). Video is a dynamic media that is an important component and should not be ignored for students whose modality is visual (Jawed et al., 2019). Visual learning has a significant influence on the development of students' high-level thinking skills in elementary and secondary schools (Raiyn, 2016). Of course, this does not mean that visual learning is not needed for learning at higher levels of education.

Another strategy, a strategy that is outside the writing of PSB is to increase the quantity and quality of training. This training focuses on empowering critical thinking indicators, especially evaluation and inference. Its activity is an increase in discussion. Discussion functions to train or familiarize students to assess the quality of evidence, think and propose alternative solutions, and draw conclusions or joint decisions based on truth and togetherness. From discussions, students interact and learn from one another, motivate themselves to speak in front of many people, and develop mutual respect among the participants (Rahmat & Jon, 2023).

The next indicator is explanation. Explanation ability can be seen when 1) students can explain and describe facts to find alleged solutions to problems and provide very precise statements from the alleged solutions, 2) students can give opinions on the interpretations made or the problems they are studying, and 3) students can arrange how to solve problems. Students who are accustomed to solving problems through observation, discussion, and reading are able to provide good explanations of solutions that are easy for others to understand.

Many questions can be used to explore or train students' explanation skills. Some of them are as follows. “Based on the discourse above, what or how is the right statement to describe the uniqueness of Ficus?” “Explain why there are no or very few Ficus seedlings on the surface of the soil under its canopy?”

The last indicator of critical thinking is self-regulation, the ability to control one's behavior and regulate emotions or feelings during actions or efforts to carry out an activity to achieve a certain target. This ability is identical to self-control which describes how long, how much, or how calmly students try to solve problems. Self-regulation needs to be trained so that students are always critical in facing problems and can realize or achieve activity targets according to expectations and with little or no wasting time. Self-regulation, in addition to the other three components, namely self-awareness, theory of mind, and threat detection, is a basic human need to be a good group member (Heatherton, 2011). High self-control and low impulsivity allow a person to live a good life (Inzlicht et al., 2021).

D. Conclusion

The value of each critical thinking indicator between the two meetings, both for expected effectiveness and actual effectiveness increased, although the average of each effectiveness was categorized as fairly good. This increase is the basis for considering that the Popular Science Book on the Ficus genus at the Lambung Mangkurat University Campus is effective and can be used to train critical thinking.

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