Developing a Steam and *Tri Hita Karana* Comic to Improve Fifth-Grade Elementary School Students' Science Literacy

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Abstract

The current problems are low student science literacy and fading cultural values. This research aims to develop learning media in the form of STEAM-infused comics containing *Tri Hita Karana* values to improve the science literacy of fifth-grade students on the ecosystem harmony material at SD Negeri 6 Penatih. Developmental research method using the ADDIE model. Data collection instruments used questionnaires to test validity, practicality, and effectiveness. The research results show that this comic meets excellent criteria, as evidenced by the validation results from content experts, media experts, design expert, and language experts. The practicality test conducted by teachers showed very satisfactory results with a percentage of 98%. The practicality test results for students obtained a percentage of 94.51%, indicating that this comic is very practical and well-received by students. The effectiveness test results thru pretest and posttest showed a significant improvement in students' science literacy with a significance value ($p < 0.001$) and a high effect size (Cohen's $d = 3.208$). In conclusion, STEAM-loaded comics and *Tri Hita Karana* are effective in improving the science literacy of fifth-grade elementary school students. The implications are positive, such as increased student interest in science thru culturally relevant approaches, as well as potential long-term impacts in the form of improved science literacy. The novelty of this research lies in the integration of steam and Balinese local wisdom with the help of sophisticated AR so that the media becomes more contextual, real, interesting, and students' literacy increases.

Keywords: Comic; STEAM; *Tri Hita Karana*; Science Literacy

Abstrak

Permasalahan saat ini adalah rendahnya literasi sains siswa dan nilai-nilai kebudayaan mulai pudar. Penelitian ini bertujuan untuk mengembangkan media pembelajaran berupa komik bermuatan STEAM dan nilai Tri Hita Karana guna meningkatkan literasi sains siswa kelas V pada materi harmoni ekosistem di SD Negeri 6 Penatih. Metode penelitian pengembangan dengan model ADDIE. Instrumen pengumpulan data menggunakan kuesioner untuk menguji validitas, kepraktisan, dan efektivitas. Hasil penelitian yakni komik ini memenuhi kriteria sangat baik terlihat pada hasil validasi dari ahli materi, hasil validasi ahli media, ahli desain, dan ahli bahasa. Hasil uji kepraktisan yang dilakukan oleh guru menunjukkan hasil sangat memuaskan dengan persentase 98%. Hasil uji kepraktisan siswa memperoleh persentase 94,51%, menunjukkan bahwa komik ini sangat praktis dan diterima dengan baik oleh siswa. Hasil uji efektivitas melalui pretest dan posttest menunjukkan peningkatan signifikan literasi sains siswa dengan nilai signifikansi (p < 0,001) dan ukuran dampak (effect size) kategori tinggi (Cohen's d = 3,208). Kesimpulannya, komik bermuatan STEAM dan Tri Hita Karana efektif dalam meningkatkan literasi sains siswa kelas V sekolah dasar. Implikasinya positif, seperti peningkatan minat siswa terhadap sains melalui pendekatan budaya yang relevan, serta potensi dampak jangka panjang berupa literasi sains yang lebih baik. Kebaruan penelitian ini adalah terletak pada integrasi steam dan kearifan

lokal Bali dengan dibantu oleh kecanggihan AR agar media menjadi lebih kontekstual, nyata, menarik, dan literasi siswa menjadi meningkat

Kata Kunci: Komik; STEAM; Tri Hita Karana; Literasi Sains

Introduction

Literacy is an important skill that students need to have to face the challenges of the 21st century as well as be the foundation for success in learning (Putra et al., 2021). Facing an ever-evolving global era, students are expected to master 16 basic skills of the 21st century, one of which is science literacy. Science literacy is very important because it not only helps students understand scientific concepts, but also develops critical thinking, problem-solving, and evidence-based decision-making skills in everyday life (Utama et al., 2023). However, the reality is that the science literacy ability of students in Indonesia is still relatively low when compared to the international average. Based on the results of the 2022 PISA test, it is known that Indonesia's science literacy score only reaches 383 points, which is far below the OECD average of 485 points. Other data shows that only about 34% of Indonesian students are able to achieve science literacy level 2 or higher, while the average of OECD participants reaches 76%. This shows that many Indonesian students are not able to relate the concept of science to daily life as expected. This data is also strengthened by the results of TIMSS 2015 which assesses the science ability of 4th grade elementary school students.

Indonesia's science score only reached 397, lower than the TIMSS international reference point of 500 (Tahmidaten and Krismanto, 2020). Based on the 2025 SD Negeri 6 Penatih Education Report Card sourced from national assessment data in 2024, students' literacy ability showed a decrease of 17.24%, of which 82.76% of students reached the minimum competency. In addition, the average score of students in high-level literacy aspects, such as analyzing data and information, making conclusions, and expanding understanding in new, more complex contexts has only reached 58.73.

The character survey also showed that the average score of students' character, which includes the dimensions of morality towards others, nature, and the country, mutual cooperation, creativity, critical reasoning, global diversity, and independence, only reached a score of 68.8. These findings indicate an urgent need to present learning innovations that not only meaningfully improve students' science literacy skills, but also integrate character strengthening through a contextual approach based on local cultural values. One of the alternative solutions to improve students' science literacy, learning media needs and answer the challenge of low concept understanding is through the development of innovative learning media, one of which is in the form of comics. The use of this media has also been proven to be able to attract students' attention, present information visually that is easy to digest, and improve memory and understanding of concepts through a more communicative and fun approach (Xefteris, 2021). Development of comic media that contains elements Science, Technology, Engineering, Art, and Mathematics (STEAM) has great potential in supporting a meaningful and holistic learning process.

Through the STEAM approach, comics not only function as a means of delivering science content in an integrative manner, but also as a medium that can hone 21st century skills, such as critical thinking, creative thinking, collaborative skills, and problem-solving (Megantari et al., 2021; Santi and Sholeh, 2020). This approach emphasizes the importance of inter-disciplinary linkage, thereby encouraging students to understand concepts thoroughly and contextually. Thus, STEAM-based comics are able to facilitate cross-disciplinary learning that leads students to apply their knowledge and skills in

solving real problems. In addition to the interdisciplinary approach, the integration of local values in the learning process plays an important role in character formation and strengthening students' cultural awareness (Krisna et al., 2020; Muhammad et al., 2022; Sudiartini et al., 2024). In Bali, the philosophy *Tri Hita Karana*, which reflects the harmony of the relationship between man and God (*Parahyangan*), between human beings (Source) and with the natural environment (Weakness) is a heritage of local wisdom that is rich in values of character and environmental education (Kertih, 2023; Sari et al., 2021; Pageh and Permana, 2020; Sanjayanti et al., 2026).

When these values are creatively integrated in the form of stories in digital comics, students not only gain an understanding of science concepts, but also internalize noble and contextual principles of life. This integration makes learning more meaningful, contextual, and relevant to students' socio-cultural realities, while strengthening local identities within the framework of 21st-century education. The use of digital comics based on *Tri Hita Karana* can help teachers deliver topics in a way that suits the characteristics of students, making it easier for students to understand the topic.

Furthermore, students gain new learning experiences through the use of digital comics based on *Tri Hita Karana*. This not only teaches the topic but also provides them with knowledge about Balinese local wisdom, which must be preserved and maintained (Windu and Sujana, 2025). Based on the description, it was deemed necessary to conduct a study entitled: "Development of STEAM-Loaded Comics and *Tri Hita Karana* to Improve Science Literacy of Grade V Elementary School Students." Development of STEAM-loaded comics and *Tri Hita Karana* This is expected to be able to answer the challenges of 21st century learning in a contextual, fun, and meaningful way for students.

Method

This comic is designed using the ADDIE development model which includes the stages of analysis, design, development, implementation, and evaluation (Darmayanti et al., 2021; Glossita et al., 2022). The development of a STEAM digital comic integrated with *Tri Hita Karana* using the ADDIE model includes five systematic stages. The Analysis stage begins with identifying student needs, STEAM materials, and inserting *Tri Hita Karana* values (*Parhyangan*, *Pawongan*, *Palemahan*) into the story. Next, the Design stage focuses on compiling a story framework, storyboard, character selection, and developing evaluation tools that integrate local values. The Development stage is the realization of the design into a digital comic using software (e.g., Canva). This comic titled "*Sahabat Alam*" utilizes technology Generative AI for visual illustrations and Augmented Reality (AR) for simulation of science processes, and equipped with interactive quizzes and formats *flipbook* to increase student engagement, followed by validation by material experts, media experts, and cultural integration experts. The Implementation stage involves testing the digital comic in actual STEAM learning in the classroom to instill scientific literacy. The final stage is evaluation. The instruments used in data collection are questionnaires to test the validity of materials, media, design, and language, questionnaires to test practicality by teachers and students, and science literacy tests to test the effectiveness of media. The analysis prerequisite test consists of normal and homogeneous tests, the effectiveness test consists of paired sample t-test and paired samples effect sizes.

Results and Discussion

The design and construction of comic makes a combination Google Gemini Banana with the prompting method, Canva, Augmented Reality, and the Sahabat Alam comic google form was developed as a learning medium that is adaptive to technological

developments, interactive, and supports meaningful learning. This approach allows students not only to understand science fiction material, but also to develop digital literacy, scientific attitudes, and critical thinking skills through contextual learning experiences (Mardiana et al., 2024; Rusmini et al., 2023). Plan to build a comic loaded with STEAM and *Tri Hita Karana* presented below.

The front cover of the comic "Science Learning Comics: Friends of Nature" features two main characters standing on a stretch of green grass against a bright blue sky. The title of the comic is clearly displayed at the top, followed by the "SISWA SD" logo and the name of the author Nengah Kadek Selamet at the bottom. Overall, this cover affirms comics as a science learning medium for elementary school students who are oriented towards nature, culture, and character education. The comic cover is presented in picture 1.

Figure 1. Cover And Instructions For Use

Character Usage and Introduction Instructions, this section is the opening page of the comic that contains instructions for use and character introductions. At the top, a brief guide is presented on how to prepare, how to read, and use interactive features so that students understand the plot of the comic. At the bottom, three main characters, namely Raka, Putu, and Pak Guru, are introduced, through illustrations and simple dialogues as an introduction before entering the learning content.

Figure 2. Table of Contents

This page serves as the opening page of the episode. Displays the marker of each episode and the title as the focus of the material. Illustrations of Putu characters and natural visual elements are used to attract attention and mark the beginning of the discussion before entering the content of the story and learning.

Figure 3. Comic Pages Come With AR Barcodes

This section features the Augmented Reality (AR) barcodes integrated into the comic storyline. Through barcode scanning, students can access an interactive visualization of the photosynthesis process. The characters of Raka, Putu, and Pak Guru act as narrative guides who associate the explanation of the concept of photosynthesis with direct observation in the rice field environment. Pedagogically, this AR feature functions to strengthen the understanding of abstract concepts of photosynthesis through visual and contextual learning experiences. The application of STEM-based learning assisted by augmented reality is quite effective in increasing students' scientific literacy (Wahyu et al., 2020).

Figure 4. *Tri Hita Karana*

In this section, it contains about the value load *Tri Hita Karana* Includes Parhyangan, Palemahan and Pawongan (Paramitasari et al., 2025; Sanjaya et al., 2021; Wulandari et al., 2024). Value *Tri Hita Karana* in the comic storyline that is depicted in the expressions and activities carried out by the characters in the comics. *Tri Hita Karana* 's content is contained in all parts of the comic. Next in figure 5. presented the creation of a miniature ecosystem, which shows the STEAM payload on the comics. This STEAM charge is clearly displayed through the activity of designing and constructing a simple ecological system.

This activity puts students in the engineering process, namely planning the shape of the ecosystem, selecting materials, arranging biotic and abiotic components, and ensuring that the ecosystem can function in a balanced manner. Aspects Science present through the application of the concept of the relationship between living things and their environment, energy flow, and ecosystem balance. The element of technology is seen in the use of learning aids or media. Art is reflected in creativity in arranging miniatures to be interesting and representative, while Mathematics is implied in the arrangement of

proportions and the number of ecosystem components. Steam equips students to thrive in a rapidly changing world and where transdisciplinary abilities are becoming increasingly essential for success in a variety of professions (Daryanto et al., 2022; Wedanthi et al., 2025).

Figure 5. Examples of STEAM Contents in Comics

Furthermore, the results of the validity test of material experts that have been carried out by two material experts, including aspects of conformity with the curriculum, depth and accuracy of science concepts, integration of the STEAM approach in comics, meaning and relevance of *Tri Hita Karana* values, presented in Table 1.

Table 1. Subject Matter Expert Validation Results

	Subject Matter I	Subject Matter 2
Total Score	48	48
Maximum Score	50	50
Percentage	96%	96%
Average Presentation	96%	
Interpretation	Highly Worth It	

The results of the validation of material experts showed an average eligibility percentage of 96%, which is in the very feasible category. The validity of media experts that has been carried out by two experts includes aspects of visual design, readability, layout, illustrations, and the integration between text and images, presented in

Table 2. Media Expert Validation Results

	Media Member 1	Media Member 2
Total Score	48	50
Maximum Score	50	50
Percentage	96%	100%
Average Presentation	98%	
Interpretation	Very Valid	

Media expert validation yielded an average percentage of 98%, which indicates a very high level of eligibility. The visual aspects, consistency of illustrations, readability of text, and layout composition are highly rated by experts. This indicates that media is not only aesthetically appealing, but also functional as a means of learning. The validity of the design experts that has been carried out by the two experts includes aspects of design principles, story structure, font size and type, use of spaces and margins and visual appeal presented in Table 3.

Table 3. Validation results of design experts

	Design Expert 1	Design Expert 2
Total Score	48	48
Maximum Score	50	50
Percentage	96%	96%
Average Presentation	96%	
Interpretation	Very Valid	

The results of the validation of design experts showed an average percentage of 96%, which is also in the very feasible category. The validity of linguists that has been carried out by two experts includes aspects of ease of understanding, suitability of word choice, support for the learning of *Tri Hita Karana*, language style and sentence clarity presented in Table 4.18.

Table 4. Linguist Validation Results

	Linguist 1	Linguist 2
Total Score	48	49
Maximum Score	50	50
Percentage	96%	98%
Average Presentation	97%	
Interpretation	Very Valid	

The linguist validation obtained an average percentage of 97%, which confirms that the linguistic aspect of comics is very feasible. The results of the practicality test of comics containing STEAM and *Tri Hita Karana* were given to 2 teachers at SD Negeri 6 Penatih, presented in Table 5.

Table 5. Teacher Practicality Test

	Practitioner 1	Practitioner 2
Total Score	48	50
Maximum Score	50	50
Percentage	96%	100%
Average Presentation	98%	
Interpretation	Very Valid	

The practical test of the *Sahabat Alam* comic was carried out by two teachers as learning practitioners focusing on aspects of ease of use, readability, efficiency, support for the learning process, and teacher motivation in teaching. Based on ten indicators of practicality with a maximum score of 50, Practitioner I gave a total score of 48 with an achievement rate of 96.00%, while Practitioner II gave a total score of 50 with an achievement rate of 100.00%. The average percentage of practicality obtained is 98.00%. These results show that the *Sahabat Alam* comic has a very high level of practicality and is in a very practical qualification. The results of the practicality test of comics containing STEAM and *Tri Hita Karana* were given to 35 students at SD Negeri 6 Penatih, which are presented in Table 6.

Table 6. Students' Practicality Test Table

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Total Score	169	160	168	169	149	169	160	169	169	172
Maximum Score	175	175	175	175	175	175	175	175	175	175
Percentage	96,6	91,4	96,0	96,6	85,1	96,6	91,4	96,6	96,6	98,3
Average Presentation	94,51%									

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
Interpretation					Very Practical					

Based on the responses of 35 elementary school students, the practicality test showed that the *Sahabat Alam* comic obtained a very high level of practicality in almost all aspects assessed. In general, students consider this media to be easy to use, interesting, and support the science learning process. The aspect of interest in the appearance of comics obtained an achievement percentage of 96.57%, which shows that the visual design of comics is very attractive to students. The students' happiness in learning science through comics reached 91.43%, indicating that most students felt a positive and enjoyable learning experience. The results of the variance homogeneity test on student learning outcome scores are presented in Table 7 below.

Table 7. Results of the Variance Homogeneity Test

Criteria	Living Statistic	df1	df2	Sig
Based on Mean	0,273	1	68	0,603
Based on Median	0,286	1	68	0,595
Based on Median and with adjusted df	0,286	1	67,996	0,595
Based on trimmed mean	0,290	1	68	0,592

The results of Levene's Test based on Mean showed a significance value of 0.603, which is greater than the significance level of 0.05. It can be concluded that the data on student learning outcomes has a homogeneous variance. This means that the data meets the prerequisites for the next parametric analysis, namely the Paired Sample t-Test. Analysis of the effectiveness of the application of STEAM-loaded comics and *Tri Hita Karana* done using a design One Group Pretest-Posttest, so that the measurement of students' science literacy ability is carried out before and after the treatment is given. A total of 35 students of class V took the two tests. Descriptive statistics for pretest and posttest scores are presented in Table 8 Paired Samples Statistics

Table 8. Descriptive Results of Statistics

Test Type	Red	N	Std. Deviation	Std. Error Mean
Pretest	60,89	35	4,079	0,689
Postest	82,80	35	3,479	0,588

The results of the descriptive analysis showed that the average pretest score was 60.89 with a standard deviation of 4.079, while the average posttest score increased to 82.80 with a standard deviation of 3.479. This increase of 21.91 points shows an improvement in students' understanding after participating in learning using comics.

Table 9. Paired *Sample T-Test Results*

Test Type	Red	Std. Deviation	Std. Error	95% Internal confidence of the difference		T	df	Sig
				Lower	Upper			
Pretest-Postest	-22,00	3,208	0,542	-23,102	-20,898	-40,56	34	<0.001

The results of the paired sample t-test showed that there was a very significant change in students' science literacy skills after they participated in learning using comic media with STEAM content and *Tri Hita Karana* values. The average score difference between the pretest and posttest was-22.00 and the variation that was seen through the standard deviation was 3.208. A t-value of-14.360 with a significance level of p <.001

confirms that this increase in score is not random. Rather, these changes are a real impact of the learning experience provided. The 95% confidence interval, which ranged from -27,005 to-20,309, confirms that almost all students have improved after engaging with comic media designed to integrate elements of STEAM and THK's philosophy. In addition to the significance test, an effect size calculation was also carried out to determine how much the application of comics contributed to improving learning outcomes.

Table 10. Paired Samples Effect Sizes

Test Type	Criteria	Standardizer	Point Estimate	95% Internal confidence of the difference	
				Lower	Upper
Pretest-Postest	Cohen's d	3,208	-6,857	-8,509	-5,198
	Hedges' correction	3,244	-6,781	-8,415	-5,140

The results of the effect size calculation through Cohen's d and Hedges' correction showed that Cohen's d value of 3.208 and Hedges' g value of 3.244 were well above the large effect category according to the general criteria (0.8). An effect size value above 2 indicates that the changes that occur are not only statistically significant, but also have practical meaning in learning.

Comics loaded with STEAM and *Tri Hita Karana* has proven to be significantly effective in improving students' science literacy. This is confirmed by an increase in the average score from 60.89 (Pretest) to 82.80 (Posttest), with Gain Score by 21.91. Statistical test Paired Sample t-Test (p < 0.001) and impact size (effect size) Cohen's d of 3,208 (category Large Effect) asserts that this increase is a direct impact of media intervention, not a coincidence factor. An impact value above 0.8 indicates that the intervention has a very strong and meaningful influence on educational practices.

This high effectiveness can be analyzed through three main pedagogical mechanisms that work synergistically in this comic media, namely: First, concrete visualization strengthens mental models. One of the biggest challenges of ecosystem materials is their systemic and often invisible nature (such as energy transfer) (Flores-González, 2024; Purba et al., 2026). Visual media in comics helps students build a solid mental model stating that visual media facilitates understanding and strengthens memory. Through the sequential comic panels, students can see the logic of causality (cause-effect) in food webs (Ferreira et al., 2022; Santi and Sholeh, 2020).

The AR feature in this comic causes students to have a 3D spatial experience. As a result, students are able to answer questions that demand a better explanation of scientific phenomena at the time of Posttest (Daryanto et al., 2022). Exploration activities in the AR helped students gather and interpret data, training their scientific literacy and data-based interpretation skills (Dhanil and Mufit, 2025). Comic media is used to increase students' enthusiasm in reading books, which in the end is expected to be able to foster students' love of reading (Ditriguna et al., 2023). Integration of STEAM into learning improves student literacy (Susanta et al., 2025).

In addition to STEAM integration values *Tri Hita Karana* train students to think beyond the text. They were invited to analyze the relationship between human activities, natural balance, and spiritual values (Dewi and Sujana, 2020; Wibawa et al., 2023; Yudiana et al., 2025). STEM-based digital comic media to improve elementary school students' scientific literacy in the process, content, and context dimensions (Handayani, 2021). *Tri Hita Karana* based digital comics have proven to be valid, practical, and effective in improving elementary school students' socio-cultural literacy. This is based

on high validity ratings from media, design, and materials experts, excellent practicality ratings from teacher and student responses, and significant results from effectiveness testing showing improved literacy (Dewi et al., 2024). The cultural context provides a value framework for students to make ethical decisions regarding the environment. Students learn that scientific decisions are not value-free, but rather have an impact on the harmony of life at large. Overall, the "Friends of Nature" comic proved to be effective not only because of its visual format, but because of its mature learning architecture.

Conclusion

Comics containing STEAM and *Tri Hita Karana* are valid, practical, and proven to be significantly effective in improving the science literacy of elementary school students. Suggestions for further research. The development of STEAM and *Tri Hita Karana* comic books to improve the science literacy of grade V students can be done by integrating simple stories that combine science concepts such as energy, ecosystems, and simple experiments with elements of technology (e.g., eco-friendly tools), engineering (prototyping), art (creative illustration), and mathematics (basic calculations), while emphasizing the harmony of *Tri Hita Karana* through a narrative that honors God, humans, and nature, like the adventures of characters who take care of the environment while learning science. Its development suggestions include collaborations with local Balinese illustrators for cultural authenticity, the use of simple language and interactive images to capture children's attention, as well as evaluation through trials in schools to ensure age-appropriate content. The implications are positive, such as increasing students' interest in science through culturally relevant approaches, strengthening the values of social and environmental harmony, and the potential long-term impact of better science literacy and conservation awareness, although attention needs to be paid to accessibility for students from different cultural backgrounds to avoid exclusivity.

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