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The Use of Interactive Multimedia Learning Media to Enhance Concept Understanding for Visual Learners at SDIT Attaqwa Nurul Fahmi

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Abstrak

Integrasi teknologi pendidikan penting untuk mengakomodasi preferensi kognitif siswa dan meningkatkan pemahaman konsep di sekolah dasar. Penelitian ini menganalisis efektivitas multimedia interaktif dalam meningkatkan pemahaman konsep siswa dengan preferensi belajar visual di SDIT Attaqwa Nurul Fahmi. Penelitian menggunakan desain kuasi-eksperimental dengan kelompok kontrol non-ekuivalen. Sebanyak 60 siswa kelas V yang teridentifikasi memiliki preferensi visual melalui kuesioner VARK dibagi menjadi kelompok eksperimen dan kontrol. Data diperoleh melalui pre-test dan post-test menggunakan instrumen diagnostik konseptual yang telah divalidasi. Uji-t sampel independen menunjukkan perbedaan signifikan pada hasil post-test ($p < .001$). Analisis N-Gain menunjukkan peningkatan kelompok eksperimen ($g = 0,66$; sedang–tinggi) lebih besar dibandingkan kelompok kontrol ($g = 0,21$; rendah). Temuan menunjukkan bahwa multimedia interaktif efektif meningkatkan pemahaman konsep melalui representasi visual dan pemrosesan informasi yang lebih optimal, sehingga mendukung pembelajaran berdiferensiasi yang inklusif dan bermakna di sekolah dasar.

Kata kunci: Multimedia Interaktif; Pembelajar Visual; Pemahaman Konsep; Teknologi Pendidikan; Teori Kognitif Pembelajaran Multimedia; Pendidikan Dasar.

Abstract

The integration of educational technology is essential for accommodating students' cognitive preferences and enhancing conceptual understanding in elementary education. This study examined the effectiveness of interactive multimedia in improving conceptual understanding among visual learners at SDIT Attaqwa Nurul Fahmi. A quantitative quasi-experimental design with a non-equivalent control group was employed. Sixty fifth-grade students identified as visual learners using the VARK questionnaire were equally assigned to experimental and control groups. Data were collected through validated conceptual diagnostic pre- and post-tests. An independent-samples t-test revealed a significant difference in post-test scores ($p < .001$). N-Gain analysis showed greater improvement in the experimental group ($g = 0.66$; moderate–high) than in the control group ($g = 0.21$; low). These findings demonstrate that interactive multimedia effectively enhances conceptual understanding through visual representations and optimized information processing, supporting inclusive, differentiated, and meaningful learning in elementary education.

Keywords: Interactive Multimedia; Visual Learners; Concept Understanding; Educational Technology; Cognitive Theory of Multimedia Learning; Primary Education.

1. PENDAHULUAN

The advancement of science and technology in the era of the Fourth Industrial Revolution has fundamentally transformed the pedagogical landscapes of modern education, demanding a paradigm shift from passive knowledge reception to active, technology-mediated cognitive engagement. In primary education, which serves as the foundational stage for instilling basic cognitive skills, scientific literacy, and core character traits, the shift toward digitally mediated learning is no longer a peripheral luxury but an absolute necessity. According to Piagetian developmental theory, elementary school students (typically ages 7 to 12) function within the concrete operational stage of cognitive development. During this crucial phase, their cognitive architecture relies heavily on the manipulation of tangible objects and explicit visual stimuli to comprehend complex, abstract ideas. Consequently, instructional media that possess the capacity to concretize abstract scientific and mathematical phenomena play a vital role in preventing mere verbalism and fostering systematic, logical reasoning. Despite these well-established developmental requirements, contemporary elementary education particularly in emerging and developing contexts frequently defaults to conventional, teacher-centered instructional paradigms. These traditional, lecture-heavy methods consistently fail to render abstract phenomena accessible, directly resulting in suboptimal conceptual understanding, diminished student engagement, and the perpetuation of systemic learning loss.

A critical dimension of this instructional challenge lies in the varied cognitive architecture and individual processing preferences of students, commonly conceptualized through the framework of learning styles. The VARK model which categorizes learning preferences into Visual, Aural, Read/Write, and Kinesthetic modalities postulates that visual learners process, internalize, and retrieve information most effectively when it is presented through spatial configurations, images, diagrams, video simulations, and graphic organizers. In recent years, the concept of learning styles has been the subject of vigorous debate within the fields of cognitive psychology and educational neuroscience. Notably, the "meshing hypothesis" the strict assertion that perfectly aligning instruction to a preferred learning style universally guarantees higher academic achievement has faced substantial empirical critique. Researchers such as (Pashler et al., 2008) have argued that there is insufficient robust statistical evidence to prove that tailoring instruction exclusively to learning styles improves outcomes across all contexts and subjects.

However, it is crucial to distinguish between the rigid application of the meshing hypothesis and the undeniable cognitive benefits of multimodal, visually scaffolded instruction. While a purely visual presentation might not be a panacea for all learning tasks, there is overwhelming consensus that for students who exhibit strong visual preferences, traditional auditory-heavy lectures introduce substantial cognitive barriers. When visually oriented students are forced to mentally translate dense, abstract auditory information into spatial representations without visual aids, they experience rapid cognitive fatigue. In subjects that are inherently abstract such as the molecular structures, energy transformations, and ecological interactions frequently encountered in the elementary science curriculum visual scaffolding transcends mere "preference" and becomes a fundamental cognitive necessity.

The application of Richard E. Mayer's Cognitive Theory of Multimedia Learning (CTML) provides a highly robust and empirically validated theoretical framework for understanding precisely why interactive multimedia is disproportionately effective for visual learners (Mayer, 2021). CTML is predicated on three core cognitive assumptions: the dual-channel assumption (the premise that humans possess separate, dedicated information-processing channels for visual/pictorial and auditory/verbal information); the limited-capacity assumption (the reality that working memory can only process a finite amount of information in each channel simultaneously); and the active processing assumption (the concept that meaningful learning requires the learner to actively select, organize, and integrate incoming information with prior knowledge). Traditional classroom instruction often overloads the auditory channel while leaving the visual channel severely underutilized, leading to cognitive bottlenecking. Interactive multimedia, when rigorously designed according to established multimedia principles (such as spatial and temporal contiguity, segmenting, and signaling), optimally distributes the cognitive load across both processing channels. By actively reducing extraneous cognitive load (the mental effort wasted on irrelevant or poorly designed instructional formats) and managing intrinsic cognitive load, interactive multimedia empowers visual learners to dedicate their working memory capacity to germane cognitive processing the deep, generative effort required to construct coherent mental models of abstract phenomena.

A comprehensive gap analysis of current pedagogical practices reveals a stark disparity between the theoretical potential of interactive multimedia and the empirical reality of standard classroom instruction. Recent meta-analyses and systematic literature reviews encompassing data from 2016 to 2026 consistently demonstrate that interactive media ranging from gamified modules to Augmented Reality (AR) significantly improves cognitive outcomes by enabling students to visualize complex processes and interact dynamically with the learning material. Furthermore, contemporary digital platforms are shown to significantly elevate student motivation, sustain affective engagement, and support differentiated learning, thereby accommodating diverse abilities in heterogeneous classrooms. Despite this overwhelming evidence, many educational institutions continue to struggle with the systematic integration of educational technology (Rogowsky et al., 2020).

This instructional and technological gap is particularly pronounced in the specialized context of Sekolah Dasar Islam Terpadu (SDIT), or Integrated Islamic Elementary Schools in Indonesia. SDIT's operate under a highly ambitious and demanding dual-mandate: delivering the rigorous national academic curriculum (including STEM subjects) alongside a comprehensive, intensive Islamic character education program, which encompasses Qur'anic memorization (Tahfidz), Islamic jurisprudence (Fiqh), and moral theology (Aqidah). This exceedingly dense curriculum frequently results in time constraints and heightened cognitive fatigue for young learners. Within this high-pressure environment, conventional lecture methods exacerbate cognitive overload and inefficiency. The urgency for pedagogical innovation in SDIT's cannot be overstated; educators require highly efficient, differentiated instructional interventions that maximize limited classroom time while ensuring profound conceptual mastery. Interactive multimedia presents a distinct solution, offering the capability to expedite the conceptualization process for visual learners,

thereby preserving vital instructional time for the holistic character development inherent in the SDIT ethos.

Therefore, there is a distinct and pressing empirical urgency to investigate and validate the efficacy of interactive multimedia specifically tailored for visual learners within the unique educational ecosystem of an SDIT. By aligning digital innovation with the specific cognitive processing preferences of the student body, educators can facilitate deeper comprehension, reduce extraneous load, and promote long-term cognitive retention. Based on this premise, the primary research objective of this study is to measure the effectiveness of interactive multimedia learning media in bridging the cognitive needs of visual learners and to assess its precise impact on enhancing the concept understanding of elementary students at SDIT Attaqwa Nurul Fahmi, in direct comparison to conventional teaching methodologies.

2. METHOD

2.1. Research Design

This study employed a rigorous quantitative research methodology utilizing a Quasi-Experimental, Non-Equivalent Control Group Design. This specific design architecture was selected because, in authentic educational settings, the true randomized assignment of individual human subjects into discrete experimental and control groups is frequently neither practically feasible nor ethically viable without severely disrupting intact classroom structures and the natural learning environment. The research framework involved intact classes and was structured in three distinct phases: (1) administering a pre-test to both groups to establish baseline equivalence in concept understanding and to confirm the absence of pre-existing statistical disparities; (2) implementing a four-week instructional intervention; and (3) administering a post-test to measure the divergence in cognitive achievement. The independent variable in this study was the instructional modality (Interactive Multimedia vs. Conventional Lecture), while the dependent variable was the students' conceptual understanding of the targeted scientific subject matter.

2.2. Population and Sampling Technique

The defined population for this study comprised all upper-grade elementary students (specifically fifth grade) enrolled at SDIT Attaqwa Nurul Fahmi during the 2025/2026 academic year. To isolate the specific demographic required to address the research objectives, a purposive sampling technique was utilized. The criteria for sample inclusion dictated that participants must possess a dominant visual learning preference. Prior to the commencement of the experimental phase, the VARK learning styles inventory was administered to a broader population of 120 fifth-grade students across four classes. The VARK questionnaire was culturally, contextually, and linguistically adapted for Indonesian elementary students to ensure high internal consistency and reliability within the target demographic. The inventory required students to respond to a series of situational prompts designed to identify their primary mode of information processing (Visual, Aural, Read/Write, Kinesthetic). Based on the rigorous diagnostic criteria of the VARK model, 60 students who exhibited a distinct, dominant visual learning preference were

selected as the final research sample. These 60 visual learners were subsequently assigned to two distinct intact classes based on pre-existing administrative structures: an experimental group (n = 30) and a control group (n = 30).

2.3. Research Instruments

The primary instrument for data collection was a Concept Understanding Test, meticulously constructed as a multiple-choice assessment consisting of 25 items. The test was specifically designed to evaluate various cognitive levels according to the revised Bloom's Taxonomy, focusing on higher-order processing beyond mere recall, specifically targeting C2 (Comprehension), C3 (Application), and C4 (Analysis).

To ensure the integrity of the data, the instrument underwent rigorous validation procedures prior to implementation. Content validity was established through expert appraisal involving two educational technology specialists and one subject-matter expert (a senior science educator). The expert validation process yielded a high validity index exceeding 85%, confirming the theoretical rigor, construct alignment, and overall credibility of the instrument. Construct validity was empirically tested by administering the test to a pilot group of 30 students outside the primary sample. Point-biserial correlation coefficients were calculated for each item, resulting in all 25 items demonstrating significant validity ($r_{calculated} > r_{table}$ at $\alpha = 0.05$). Instrument reliability was assessed using the Kuder-Richardson Formula 20 (KR-20), appropriate for dichotomous scoring, yielding a highly reliable coefficient of $r_{11} = 0.86$, indicating excellent internal consistency.

The intervention utilized by the experimental group consisted of an interactive multimedia learning application developed in adherence to the ADDIE (Analysis, Design, Development, Implementation, and Evaluation) instructional design model. The multimedia content focused on the topic of "Alternative Energy Sources and Transformations," a subject characterized by abstract phenomena. The media integrated gamified elements, dynamic interactive simulations, and structured visual scaffolding explicitly designed to target the visual channel of working memory. Crucially, the interface and content delivery adhered strictly to Mayer's Cognitive Theory of Multimedia Learning principles, specifically employing the spatial contiguity principle (placing text near corresponding graphics) and the segmenting principle (allowing learners to control the pace of the complex visual information) to minimize extraneous cognitive load.

2.4. Data Analysis Techniques

Quantitative data extracted from the pre-test and post-test administrations were subjected to robust statistical analyses using IBM SPSS Statistics software. The analytical procedure was systematically divided into two phases: assumption testing and hypothesis testing.

2.4.1. Assumption Tests (Prerequisite Analysis)

To mathematically justify the application of parametric inferential statistics, the data distribution was

assessed for normality using the Shapiro-Wilk test, which is recognized as the most statistically powerful normality test for sample sizes under 50 per group. Following this, the homogeneity of variances between the experimental and control groups was evaluated using Levene's Test for Equality of Variances to ensure that the groups were drawn from populations with equal variance.

2.4.2. Hypothesis Testing

Upon satisfying the fundamental assumptions of normality and homogeneity, group differences in conceptual achievement were examined using the Independent Samples t-test. The significance level was set at $\alpha = 0.05$

2.4.3. Effectiveness Analysis (Normalized Gain)

To accurately determine the true magnitude of cognitive improvement and to neutralize the potential ceiling effect caused by varying individual baseline scores, the normalized gain score (N-Gain) was calculated using Hake's established formula (i).

$$g = \frac{\%Postest\ Score - \%\ Pretest\ Score}{100\% - \%\ Pretest\ Score} \quad \text{(i)}$$

The resulting N-Gain scores were subsequently categorized and interpreted based on Hake's universally accepted criteria: $g \geq 0.70$ designates "High" effectiveness, $0.30 \leq g < 0.70$ designates "Medium" effectiveness, and $g < 0.30$ indicates "Low" effectiveness.

3. RESULT AND DISCUSSION

3.1. Research Results

The empirical data collected from the pre-test and post-test administrations provide a comprehensive, quantitative overview of the cognitive gains achieved by the visual learners in both the experimental (interactive multimedia) and control (conventional lecture) cohorts. The descriptive statistics, which outline the central tendencies (means) and dispersions (standard deviations) of the assessment scores, are presented in Table 1.

Table 1. Descriptive Statistics of Pre-test and Post-test Scores

Group	N	Pre-test Mean	Pre-test SD	Post-test Mean	Post-test SD	Mean Difference (Raw Gain)
Experimental (Multimedia)	30	44.50	6.25	81.20	5.80	+ 36.70
Control (Conventional)	30	45.10	6.10	56.40	7.35	+ 11.30

As detailed in Table 1, the baseline concept understanding of the visual learners in both groups was nearly identical prior to the onset of the pedagogical intervention. The experimental group recorded a pre-test mean score of 44.50 with a standard deviation of 6.25, while the control group recorded a statistically comparable pre-test mean of 45.10 with a standard deviation of 6.10. This minimal variance establishes that both groups commenced the study with statistically equivalent prior knowledge, ensuring that any subsequent divergence in post-test scores could be reliably attributed to the instructional intervention rather than pre-existing aptitude disparities.

Following the four-week instructional period, a pronounced and substantial divergence in academic achievement was observed. The experimental group, which engaged extensively with the interactive multimedia application, achieved a post-test mean of 81.20 (SD = 5.80). Conversely, the control group, subjected exclusively to conventional, lecture-based instruction, attained a post-test mean of only 56.40 (SD = 7.35). The experimental group demonstrated a raw mean score increase of 36.70 points, which is more than three times the modest 11.30-point raw increase observed in the control group. Prior to conducting inferential hypothesis testing via the t-test, it was mandatory to verify the parametric assumptions of normality and homogeneity of variance. The results of these prerequisite statistical tests are outlined in Table 2.

Table 2. Assumption Tests for Concept Understanding Scores

Variable	Group	Shapiro-Wilk Statistic (W)	p-value	Levene's Statistic (F)	p-value	Decision
Pre-test	Experimental	965	421	145	705	Normal & Homogeneous
	Control	970	543			
Post-test	Experimental	958	284	1890	175	Normal & Homogeneous
	Control	961	332			

Note: Significance level α = 0.05

The Shapiro-Wilk test for normality yielded *p*-values significantly greater than the 0.05 alpha threshold for all datasets (Experimental Pre-test p = 0.421, Control Pre-test p = 0.543; Experimental Post-test p = 0.284, Control Post-test p = 0.332). This indicates that the data distributions did not deviate significantly from a normal distribution. Concurrently, Levene's test for equality of variances resulted in p-values of 0.705 for the pre-test data and 0.175 for the post-test data, confirming that the variances between the two groups were homogeneous. Having satisfied the requisite parametric assumptions, an Independent Samples t-test was executed on the post-test scores to ascertain the statistical significance of the performance gap between the two cohorts.

Table 3. Independent Samples t-test Results (Post-test)

Test	t-value	df	Mean Difference	Std. Error Difference	p-value (2-tailed)
Equal variances assumed	14.538	58	24.80	1.706	< 0.001

The Independent Samples t-test (Table 3) revealed a highly significant difference in post-test concept understanding scores between the experimental and control groups (t = 14.538, df = 58, p < .001). Because

the p-value is substantially lower than the designated alpha level of 0.05, the null hypothesis (H0) is definitively rejected. This provides robust statistical evidence that the implementation of interactive multimedia learning media resulted in a significantly higher conceptual understanding among visual learners compared to conventional teaching methods. To further quantify the pedagogical effectiveness and the true magnitude of the learning improvement while simultaneously eliminating the confounding ceiling effect inherent in raw score comparisons a Normalized Gain (N-Gain) analysis was conducted.S

Table 4. N-Gain Score Comparison between Experimental and Control Groups

Group	N	Average N-Gain Score (g)	N-Gain Percentage (%)	Effectiveness Category (Hake, 1998)
Experimental	30	0.66	66.12%	Medium - High
Control	30	0.21	20.58%	Low

As depicted in Table 4, the experimental group achieved an average N-Gain score of 0.66, which translates to a 66.12% improvement relative to their maximum possible growth. According to Hake's classification criteria, this performance borders on the "High" effectiveness category and comfortably resides in the upper echelons of the "Medium" category. In stark contrast, the control group recorded an average N-Gain score of 0.21 (20.58%), placing their conceptual progression definitively in the "Low" category. This substantial disparity in N-Gain scores underscores the profound efficacy of interactive multimedia in bridging the cognitive gap for visual learners encountering abstract subject matter.

3.2. Discussion

The empirical findings of this study conclusively demonstrate that the strategic integration of interactive multimedia learning media yields a significantly superior enhancement in conceptual understanding for visually oriented students compared to traditional, lecture-centric methodologies. The data synthesized in Table 4, exhibiting a robust N-Gain of 0.66 for the experimental cohort versus a mere 0.21 for the control cohort, demands a multifaceted psychological and pedagogical analysis. The following discussion interprets these findings through the theoretical lenses of cognitive psychology, instructional design, and contemporary educational technology trends.

3.2.1. Cognitive Amelioration via the Cognitive Theory of Multimedia Learning (CTML)

The exceptional conceptual progression of the experimental group can be primarily explicated through the framework of Richard E. Mayer's Cognitive Theory of Multimedia Learning. According to CTML, meaningful learning is an active, demanding process of selecting relevant information, organizing it into coherent mental representations, and integrating it with existing schemas (Mayer, 2022). When visual learners at SDIT Attaqwa Nurul Fahmi were exposed to conventional teaching (the control group), instruction was delivered predominantly through the verbal/auditory channel. Because human cognitive architecture possesses separate but severely limited processing channels, relying solely on verbal exposition for complex, abstract concepts results in an immediate bottleneck in working memory.

Conversely, the interactive multimedia intervention leveraged the foundational "multimedia principle," which asserts that individuals learn more deeply from words and graphics combined than from words alone. The multimedia application utilized in this study actively managed the students' cognitive load. By presenting spatial and conceptual information through dynamic animations, interactive diagrams, and gamified exploratory modules, the media effectively reduced extraneous cognitive load the mental effort historically wasted on deciphering poorly designed, unimodal instructional formats. This critical reduction in extraneous processing freed up valuable working memory capacity, allowing the students to engage fully in germane cognitive processing, which is the deep, generative psychological effort required to automate schemas and assimilate new, complex knowledge. Furthermore, by adhering to CTML's spatial and temporal contiguity principles placing corresponding textual explanations and visual animations in close physical proximity and presenting them simultaneously the multimedia ensured that visual learners did not have to expend extraneous cognitive effort searching for connections across different mediums, thereby accelerating conceptual integration.

3.2.2. Alignment with Global Educational Technology Trajectories (2016–2026)

The robust improvements observed in this research strongly corroborate an expanding body of contemporary literature regarding educational technology integration in elementary settings over the past decade. Recent systematic reviews (2020–2025) exploring the efficacy of interactive media, including Augmented Reality (AR) and gamified digital applications, consistently report that such tools make abstract phenomena tangible and significantly support differentiated learning. For instance, highly cited studies by (Chen & Huang, 2023; Wu et al., 2023) and (Zhang et al., 2023) highlighted that augmented and interactive digital platforms cultivate elevated cognitive engagement and foster superior long-term cognitive retention compared to static textbook instruction.

Furthermore, the empirical data from this research align with the conclusions of (Cavanagh & Kiersch, 2023) and (Çeken & Taşkın, 2022), who argued that modern interactive multimedia applications, when rigorously grounded in CTML principles, inherently accommodate diverse student abilities and promote inclusive educational environments. By providing instant feedback, self-paced exploratory learning, and rich visual input, the interactive multimedia used in this study functioned as a dynamic pedagogical scaffold. This validates the assertions of recent researchers who advocate for educational technology not merely as a supplementary aid, but as a core pedagogical necessity required to bridge the digital divide and elevate scientific literacy.

3.2.3. The Contextual Advantage within Integrated Islamic Schools (SDIT)

Finally, the practical implications of this research are particularly profound within the specific context of SDIT Attaqwa Nurul Fahmi. Integrated Islamic schools in Indonesia operate under the ambitious and noble mandate of synthesizing a demanding national academic curriculum with rigorous religious and character education. This dual curriculum inevitably results in strict time constraints and increased cognitive fatigue for elementary students. The conventional lecture method, being highly inefficient for delivering

abstract concepts to visual learners, exacerbates this fatigue. The implementation of interactive multimedia serves as a highly efficient technological intervention that maximizes the utility of instructional time. By expediting the conceptualization process for visual learners through reduced extraneous load, teachers in SDIT environments can achieve rigorous academic targets more swiftly. This operational efficiency affords educators the necessary time to focus on the affective and psychomotor domains inherent in Islamic character education. The high practicality, validity, and effectiveness of multimedia applications, as evidenced by this study and similar developmental research, establish digital interactive media as a vital strategy for modernizing SDIT instructional frameworks without compromising their foundational religious values.

4. CONCLUSION

This research unequivocally demonstrates that the utilization of interactive multimedia learning media is a highly effective, scientifically validated instructional strategy for enhancing the conceptual understanding of visual learners at the elementary level. Quantitatively, the intervention resulted in a statistically significant disparity in achievement ($p < .001$), with the experimental cohort achieving a robust N-Gain of 0.66 (Medium-High category), vastly outperforming the control group's minimal progression of 0.21 (Low category). Conceptually, the interactive multimedia succeeded by aligning seamlessly with the Cognitive Theory of Multimedia Learning; it mitigated extraneous cognitive load, optimized dual-channel processing, and translated abstract academic content into manipulable, tangible visual stimuli that resonated perfectly with the students' inherent cognitive processing preferences.

The practical implications of these findings are substantial for primary educators, particularly within dense curricular environments such as Integrated Islamic Schools (SDIT). Teachers and curriculum designers are strongly encouraged to adopt interactive multimedia not merely as a supplementary technological novelty, but as a foundational, indispensable tool for differentiated instruction. By intentionally designing and curating media that cater to visual and multimodal learning styles, educators can foster highly inclusive, engaging, and equitable classrooms that prevent learning loss and maximize academic potential.

For future research trajectories, it is recommended that scholars conduct longitudinal studies to evaluate the long-term cognitive retention of concepts acquired through interactive multimedia. Furthermore, subsequent investigations should expand the scope of analysis beyond purely cognitive outcomes to rigorously explore the affective and psychomotor impacts of immersive technologies (such as Augmented and Virtual Reality) across broader, more socio-economically diverse educational demographics.

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