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Article

A Brain-Based Learning Augmented Reality Framework Combined with the *Tri Kaya Parisudha* Values for Early Childhood Character Education

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Abstract: Most technology advancements for early childhood education focus on cognitive development. They tend to neglect character education that incorporates local wisdom and integrative methods. Thus, this study aims to design, develop, and evaluate a brain-based learning (BBL) and *Tri Kaya Parisudha* values (*Manacika*, *Wacika*, *Kayika*) Augmented Reality (AR) framework. Using the ADDIE (Analysis, Design, Development, Implementation, Evaluation) model of instructional design, the development process of the AR framework is made as systematic as possible. The developed AR media is interactive and provides multisensory, emotionally fused learning experiences through 3D visualization, animation, and interactive story. Such experiences are designed to stimulate neural pathways important for cognitive and moral development. The learning experiences align with the thematic teaching of the positive values integrated into the Indonesian early childhood education (ECE) curriculum. The validity and practicability of the AR framework were assessed through expert review and its functionality with preschool-aged children, using a quasi-experimental design. The design of the pedagogical media and the integration of culture were validated by the experts and scored highly for validity. The classroom application had an exceptionally positive impact on children's prosocial, critical thinking, and communicative behavior. The study claims that the suggested AR framework is a constructive technological and pedagogical framework to promote Character Education. It integrates cutting-edge technology, neuroscientific learning, and cultural values, providing a model to design contextually appropriate educational technology for early childhood education.

Keywords: Augmented Reality; Brain-Based Learning; Character Education; Early Childhood; *Tri Kaya Parisudha*

1. Introduction

The phase of life from birth to age 8 is recognized as early childhood, a critical period for cognitive development. Often described as a golden age, the early childhood development stage has the greatest degree of brain plasticity. It means a tremendous number of neural connections are created at this stage of life, and the building blocks for the cognitive, social, emotional, and moral competencies for subsequent learning and behavior are established [1–4].

The experiences a child has during this time period can no longer be described as beneficial; they are instead imperative to the child's potential [5]. Most traditional paradigms in early childhood education have not created personalized, immersive learning experiences that meet the needs of the 21st century [6]. Digital technology, including Augmented Reality, can provide an immersive and personalized learning experience. Augmented Reality is one of the many digital technologies available to early education and can provide a personalized experience.

Combining digital visuals such as 3D models, animations, and sounds with the real world is what makes AR special. This learning environment is both engaging and interactive [7,8]. It is unlike Virtual Reality (VR) because it does not immerse users in a digital world but enhances the real, physical world, making it optimal for young children who are still grasping reality and the concept of abstraction. Numerous studies have noted the effectiveness of AR in early learning, literacy [9], numeracy [10], and spatial understanding [11]. AR helps children grasp a concept better through visual and physical representations, and helps solidify that understanding through abstraction in their thinking and learning [12].

There remains a notable gap in the present use of AR in education. The most common use of AR has been to help students develop cognitive skills, while its potential for students' socio-emotional learning and character education has been largely ignored [13]. The majority of AR education apps are created based on available technology rather than on solid educational, pedagogical, or neuroscientific reasoning. Brain-based learning (BBL) is where it becomes most relevant. BBL is based on the science of how the human brain works and what it's designed to do, while also incorporating the science of education [12,13]. Some of the key aspects of BBL are: 1) Multisensory Engagement: This means using more than one system of input (visual, auditory, and body movement) to engage as many brain pathways as possible to increase the likelihood that what is being taught is remembered [14]; 2) Emotional Connection: Learning activities should engage the brain's limbic system, where emotions are felt and processed, to create memorable and meaningful learning experiences [15]; 3) Pattern Recognition and Meaning Making: The brain naturally organizes information into patterns. When information is structured, the brain organizes it into a pattern it recognizes, leading to a higher level of understanding [16]; 4) Social Collaboration: The brain learns most effectively when it is socially engaged [17].

Combining AR and BBL will create a strong partnership. As described earlier, AR provides an engaging, multisensory environment that incorporates all relevant BBL principles. But the combination of BBL and AR lacks an important aspect that's needed for holistic development: Character and moral education. Character education is the process of teaching children universal and culture-specific values, such as honesty, respect, empathy, and responsibility. In preparation for children to be good as well as smart, character education is a cornerstone [18]. The world is becoming geographically closer and socially distant, so it's important to juxtapose local wisdom and cultural values with global education to help shape one's identity and provide an ethical foundation [19].

The literature shows three gaps in research regarding technology-enhanced learning for the youngest learners. While the individual domains have received attention, the gaps in the intersecting domains have not. AR and BBL: Research exists on both areas, but very few have designed AR applications from the BBL perspective. Most applications use engagement as a metric of success and do not explain how interactive design decisions relate to specific neuroscientific principles [20]. AR and Character Education: Research on the use of AR for character education is limited. Most story-based applications lack an explicit value system. The use of AR to create safe, blended digital and physical experiences that enable children to engage in and practice prosocial behaviors (e.g., sharing, helping) remains an unexplored opportunity [21]. BBL and local cultural values: BBL is framed in purely universal terms of brain function, but it is most useful when applied to a specific context [22]. A major gap in the literature is the use of specific local cultural frameworks, including indigenous knowledge systems and ethics, in BBL-based curriculum design.

The study covers three areas of research: Augmented Reality, Brain-Based Learning, and Local Wisdom-Based Character Education. It proposes fully immersive, brain and culture-aligned technology as the optimal educational method for all-around development in early childhood.

This study uses the Balinese philosophical principle *Tri Kaya Parisudha* to bridge the identified gap, thereby situating the ethical and cultural essence of the framework to be developed. *Tri Kaya Parisudha* translates to "the three ways of pure action" [23–25]. It is a principle of Hindu ethics that instructs people to achieve unity among what they think, say, and do [26–29]. The principle is made up of three, and only three, components: 1) *Manacika* (Pure Thinking): Cultivating purity in the mind. Pure thinking, pure intentions, and pure intellectual operations. It means thinking positively, compassionately, and ethically. 2) *Wacika* (Pure Speaking): Speaking, and thereby, saving, and being pure. It means speaking and disappearing, and being free from the wicked, the circumspect, and the harsh, gentle, and fightless. 3) *Kayika* (Pure Action): To be virtuous means to perform steps, and to be righteous means to act and to do. It means respecting, being responsible, being integrated, and being thoughtful.

It is the simplicity, comprehensiveness, and direct relevance to a child's daily activities that put *Tri Kaya Parisudha* in good standing. For the cultivation of the good, a three-part framework, readily usable and deeply embedded in the Balinese culture of Bali, Indonesia, should be used. It is a perfect set of usable values, and for good reason. It is an ideal culture to be embedded. It goes beyond being good and holds and uses the good in action to be seen in the good, and in the good, and in the good, and in the good, and in the good, and in the good, and in the good, and in the good and the good, and the good, and the good, and the good, and the good, and the good, to hold and to use the good, good, and the good, and the good, and the good, and the good of the social, and the good of the social, and the good of the social, and the good of the social, and the good of the culture, and the good of the social.

This paper aims to examine a new framework for brain-based learning (BBL) that uses augmented reality (AR) to facilitate the integration of *Tri Kaya Parisudha* (TKP) values. This framework is structured to address the identified gaps by integrating the key design, development, and assessment branches of AR and BBL, and the principles of TKP. It integrates multiple new technologies to turn AR into an effective educational resource for teaching core TKP values. The primary goal here is to use AR to develop immersive, three-dimensional, interactive learning environments with spatial audio. The second goal is to ensure that the design of the AR environments maximizes the targeted cognitive load and emotional engagement, as well as the development of long-term memories, in accordance with BBL principles. Finally, the AR learning environments should be designed to integrate the TKP values through learning stories, quests, and interactive avatars, with a primary emphasis on cultivating character education as the primary outcome.

An example AR story could include a virtual character who is upset because a toy has been broken. Each of the following steps represents a part of the *Manacika-Wacika-Kayika* process that the application would guide the child through. To help the character feel better, the child must first come up with a solution (*Manacika*). Next, the child must console the character using a voice command or by selecting a phrase (*Wacika*) from a menu that includes options such as "It's okay, we can fix it together". Finally, the child must complete the console (Kayika) trigger by virtually dragging a tool to fix the toy on the screen (*Kayika*). In combination, all of these elements represent a single, unified experience that employs augmented reality (AR) technology to activate several neurological processes as outlined in the brain-based learning (BBL) model and simultaneously teach a fundamental cultural concept.

The main aim of this research is to construct and verify the proposed integrated framework. This aim is segmented into the following objectives: 1) Construct a conceptual and technical framework of an AR framework that integrated the operation of principles of Brain-Based Learning and the components of *Tri Kaya Parisudha*; 2) Create a working model of an AR learning application based on the developed framework intended for children 4–6 years of age with thematic content on social and environmental care; 3) Through an expert review of a computer scientist, an early childhood educator, and a culture expert, examine the framework's technical, pedagogical, and cultural sufficiency; 4) In an actual educational context, do a formative assessment of the operationalization of the framework and its effect on children's prosocial, verbal communication, and problem thinking and solving behaviors.

This work is poised to make several important contributions to the domains of computer science, educational technology, and child development. 1) Theoretical Contribution: We present an original integrated conceptual framework for education technology, which is both scientifically and culturally adaptable. 2) Technical Contribution: We present proof of concept for the functional AR app designed and developed based on our framework, and offer the framework as something other developers can replicate. The framework details specific strategies for aligning the Interactive AR components with BBL principles and ethics. 3) Practical/Pedagogical Contribution: Based on the validation of experts and a quasi-experimental study, we demonstrate the preliminary effectiveness of the framework and, in turn, offer teachers and educational policymakers a tangible means of integrating technology and character education holistically.

2. Method

This study uses a Research and Development (R&D) approach, which is particularly useful for the construction and evaluation of educational tools and processes. Its main goal is to construct, improve, and ascertain the viability of a Brain-Based Learning Augmented Reality Framework combined with the *Tri Kaya Parisudha* values. The research is divided into two stages: (1) Design and Development Stage using the ADDIE model, and (2) Validation and Evaluation Stage using expert review and a quasi-experimental field evaluation study. The mixed-method approach will ensure the framework is pedagogically sound, technically accurate, and successful in the educational field.

2.1. Research and Development Model: The ADDIE Framework

ADDIE (Analysis, Design, Development, Implementation, Evaluation) serves as the procedural framework for this research. Given the complexity of the required digital learning intervention across the pedagogical (BBL) and cultural (*Tri Kaya Parisudha*) aspects, the systematic, structured, and iterative nature of the ADDIE model helps engineer these complexities. The subsequent subsections elaborate on the activities conducted within each phase.

2.1.1. Analysis Phase

The most important part of the analysis is to address the framework's fundamental requirements and limitations. For analysis, the author used multiple methods, including an analysis of the existing body of knowledge, to identify a research gap, which is discussed in the introduction. It was found that Integrated AR-BBL-Cultural Value Frameworks focused on early childhood education do not exist (Front-End Analysis). Children in the 4–6-year age bracket (Learner Analysis) are the target users. Some key design attributes include the Cognitive, Physical, Attention, Social and Emotional, Context, and Task analyses.

The children largely operate in the pre-operational stage, which is characterised by egocentrism, symbolic thinking, and reliance on visual and concrete representations. They are developing their fine and gross motor skills and avoiding interactions that require precise gestures. Activities are usually short (10–15 min), and so they utilize short, concise, and highly dynamic learning modules. They favour learning through play, imitation, and social interaction. Children are highly responsive to the emotional cues of characters in storybooks and tales. The author conducted the research in a Kindergarten in Gianyar, Bali, and the analysis confirmed the technological infrastructure, cultural context, learning needs, and goal analysis.

The presence of Android tablets and a stable Wi-Fi connection enabled marker-based AR applications. As a Hindu-affiliated institution, *Tri Kaya Parisudha*'s values are integrated into the school's ethos, enabling teachers and parents to relate to and accept the school culturally. In teacher interviews, it was noted that there is a demand for media that exemplifies prosocial behavior (e.g., sharing, assisting, polite language) and is more stimulating than traditional storytelling or role-playing techniques. It was a clear focus for the team. One of the key objectives was stated as follows: "To develop a validated AR framework that is expected to enhance the development of prosocial behaviors consistent with *Tri Kaya Parisudha* (*Manacika*, *Wacika*, *Kayika*) for children 4 to 6 years old, designed based on Brain-Based Learning principles".

2.1.2. Design Phase

The design phase translated the findings from the analysis phase into a detailed blueprint for the AR framework and its learning content. This phase was the conceptual heart of the project, where the integration of BBL and *Tri Kaya Parisudha* was explicitly operationalized.

(1) Theoretical Framework Design

BBL Principles Mapping Core BBL principles were mapped to specific AR design features (See **Table 1**). *Tri Kaya Parisudha* Integration is the three tenets were broken down into measurable, teachable concepts and woven into the narrative structure of the learning modules. For example, a story scenario would present a problem requiring a child to first think of a solution (*Manacika*), then verbalize it kindly (*Wacika*), and finally act it out via an AR interaction (*Kayika*).

Table 1. Mapping of BBL Principles to AR Framework Design Features.

BBL Principle	Operationalization in AR Framework Design
Multisensory Engagement	High-fidelity 3D models, spatial audio (character voices, environmental sounds), and haptic feedback (device vibration) upon task completion.

Table 1. *Cont.*

BBL Principle	Operationalization in AR Framework Design
Emotional Connection	Use of relatable, emotionally expressive animal characters; storytelling with moral dilemmas; background music that reflects the narrative mood (e.g., cheerful, contemplative).
Pattern Recognition	Consistent UI/UX design; repetitive interactive patterns (e.g., tap to help, drag to share); predictable story arcs with clear cause-and-effect.
Social Collaboration	Design of activities for pairs of children, requiring turn-taking and verbal communication to solve an AR-based puzzle or scenario.
Safe Environment	No "game over" or failure states; instead, supportive feedback and guided retries. The AR environment is a non-threatening space for exploration.

(2) Technical Architecture Design

Given the target context, the application was initially developed for Android because of its popularity. Also, Unity 3D was selected as the primary development environment for its strong AR support and ability to develop for multiple platforms. For AR, the Vuforia Engine was used because of its image target recognition and tracking. A client-server architecture was chosen. The client application (the AR app on the tablet) manages the user interface, AR rendering, and local logic. A thin backend was created to handle user profiles and to collect anonymized interaction data for research purposes. Interactions were designed to be as simple and intuitive as possible for small children: tap to select and activate; drag & drop to move virtual objects to help characters; and (optional) voice input to encourage children to say nice things (Wacika) while the device was listening for keywords.

(3) Instructional and Content Design

Three thematic modules were storyboarded: (1) "Helping a Friend in Need", (2) "Keeping Our Environment Clean", and (3) "Speaking Kindly". Each module contained a narrative script and described AR (Augmented Reality) triggers (determined images or flashcards that activate the AR experience). The character dialogues highlight the values of *Tri Kaya Parisudha* and outline the particular interactive activities that the child will engage in. Friendly animal 3D character models and props were designed to be colorful, non-threatening, and stylized. Illustrating sharing, cleaning, and displaying emotions (happy, sad) were the focus of the animations.

2.1.3. Development Phase

In this stage, the design documents were converted into a working software prototype. 3D models, animations, and audio (background music, sound effects, and character voice-overs in Indonesian) were developed and added to the Unity project. The application logic was coded in C#. Some of the major features coded in this version include: Vuforia image target recognition; touch and drag interaction handlers for virtual objects; animation state controllers for character animations; audio controllers for dialogues and sound effects; a simple data logging system to capture interaction duration and user choices (e.g., which helpful action was selected).

A prototype of one module was developed and piloted for internal testing with a small group of developers and one early childhood education consultant. This round of "alpha" testing was primarily to establish a functioning pedagogical flow and to capture user reactions to system features (e.g., tracking and UI responsiveness). The feedback obtained at this stage was used to refine interactions and simplify text in the on-screen instructions before full development. After undergoing a series of iterative refinements, a beta version of the application with all three learning modules was completed and prepared for distribution on Android tablets.

2.1.4. Implementation Phase

The practicality of the AR application was assessed, along with initial user experience feedback after the app was deployed in the actual learning context. Some teachers were trained for two hours on application specifics, module objectives, and their facilitator roles. Image targets (printed flashcards) were placed in the learning space. Five (n = 5) children not included in the subsequent research study were used in this pilot study to test for technical problems, usability issues, and engagement with the AR application. Volume adjustments and interaction sensitivity for dragging and dropping were adjusted after pilot testing. A pseudo-experimental framework was used to assess the main study.

2.1.5. Evaluation Phase

The evaluations used both formative and summative methods at each stage of the ADDIE process. In the Design and Development phases, formative evaluation was used to guarantee quality. The summative evaluation, described below, assessed the overall effectiveness and the validity of the final product.

2.2. Expert Validation—Subjects and Instruments

Before the intended field tests, the authors conducted expert validation to assess the overall quality of the framework. Two Computer Science Lecturers, one specializing in HCI and multimedia development, were brought in to assess the framework's technical and software components, as well as UI/UX and AR performance. Three Senior Lecturers in Early Childhood Education and Educational Psychology, who have written on BBL or child development, were assigned to review the content related to the BBL principles to evaluate its consistency, developmental appropriateness, and learning effectiveness. A philosopher of Hinduism and a Cultural Studies scholar were brought together to assess the correctness, contextualization, and articulation of the *Tri Kaya Parisudha* values within the app.

Using a 5-point Likert scale (1 = Very Poor, 2 = Poor, 3 = Fair, 4 = Good, 5 = Very Good), a validation questionnaire was created. The questions in the three categories of Media Validity (visual display quality, auditory clarity, application stability, usability, and interactivity), Pedagogical and Content (accuracy, consistency with BBL principles, age-appropriate language, and potential to elicit critical thinking and communication), and Cultural and Character Education Validity (correctness of the portrayal of *Tri Kaya Parisudha*, the effectiveness of its incorporation within the story, and the capacity to modify children's comprehension of good thoughts, words, and deeds) were evaluative with culminative scoring.

Specialists were given the application and the accompanying validation questionnaire and were prompted to describe the features. They were asked to interact with all three modules and provide a combination of quantitative ratings and qualitative feedback, including suggestions for revisions. The summary of quantitative feedback was determined to be the average rating for each item. A product was viewed to have 'valid' functionality if the average rating for each criterion was ≥ 4.0 (Good). Qualitative feedback was ultimately used for the final refinements.

2.3. Quasi-Experimental Field Study—Subjects, Instruments, and Procedure

A pretest-posttest control-group quasi-experimental design was used to assess the effectiveness of the framework.

2.3.1. Design Phase

The sample consisted of purposively selected children from a Kindergarten in Gianyar, Bali, aged 5–6 years. Thus, of the 40 children selected, 20 had not had any formal contact with AR learning media. They were grouped as follows. Experimental Group (n = 20): Children in this group engaged in learning activities with the developed AR framework. Control Group (n = 20): These children received thematic learning activities (helping, being clean, and kindness) taught through stories, picture cards, and direct instruction. The study received full informed parental consent for all children. The study protocol was fully explained to protect participant anonymity and to inform participants of their right to withdraw from the study at any time.

2.3.2. Research Instruments

An instrument has been developed to evaluate the observable manifestations of *Tri Kaya Parisudha* and the target skills related to it, consisting of a range from 0 to 2 (0 = Not Visible, 1 = Emerging/Inconsistent, 2 = Clearly Visible). The OSPB included items such as: *Manacika*: "The child offers a simple solution to a problem a peer is having," *Wacika*: "The child uses 'please', 'thank you', and 'sorry' of their own initiative", and politeness when talking to others and peer," *Kayika*: "The child goes out of his/her way to help a peer complete a task"; Critical Thinking: "The child can justify his/her action"; Communication: "The child speaks and shares his/her opinion or asks questions in the group".

To assess inter-rater reliability, two independent observers scored a sample of children, yielding a Cohen's Kappa of 0.85, indicating high chance agreement. The Child Engagement Scale (CES) is a more concise scale that allows the teacher to assess children's attention, enjoyment, and participation in learning sessions (1 = Low, 5 = High). He also used a Semi-Structured Interview Guide to collect participants' feedback on changes in children's behavior, the ease of use of the AR media, and the obstacles encountered, to obtain qualitative data.

2.3.3. Research Procedure

Pretest (Week 1): Both the experimental and control groups were observed using the OSPB during their regular play and learning activities to establish a baseline for prosocial behavior. Intervention (Weeks 2–4): The experimental group participated in three 20-min learning sessions per week (a total of 9), each focusing on one of the AR modules. The sessions were facilitated by a teacher who introduced the theme and provided guidance, but the primary interaction was between the child and AR. The Control Group was engaged in the same number and duration of sessions on the same themes, but using conventional methods led by the teacher. Posttest (Week 5): The OSPB was administered again to both groups under conditions similar to those of the pretest. Data Collection: Teachers also filled out the CES after each session for their respective groups. At the end of the intervention, teachers from both groups were interviewed.

2.4. Data Analysis

Data encompasses both quantitative and qualitative approaches. Averages were computed and compared for the Media, Pedagogical, and Cultural domains. To support the claim, the mean and the standard deviation were calculated from the descriptive statistics. Normality testing of the OSPB pretest and posttest scores was done using the Shapiro-Wilk test. For the data, which are nonparametric, the Wilcoxon Signed Rank was employed to determine within-group (pretest and posttest) differences between the experimental and control groups. Group differences in CES scores were assessed using the Mann-Whitney U Test for comparisons between the experimental and control groups.

CES score group comparisons were assessed using the Mann-Whitney U Test. The significance level was determined at $p < 0.05$. Teacher interview transcripts were coded for emerging themes on the use, impact, and integration challenges of the framework using thematic analysis.

3. Results and Discussion

In this section, the study's empirical findings are presented. The AR's design is illustrated in **Figures 1–5**.

3.1. Expert Validation Results

Prior to implementation, the quality of the "Brain-Based Learning Augmented Reality Framework Integrated with *Tri Kaya Parisudha* Values" needs to be validated by specialists. Below is a summary of the expert feedback across the three domains.

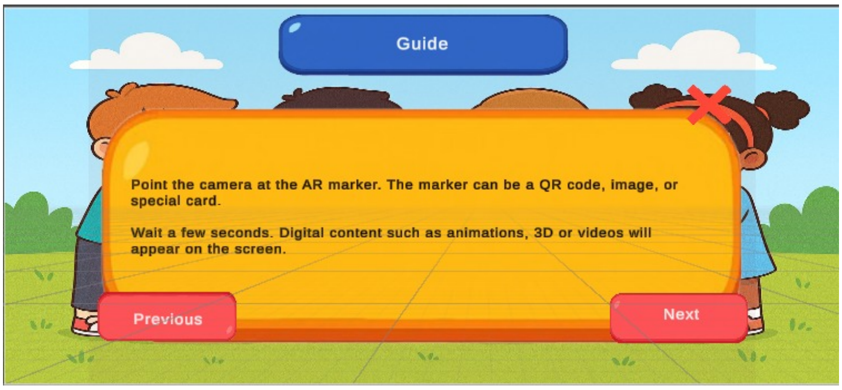

Figure 1. Guide Page.

Figure 2. Games Selection Page.

Figure 3. AR Page.

Figure 4. Download Page.

Figure 5. Learning Objectives Page.

3.1.1. Media and Software Validity

The validation from the two media and software experts focused on the constructional strengths, user interfaces (UI), user experience (UX), and stability of the AR application. **Table 2** presents results confirming a high level of construct validity.

Table 2. Media and Software Expert Validation Results (N = 2).

Aspects	Mean Score (1–5)	SD	Qualitative Feedback Summary
Visual Display Quality	4.75	0.35	"The 3D models are highly appealing, colorful, and appropriate for young children. Animations are smooth and enhance understanding".
Audio Clarity and Quality	4.50	0.71	"Character voices are clear and emotionally expressive. Background music is non-intrusive and supports the narrative mood effectively".
Application Stability & Performance	4.00	0.00	"The application runs without crashes. AR tracking is stable and robust, with minimal jittering of virtual objects".
Ease of Use and Intuitiveness	5.00	0.00	"For touch interactions (tap, drag), no on-screen instructions will be required beyond the first demonstration. The target age group's motor skills will be most suited".
Interactivity and Responsiveness	4.50	0.71	"The system provides immediate and logical feedback for every user action, maintaining a high level of engagement".
Overall Media Validity	4.55	0.35	"A technically proficient and well-engineered AR application that demonstrates high production value and usability".

A validity score of 4.55 (5-point scale) substantiates the application's above-average technical quality. Experts were especially positive about the ease of use of the interaction design, as no verbal instructions were needed. One expert stated, "The children at the test site dragged and dropped virtual food to the character, which shows the drag and drop UX design is of very high quality".

3.1.2. Pedagogical and Content Validity

The three pedagogical and BBL experts assessed the framework's coherence with developmental psychology and the principles of Brain-Based Learning. **Table 3** displays the very positive results.

Table 3. Pedagogical and BBL Expert Validation Results (N = 3).

Aspects	Mean Score (1–5)	SD	Qualitative Feedback Summary
Developmental Appropriateness	4.67	0.58	"The content complexity, language, and narrative structure are perfectly tailored to the cognitive and emotional level of 5–6 year-olds".
Alignment with BBL Principles	4.83	0.29	"Excellent manifestation of multisensory learning (visual, auditory, haptic). The stories create a strong emotional hook, aligning with the principle of emotional engagement".
Clarity of Learning Objectives	5.00	0.00	"Each module has a crystal-clear objective related to a specific prosocial behavior. The connection between action and outcome is immediate and understandable".
Potential for Stimulating Critical Thinking	4.33	0.58	"The problem-based scenarios (e.g., 'how can we help the sad monkey?') effectively prompt children to think of solutions before acting".
Potential for Enhancing Communication	4.67	0.58	"The design naturally encourages children to talk about what they are seeing and doing, both with the device and with peers nearby".
Overall Pedagogical Validity	4.70	0.36	"The framework exemplifies how to convert BBL theory to a digital learning instrument. It is not only sound from a pedagogical perspective but also extremely engaging".

The total pedagogical validity score of 4.70 demonstrates that integrating BBL into the design was highly successful. Experts pointed out the 'smooth embedding of BBL principles', one even said, 'The use of a consistent, predictable pattern in the interactive storytelling directly supports the brain's need for routine and pattern recognition, thus, lowering the cognitive load and improving the understanding of the moral lesson'.

3.1.3. Cultural and Character Education Validity

The two culture specialists reviewed the effectiveness and accuracy of *Tri Kaya Parisudha*'s integration. The results shown in **Table 4** confirmed the framework's cultural relevance and appropriateness.

A cultural validity score of 4.88 is almost perfect. One of the reviewers said, "What is particularly clever about the structure is how it interprets the *Tri Kaya Parisudha* values. Simply telling children to 'be good' is insufficient. The framework motivates kids to take on the role of an active digital citizen. Still, within this framework, they need first to think (*Manacika*), then speak (*Wacika*), and then do (*Kayika*) something positive. That is true internalization of positive character". Overall, the expert review indicated that the AR framework is highly valid across technical, pedagogical, and cultural aspects, and that the means in all fields were above the 4.0 threshold.

Table 4. Cultural and Character Education Expert Validation Results (N = 2).

Aspects	Mean Score (1–5)	SD	Qualitative Feedback Summary
Accuracy of *Tri Kaya Parisudha* Representation	5.00	0.00	"The concepts of *Manacika*, *Wacika*, and *Kayika* are represented authentically and in accordance with the philosophical teachings".
Clarity of Value Transmission	4.50	0.71	"The values are not preached but are naturally embedded in the narrative and gameplay. Children learn by doing, which is powerful".
Contextual and Cultural Relevance	5.00	0.00	"The stories and character designs (e.g., using local animals and environments) are deeply contextual and relatable for Balinese children".
Appropriateness for Character Education	5.00	0.00	"An innovative and effective tool for modern character education. It makes abstract ethical concepts concrete and actionable for a child".
Overall Cultural Validity	4.88	0.18	"A remarkable fusion of traditional knowledge and contemporary technology enhances the digital generation's experience while safeguarding and valuing cultural traditions".

3.2. Quasi-Experimental Field Study Results

The purpose of the field study was to assess the practical effectiveness of the framework compared with traditional instructional approaches in a real classroom environment.

3.2.1. Pre-Test Homogeneity and Baseline Comparison

To confirm that any differences observed after the intervention were due to the treatment rather than other preexisting factors, a Mann-Whitney U test was conducted on the pre-test scores from the Observation Sheet on Prosocial Behavior (OSPB). **Table 5** illustrates that there was no statistically significant difference (p = 0.841) between the experimental and control groups before the intervention, confirming the groups' equivalence at baseline.

Table 5. Pre-Test Homogeneity of OSPB Scores.

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	*p*-Value
Experimental	20	20.18	403.50	192.50	0.841
Control	20	20.83	416.50		

3.2.2. Within-Group Analysis: Pre-Test vs. Post-Test

As summarized in **Table 6**, a Wilcoxon Signed-Rank Test was conducted for each group to determine differences in OSPB scores between the pre-test and post-test.

Table 6. Within-Group Analysis of OSPB Scores (Wilcoxon Signed-Rank Test).

Group	Test	Mean Rank	N	Z	*p*-Value	Effect Size (r)
Experimental	Post-test > Pre-test	10.50	20	−3.927	<0.001**	0.62 (Large)
Pre-test > Post-test	0.00	0				
Control	Post-test > Pre-test	8.00	16	−2.530	0.011*	0.40 (Medium)
Pre-test > Post-test	5.50	4				

Note: ** p < 0.001, * p < 0.05.

The data show a statistically significant improvement in OSPB scores for both groups; however, the effect was substantially stronger in the experimental group. The Experimental Group showed a highly significant improvement (p < 0.001) with a large effect size (r = 0.62). It shows that the AR framework had a strong, positive influence on children's display of prosocial behaviors. The Control Group also showed a significant improvement (p = 0.011), but with a medium effect size (r = 0.40), suggesting that the AR intervention was less effective than conventional teaching methods.

3.2.3. Between-Group Analysis: Experimental vs. Control

The analytical objective was to measure the effectiveness of both methods. It was done by calculating the gain scores (Post-test score − Pre-test score) for each child. It was followed by a Mann-Whitney U test of these gain scores to determine whether the improvement in the experimental group was substantially greater than that in the control group. **Table 7** shows the results.

Table 7. Between-Group Analysis of OSPB Gain Scores (Mann-Whitney U Test).

Group	N	Mean Rank	Sum of Ranks	Mann-Whitney U	Z	*p*-Value
Experimental	20	26.38	527.50	132.50	−2.841	0.004**
Control	20	14.63	292.50			

Note: ** $p < 0.01$.

The results show statistical significance ($p = 0.004$). It confirms that there was a greater improvement in prosocial behaviors in the experimental group utilizing the AR framework, compared to the control group that received regular instruction.

3.2.4. Analysis of Child Engagement

The resulting Child Engagement Scale (CES) scores, completed by teachers post-session, were considered. The experimental group had a mean engagement score of 4.45 (SD = 0.51) compared to 3.60 (SD = 0.68) in the control group. The Mann-Whitney U test performed on these scores yielded U = 105.0, $p < 0.001$; therefore, children's engagement and attention during the AR-based learning sessions were considerably higher.

3.2.5. Detailed Behavioral Analysis (OSPB Sub-Components)

The most remarkable changes for *Tri Kaya Parisudha* were in the sub-components of OSPB. Comparative assessments of the means for these sub-components of the pre-test and post-test are illustrated in **Figure 1**, while **Table 8** presents the statistical analysis of the gain scores.

Table 8. Analysis of *Tri Kaya Parisudha* Sub-Component Gain Scores.

OSPB Sub-Component	Experimental Group Gain (Mean)	Control Group Gain (Mean)	Mann-Whitney U	*p*-Value
Manacika (Good Thoughts)	0.90	0.45	135.5	0.005**
Wacika (Good Words)	1.05	0.50	120.0	0.002**
Kayika (Good Deeds)	1.20	0.60	110.5	<0.001**
Critical Thinking	0.80	0.40	142.0	0.008**
Communication	0.95	0.35	115.5	0.001**

Note: ** $p < 0.01$.

The data show that the experimental group improved markedly across all subcomponents measured. Gain's largest magnitude was in *Kayika* (Good Deeds). This sub-component is the first measurable outcome visible, and is a product of the AR app's active, direct "call to action". Significant improvement was also observed in *Wacika* (Good Words) and Communication, aided by the story dialogues and the social aspect of the activities.

3.3. Qualitative Findings from Teacher Interviews

Thematic analysis of semi-structured interviews with teachers provided additional insight that justified the quantitative data. Increased Engagement and Motivation: Teachers reported a substantial increase in concentration and excitement. A teacher commented, 'Usually, they are very restless after 10 minutes, but with the AR, they were totally focused for the entire 20 minutes. They would say, "Can we do it again?" Teachers noticed children using the AR module lessons in their everyday activities. A teacher recounted, 'After the module on helping, I saw a child unprompted help a friend pick up crayons that had spilled. He even said, "I'm helping like in the tablet". It was a breath of fresh air for the direct transfer from the real to the virtual. Teachers said the AR sessions inspired children to use more sophisticated language and evidence. "The children were very active. They were talking to the characters on the screen, giving directions to their friends, and arguing over the best course of action to solve the problem posed. It was way more than our typical storybook reading". One teacher remarked. Teachers initially had concerns about the technology, but they found the application easy to use.

"My role described how the framework was constructed so that I moved from teacher to coach. The application itself took the children on a learning journey. All I had to do was facilitate the group, and then, as usual, wait for their reflections". This study successfully developed and validated an innovative framework based on Brain-Based Learning (BBL) and Augmented Reality (AR) integrated with local wisdom values of *Tri Kaya Parisudha*. The results of expert validation for the framework scored >4.5 in all 3 categories (media, pedagogy, and culture). These results confirm that the framework is viable from the technical, pedagogical, and cultural perspectives. The results of the quasi-experimental study also showed that the framework positively affected the child participants' prosocial behaviors in the experimental group ($p < 0.001$, r = 0.62) compared with the control group. This section provides an interpretation of the core findings in relation to the existing body of knowledge.

Additionally, the built-in data logging module suggests that Learning Analytics (LA) could be implemented in the future [30]. It would, for example, allow the provision of real-time, adaptive feedback based on a child's interaction patterns, aligning with the literature on next-generation cyber technology and its social implications, which describe "fully automated smart" educational settings. It is essential for HCI research that such systems have the potential to support not only cognitive but also socio-emotional development in learners. The development of young learners' "conceptual awareness," as Kommers and Babulak describe, along with AI, provides an applicable instance in this case, where children are digitally immersed in a scenario involving moral issues, thereby integrating the physical and the abstract [31].

What sets this study apart is its pioneering of the innovative framework. Rather than employing AR as a marketing strategy, the framework leverages it as a technology engine to offer instruction that is both pedagogically and culturally relevant. It explains the positive outcomes observed in the experimental group. AR as a Means to Support BBL Principles: The framework's design differentiated and incorporated the most important BBL principles in its use of AR technology. The 3D visuals and spatial audio of AR provided multisensory access to the BBL principle of using multiple neural pathways to enhance memory encoding [32]. For example, the virtual object-dragging activity to assist the character (Kayika) stimulated visual, auditory, and kinesthetic participation, thereby forming a neural imprint that is richer and more memorable than that from a verbal instruction with a 2D picture.

This finding supports prior research suggesting that AR enhances memory retention and situational interest [33,34]. In addition, Brain-Based Learning notes that the emotional connection to the AR characters and storylines creates a positive emotional state, which is important for long-term memory retention [32]. The noted social communication and collaboration among children during AR activities support the BBL principle, the brain is a social organ [32], and support the research that AR can enhance collaborative learning [34].

Using components of *Tri Kaya Parisudha* in an integrated manner in character education. Using *Tri Kaya Parisudha* provides an integrated, culturally appropriate approach to this facet of character education. The positive changes in the sub-components of *Manacika* (thinking well), *Wacika* (speaking well), and *Kayika* (acting well) demonstrate the framework's success in bringing moral philosophy into practice. The AR experiences were purposefully constructed to order these values. Children were required to think (*Manacika*), which could include speaking (*Wacika*) and acting through an AR (*Kayika*) interaction. It is character internalization and also a clear pedagogical framework for moral and values education, which is often a gap in the practice of early childhood education. The results of the study support Hartawan et al. and *Tri Kaya Parisudha*, showing that character interpersonal education occurs through the cognitive (*Manacika*), affective (*Wacika*), and psychomotor (*Kayika*) areas, and that this education develops social consciousness, social insight, and social communication.

As the literature shows, the predominant concern in the field of AR in education is the "low pedagogical value," a problem characterized by a heavy focus on technology features but a relatively limited implementation of appropriate instructional design [34]. The present study attempts to address this issue by constructing a framework grounded in the solid theoretical underpinnings of BBL and the *Tri Kaya Parisudha* ethical framework. Along with feedback from BBL experts, the framework's recipients scored very high on pedagogical validity (4.70), indicating that it balances technological prospects and pedagogical requirements. The real value of AR tools will lie more in how effectively the accompanying AR tool recognizes the pedagogical value within the frameworks [34,35]. With that, the present framework attempts to illustrate that both AR and pedagogy do not exist in a vacuum. When instructional design is properly integrated, AR can be a valuable resource for supporting the teaching of complex and abstract ideas and for providing opportunities to practice prosocial and other behaviors in a risk-free environment [36].

In growing AR education studies, using AR appears to be more effective than other methods. For example, Simsek reports that AR learning activities helped children better understand than coloring-based activities [36]. Also, Pan et al. recognize that children's literacy skills, such as rapid letter naming, can be supported through AR [7]. Our study further explores these studies by using AR for character education and comparing its effectiveness. The increase in Child Engagement Scale (CES) scores for the experimental group supports the positive impact of AR on learners as an attention- and interest-capturing learning opportunity [33,34].

The outcome of this work possesses value for researchers, developers of educational technologies, and practitioners of early childhood education. This work contributes several key aspects to theory. First, it offers, for the first time in an empirically verifiable form, a conceptual and practical framework for the fusion of emerging educational technologies (AR), neuroscience-informed pedagogy (BBL), and local cultural pedagogy (*Tri Kaya Parisudha*). This model has the potential to guide future research and development in culturally responsive educational technologies. Second, it offers a new perspective on the application of the *Tri Kaya Parisudha* pedagogy and ethics, moving from the conceptual to the practical, and illustrates the pedagogy's relevance in the 21st-century digital era [37,38]. Lastly, it reinforces the conviction that an interdisciplinary approach is fundamental to developing comprehensive and effective educational innovations, especially for developmental challenges such as character education.

This study provides a framework for educational practitioners and policymakers on implementing technology-based character education. This framework demonstrates how AR can be a strong medium for socio-emotional and moral learning, and not just a cognitive learning tool. This study also emphasizes the importance of teacher training. Teacher readiness, as our qualitative results and the literature indicate, is a crucial factor for successful technology integration [34]. Thus, AR-based teacher training for professional development should be conducted.

For educational technology practitioners, this study provides a rationale for a human-centered design process. It also provides the rationale for a design approach that goes beyond the technical to include pedagogical and socio-cultural considerations. The framework demonstrates how to integrate a range of values and learning theories into the design of an educational app, ensuring the technology serves an educational purpose rather than merely for its own sake.

Although this research has positive aspects, it also has shortcomings that need to be addressed and highlight opportunities for future research. The research was confined to a specific cultural context (Bali) and a specific school, which limits generalizability to other settings. While the sample of contacts was limited and the shortcomings of a quasi-experimental design hampered the research, the research was sufficient. Since the research relied on measurement data obtained from the observations and reports of teachers to determine behavioral changes, this inspired innovations in measurement data to be used for conducting longitudinal studies, research that incorporates measurement data from parents, and conducting repeated measures that are closer to the longitudinal design to increase the validity of the research. However, the OSPB was highly evaluated and demonstrated inter-rater reliability.

The current framework uses a marker-based AR application, but in future designs, it would be reasonable to use a marker-less or location-based AR application. This application also enables the creation of more flexible, context-sensitive, and immersive AR learning environments. This research focused on a specific age group (4–6 years). Thus, a framework to investigate the AR learning environment for younger and slightly older children would be useful. Consequently, numerous potential research directions present themselves. For replication and scaling, it is necessary to define the framework's boundaries through large-scale research across diverse cultural and socio-economic contexts. For longitudinal studies, the framework's impact on long-term character consolidation should be examined. How do positive prosocial behaviors decay over time? In future studies, it is important to incorporate LA methods as suggested by the frameworks of Kazanidis et al. [39]. By using LA in the AR environment, researchers will know how long it takes to complete a helping task or how quickly a child makes a choice, providing insight into a child's thinking and moral reasoning and helping personalize learning. Other Pedagogical Models: The AR and *Tri Kaya Parisudha* framework, in conjunction with other inquiry-based or problem-based learning models as seen in other works [35,38], will add to the character education pedagogical framework. Teacher Role and Orchestration: The teacher's role as a facilitator in AR-supported value-based learning remains unclear.

4. Conclusion

This study successfully designed, developed, and validated a Brain-Based Learning Augmented Reality framework in alignment with the *Tri Kaya Parisudha* values and is now regarded as a valid and effective intervention for early childhood character development. The framework has proven to foster even more prosocial behaviors than standard character development interventions. However, characterizing the framework as simply 'effective' is reductive. The framework also acts as a scaffolding for 'value sensitive' and 'design for' pedagogical frameworks. Additionally, the framework also acts as a starting point for interdisciplinary discourse on HCI, neuroscience, and cultural studies. It reasserts the role of digital technology as a pedagogical partner to facilitate embodied, experiential learning. With all these frameworks within the main structure, the main framework serves as a systematic and comprehensive mapping of neuroscience to interaction design (i.e., the architecture of interaction design). Along with this contribution, the study had some limitations, including the cultural context and the participant sample size. These limitations highlight the importance of future studies that test the framework across different contexts and examine the duration of behavioral changes resulting from the inclusion of technologically interdisciplinary components. These components include markerless augmented reality and learning analytics to develop adaptive, ethically designed 'ultra-smart' educational systems. Additionally, these systems should evaluate the evolving role of the teacher as a facilitator in future learning environments and how they integrate sophisticated technologies.

Author Contributions

Conceptualization, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); methodology, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); software, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and D.G.H.D.; validation, N.M.C., I.G.P.S. and D.G.H.D.; formal analysis, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); investigation, N.M.C., I.G.P.S. and D.G.H.D.; resources, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); data curation, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); writing—original draft preparation, N.M.C.; writing—review and editing, N.M.C., I.G.P.S. and D.G.H.D.; visualization, N.M.C., I.K.S. (I. Kadek Suartama) and D.G.H.D.; supervision, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma); project administration, N.M.C., K.A., I.K.S. (I. Kadek Suartama), and I.K.S. (I. Komang Sudarma). All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflict of interest.

AI Use Statement

The authors declare that no artificial intelligence (AI) tools were used in the preparation of this manuscript.

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