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Enhancing Civic Knowledge Through an Immersive Virtual Reality Museum: Development and Effectiveness of Bumantara.edu in Indonesian Civic Education

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ABSTRACT

Indonesian schools have adopted one-to-one tablet programmes rapidly, but the devices meant to support learning now compete with it for attention. This study developed and evaluated Bumantara.edu, a tablet-deployed Virtual Reality (VR) museum with an integrated AI chatbot tutor, built to strengthen Civic Knowledge in the national-movement history strand of Pancasila and Civic Education (PPKn). Using an ADDIE-based Research and Development design, the product was assessed by a content expert, a media expert and the class teacher, then tested with 25 eighth-grade students at SMP Thursina IIBS Malang through a one-group pretest–posttest design with a 20-item higher-order thinking instrument (Cronbach's α = .812). Validation reached 89% for content and 97% for media, and practicality 91% from the teacher and 88.20% from students. Civic Knowledge rose from M = 53.40 (SD = 21.59) to M = 88.60 (SD = 3.69), a mean normalised gain of 0.70, and after Shapiro–Wilk indicated non-normality a Wilcoxon signed-rank test confirmed the improvement ($Z = -4.299$, $p < .001$). Gains were uneven: where students had already answered most items correctly, movement was negligible; where they did not, correct responses rose sharply. Immersive media appear to work as targeted compensation for conceptual difficulty rather than general enrichment.

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1. INTRODUCTION

School systems have been spent heavily on one-to-one device programmes, assuming that access to digital tools converts into learning. Large-scale evidence complicates that assumption. Students who use devices intensively for non-academic purposes during lessons score substantially below peers who do not [1]. Its mechanism is well documented: device-mediated multitasking fragments attention, weakens comprehension and damages retention [2]. Confiscation policies treat the symptoms. They leave the underlying competition for attention untouched, which is why digital distraction is increasingly framed as a design problem rather than a discipline problem [3].

In Indonesian Pancasila and Civic Education (PPKn) the stakes are specific. The

national-movement history strand carries much of the work of forming national identity. Civic Knowledge — a citizen's grasp of governmental structure, rights and obligations, and democratic principles — is the foundation on which civic skills and dispositions are built [4]. Acquiring it means connecting past events to present responsibility. Instruction in this strand, however, remains largely textual and pitched at recall of dates and names, and a recent analysis of Indonesian high school civic education argues the subject has not kept pace with the digital generation it serves, producing awareness without the disposition to act [5]. Indonesian scholarship on PPKn has long made the same case for a more constructive, experience-based approach [6], [7].

A need assessment with 100 eighth-grade students at SMP Thursina IIBS Malang, an Islamic integrated boarding school in East Java, put numbers to the problem. Ninety-four per cent used school-issued tablets independently during lessons. Sixty-six per cent admitted their attention drifted to social media or games while doing so. Seventy-five per cent found history instruction boring and 64% said it amounted to memorising dates and figures, but most revealing of all was this: 86% agreed that national history matters for citizenship, yet 75% could not connect the values in their textbooks to their own civic responsibilities. Eighty-nine per cent wanted interactive visual media instead of static text, and 87% had used virtual reality before.

Immersive virtual reality addresses both halves of the problem at once: occupying the visual field narrows the channel through which competing stimuli can reach a learner, while rendering historical narrative as navigable space turns text into something much closer to experience. Evidence has been accumulating. Commemorative history teaching in VR produces affective engagement that conventional media do not [8], virtual museum environments raise both learning effectiveness and active participation [9], VR applications have improved achievement in social studies [10], and immersive inquiry has been used to build civic competencies such as disciplinary thinking and argumentation [11]. Indonesian secondary classrooms show the same pattern, with immersive VR outperforming conventional multimedia on achievement and on thinking dispositions [12], [13], and local development studies have applied VR and augmented reality to PPKn and to related subjects, with promising results [14], [15], [16].

Two gaps persist. VR history research clusters in Western and East Asian settings and usually measures historical understanding in general rather than civic competence as a separately defined construct. And immersive applications are almost always evaluated alone, without the conversational scaffolding that keeps inquiry going once the headset comes off. This study takes on both. It develops Bumantara.edu, a tablet-deployed VR museum paired with an AI chatbot tutor configured for the curriculum, and measures its effect on Civic Knowledge specifically, guided through by two questions: is the product valid and practical for classroom use, and does it produce measurable gains in Civic Knowledge?

2. LITERATURE REVIEW

2.1 Immersive Virtual Reality in History and Heritage Education

Museum-based VR in history education has expanded quickly since 2023, and bibliometric mapping now identifies immersion, presence and cultural preservation as the field's dominant themes [17]. Its pedagogical logic is straightforward enough. Historical reasoning requires situating events in context, and a virtual environment supplies that context perceptually rather than by description, which is why reviews argue that VR contributes less through information transfer than through spatial and emotional relationships it lets learners build with the past [18]. Design-oriented work in heritage education adds a caution: outcomes depend on how an environment is structured, not on immersion by itself [19].

Practical barriers have fallen as authoring tools matured. Platforms now let teachers without programming backgrounds build heritage environments, with measurable learning gains and a shift towards student content creation [20], while systematic review evidence from K–12 settings confirm moderate positive effects for immersive technologies while noting that effect sizes swing widely with instructional design [21]. That qualification matters here. Technology is necessary but not sufficient, and the pedagogy wrapped around it carries much of the explanatory weight.

2.2 *Cognitive Foundations of Immersive Multimedia Learning*

Two frameworks govern how such environments ought to be designed. The Cognitive Theory of Multimedia Learning holds that learners take in verbal and pictorial information through separate channels of limited capacity, and that instructional design should suppress extraneous load so whatever capacity remains can go to generative processing [22]; cognitive load theory describes the same constraint in terms of working memory architecture, distinguishing the load a topic imposes from the load its presentation imposes [23]. Immersive environments sit awkwardly inside both. Perceptual richness that generates engagement is also detail the learner must filter out.

The Cognitive Affective Model of Immersive Learning offers a way through, treating immersion as an indirect influence that works by way of presence and agency, which in turn drive interest, motivation and self-efficacy [24]. Empirical work supports the affective pathway, since against equivalent desktop media immersive VR raises both perceived enjoyment and perceived value [25]; underlying all of it is the older argument that what distinguishes VR is the illusion of place and plausibility [26], [27]. But the benefits are uneven. Immersion favours some kinds of acquisition over others [28], and classroom studies report gains in concentration as well as in experience [29] the outcome that matters most when the problem you are solving is rooted in distraction.

2.3 *Civic Knowledge and Conversational Scaffolding*

Civic Knowledge is acquired through understanding, not recognition [4]. Measuring it therefore demands instruments that reach past factual recall into analysis and evaluation, which is why the test used here was written at the analytical and evaluative levels, and it separates this study from work that treats history achievement as one undifferentiated score.

Conversational agents supply a second mechanism. Large language model chatbots have raised assignment performance among middle school students [30], though that same literature warns that improvements in perceived support do not automatically become retention, and that agent which offer hints rather than answers preserve the cognitive engagement learning depends on. Systematic analysis of chatbot design confirms that pedagogical configuration, not raw model capability, determines instructional value [31]. Pairing an immersive environment with a deliberately constrained tutor is therefore a reasonable response, and meta-analytic evidence on VR in education supports the wider premise that well-designed immersive interventions produce positive but context-dependent effects [32], [33], [34].

3. METHODS

3.1 *Design and Procedure*

This study used Research and Development structured by the ADDIE model, moving through analysis, design, development, implementation and evaluation [35], [36]. Analysis produced the need assessment reported above and mapped the eighth-grade PPKn learning outcomes for the national-movement

strand, after which design work covered four things: the storyboard for the three-dimensional environment, the interface, the system prompt governing the conversational agent, and the assessment blueprint. Development built the environment and integrated a language model through an application programming interface, after which the product went to expert validation and revision. Implementation ran the revised product across two lesson sessions, one for the pretest and initial exploration and one for deeper work with the museum and the chatbot. Evaluation drew on three sources: validation data, practicality questionnaires and pretest–posttest scores.

3.2 Participants and Setting

Twenty-five eighth-grade students at SMP Thursina IIBS Malang took part. They were selected purposively, on the grounds that they are issued school tablets and had formed the population for the need assessment described above. Three evaluators assessed the product: a content expert in civic education and national history, a media expert in educational technology, both academics at Universitas Negeri Malang, and the class PPKn teacher acting as practitioner-validator. One practical condition shaped the trial. The application depends on the school's campus-wide Wi-Fi for the chatbot and for score synchronisation, so network stability was a precondition rather than a convenience.

A single group was used without a comparison class. This follows from the purpose of development research, where the object is to establish whether a product performs as designed rather than to rank it against alternative methods. The limitation this creates is addressed in Section 4.6.

3.3 Instruments

Expert validation used five-point Likert instruments. Its content instrument covered curriculum alignment, conceptual accuracy, depth of civic content and contextual relevance; the media instrument covered visual design, navigation and interactivity, functionality and ease of use. Student practicality was measured through a 20-item questionnaire across five indicators, four items each. Civic Knowledge was measured with a 20-item multiple-choice test written at cognitive levels C3 to C6 and distributed across three indicators of the national-movement strand: Kebangkitan Nasional, Sumpah Pemuda and Proklamasi Kemerdekaan. Content validity came from expert review [37]. Internal consistency reached Cronbach's α = .812 [38], equivalent to KR-20 for dichotomous items [39].

3.4 Data Analysis

Validation and practicality percentages were interpreted against established qualification bands [40]. Learning improvement used the normalised gain statistic, with g of at least 0.70 taken as high, 0.30 to 0.69 moderate and below 0.30 low [41]. Normality was tested with Shapiro–Wilk, appropriate at this sample size. The assumption failed, so hypothesis testing used the Wilcoxon signed-rank test. Qualitative validator comments were analysed following the interactive model of data reduction, display and conclusion drawing [42]. Analyses were run in IBM SPSS Statistics.

4. RESULTS AND DISCUSSION

4.1 The Bumantara.edu Environment

Development produced a tablet application built around three components. Arung Masa is a three-dimensional museum split into thematic zones, navigated by avatar, where documents, photographs and interpretive wall text are arranged as an exhibition narrative. Pandita is a conversational tutor held by its system prompt to the curricular scope of the national movement and configured to answer with guiding questions rather than finished explanations. A quiz module delivers analytical items and returns immediate feedback. Figure 1 shows two zones of the

museum; Figure 2 shows Pandita responding to a student question about the Sumpah Pemuda.

(a) Zone 2 – Kristalisasi Persatuan (Sumpah Pemuda 1928)

(b) Zone 3 – Aula Proklamasi & Dasar Negara

Figure 1. Zones of the Arung Masa virtual museum environment
Source: Processed primary data (2026)

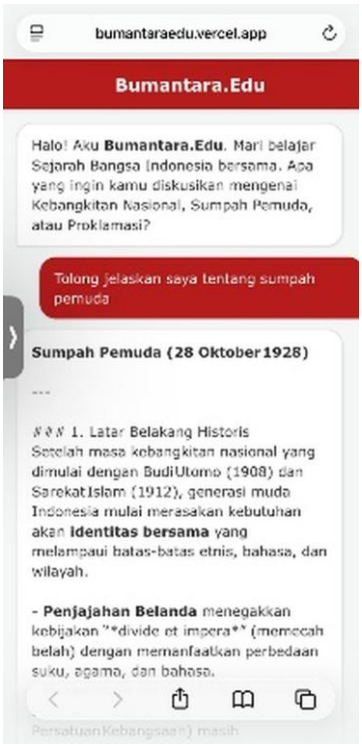

Figure 2. The Pandita AI tutor responding to a student query
Source: Processed primary data (2026)

4.2 Validity and Practicality

Every evaluation source placed the product in the highest qualification band. Table 1 summarises the four headline figures and Table 2 breaks the two expert assessments down by indicator.

Table 1. Validation and practicality results

Evaluation source	Score (%)	Category
Content expert	89.00	Highly valid
Media expert	97.00	Highly valid
Teacher (practitioner)	91.00	Highly practical
Students (n = 25)	88.20	Highly practical

Source: Processed primary data (2026)

Table 2. Expert validation by indicator

Indicator	Score	%
Content: curriculum alignment	23/25	92.0
Content: conceptual accuracy	21/25	84.0
Content: depth and completeness	21/25	84.0
Content: contextual relevance	24/25	96.0
Media: visual design	23/25	92.0
Media: navigation and interactivity	24/25	96.0
Media: functionality	25/25	100.0
Media: ease of use	25/25	100.0

Source: Processed primary data (2026)

Content validation reached 89%. Contextual relevance scored highest at 96%, confirming that the historical material was tied to present-day civic questions rather than presented as chronology. Conceptual accuracy and depth both scored 84%, and this is where the expert's written comments concentrated: he asked for fuller treatment of the Sumpah Pemuda and of the sequence of events immediately preceding the Proklamasi Kemerdekaan. Both were expanded before field testing. Media validation reached 97%, with functionality and ease of use at ceiling. The media expert's recommendations were narrow, covering polygon load on certain assets and the smoothness of navigation controls, and both were implemented.

Table 3. Student practicality by indicator (n = 25)

Indicator	Items	%
Content suitability	4	81.20
Immersive appeal	4	91.40
Ease of use	4	87.80
Instructional effectiveness	4	90.00
Engagement and focus	4	90.60
Overall	20	88.20

Source: Processed primary data (2026)

Student practicality averaged 88.20%. Ordering matters here, because immersive appeal scored highest at 91.40% and engagement and focus followed at 90.60%, while content suitability came last at 81.20%. That pattern fits the design rationale rather than undercutting it: the environment succeeded first at holding attention, which is the problem it was built to solve.

4.3 Effect on Civic Knowledge

Table 4 reports the score distributions. Mean performance moved from 53.40 to 88.60 on a 100-point scale, a gain of 35.20 points. Standard deviation tells a second story: dispersion fell from 21.59 to 3.69, compressing a widely scattered group into a narrow high-performing band, which means the students who began furthest behind were the ones who gained most.

Table 4. Descriptive statistics of Civic Knowledge scores (n = 25)

Statistic	Pretest	Posttest
Mean	53.40	88.60
Standard deviation	21.59	3.69
Minimum	15.00	85.00
Maximum	90.00	100.00

Source: Processed primary data (2026)

Mean normalised gain was 0.70, sitting exactly on the boundary between the moderate and the high categories, and Table 5 shows fourteen students (56%) reaching high gain against ten (40%) at moderate. One case fell into the low band. That student scored 90 on both tests — a ceiling artefact, not an instructional failure. Shapiro–Wilk confirmed non-normality in both distributions (pretest $W = 0.908$, $p = .027$; posttest $W = 0.751$, $p < .001$), so hypothesis testing proceeded with the Wilcoxon signed-rank test, which returned 24 positive ranks, one tie and no negative ranks at $Z = -4.299$, $p < .001$.

Table 5. Distribution of normalised gain (n = 25, mean g = 0.70)

Category	n	%
High ($g \geq 0.70$)	14	56.0
Moderate ($0.30 \leq g < 0.70$)	10	40.0
Low ($g < 0.30$)	1	4.0
Total	25	100.0

Source: Processed primary data (2026)

4.4 Gains by Civic Knowledge Indicator

The aggregate figure hides considerable variation. Table 6 and Figure 3 report correct responses by indicator across the whole cohort, before and after instruction.

Table 6. Correct responses by Civic Knowledge indicator

Indicator	Pretest	Posttest	Gain
Kebangkitan Nasional	108	111	+3
Sumpah Pemuda	90	178	+88
Proklamasi Kemerdekaan	69	153	+84

Source: Processed primary data (2026)

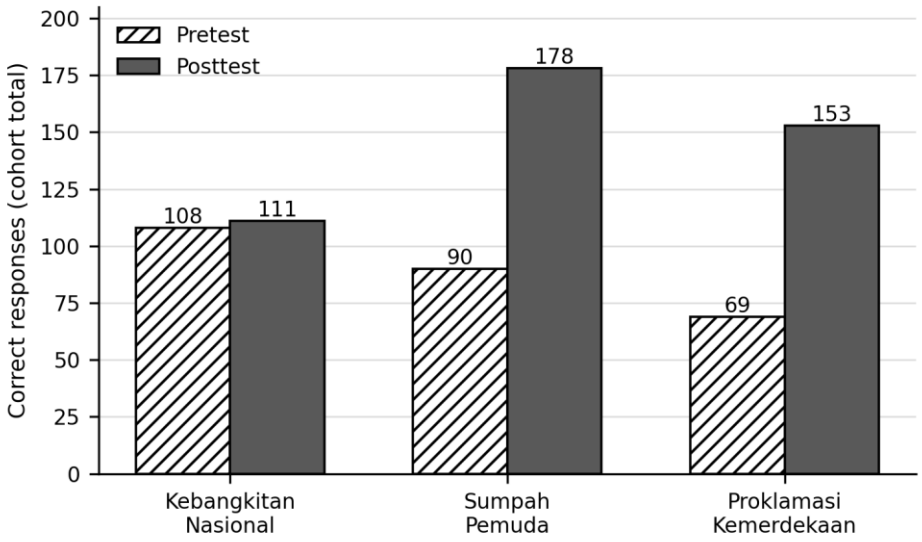

Figure 3. Correct responses by Civic Knowledge indicator, before and after instruction
Source: Processed primary data (2026)

Kebangkitan Nasional barely moved, gaining three correct responses across the whole cohort, while Sumpah Pemuda rose by 88 and Proklamasi Kemerdekaan by 84. That contrast is not a defect in the intervention; it is the finding. Students already answered most Kebangkitan Nasional items correctly before the lesson began, which left almost no headroom for the intervention to work in; where they did not, the immersive treatment closed most of the gap.

Content also differs in kind. Kebangkitan Nasional is largely a matter of organisational chronology, which textbooks handle adequately. Proklamasi Kemerdekaan asks students to follow a compressed chain of contingent events across a few days, and Sumpah Pemuda asks them to grasp the subordination of regional identity to a national one. Those are conceptual demands, not factual ones, and they are exactly what spatial and visual presentation supports.

4.5 Discussion

Improvement on this scale is consistent with the moderate positive effects reported for immersive technologies in K–12 settings [21] and with VR work in social studies [10], and with Indonesian experiments finding immersive media ahead of conventional multimedia [12], though this study sits at the upper end of that range. Three design features plausibly explain the position. The intervention was aimed at a documented attentional problem rather than added as enrichment, and students rated engagement and focus among the strongest outcomes, which lines up with classroom evidence that immersive environments improve concentration [29]. Indicator-level results match what the cognitive affective model predicts, namely that immersion works through presence and interest rather than through delivery of information [24]: gains concentrated where conceptual integration was required.

Third, the conversational agent carried engagement past the immersive episode. Because Pandita was constrained to reply with guiding questions, it preserved the cognitive engagement that chatbot research identifies as the condition under which such tools help rather than substitute [30], [31]. That separates this design from standalone VR implementations and offers a partial account of why analytical indicators gained more than factual ones.

4.6 Limitations

Three limitations qualify for these findings, and two deserve direct treatment. Using a single group means improvement cannot be attributed to the immersive medium as distinct from the extra instructional attention the lesson sequence carried. Nor can novelty effects be ruled out. This is a known cost of formative development research, where the question is whether a product works as designed, and it should be read as a boundary on the claim rather than a flaw in the execution. A controlled comparison is the obvious next step.

A second concern is the posttest distribution. A standard deviation of 3.69 with scores between 85 and 100 indicates a ceiling effect, and it is fair to ask whether the instrument was simply too easy after instruction. Two observations bear on this. The same instrument produced a pretest range from 15 to 90, so it discriminated well before the intervention; and the Kebangkitan Nasional indicator showed almost no movement, which an uniformly easy posttest would not produce. The compression is more consistent with convergence on mastery than with instrument failure, though a harder instrument would test that reading. Finally, the sample of 25 students at one well-resourced boarding school limits generalisation, and the posttest followed instruction immediately, leaving retention unmeasured — real caveat given evidence that immersive media can lift immediate performance without matching durability [28].

5. CONCLUSION

This study asked whether an immersive virtual reality museum joined to a constrained conversational tutor could be built to an acceptable standard, and whether it would strengthen Civic Knowledge among Indonesian junior secondary students. Both questions are answered in the affirmative. Bumantara.edu was judged valid by content and media experts and practical by the teacher and the students who used it, and its implementation was followed by improvement in Civic Knowledge that was both statistically significant and educationally meaningful. More useful, though, is where that improvement occurred. Gains concentrated in the conceptually demanding material that textual instruction handles least well, and were negligible where students already performed near ceiling. This suggests that immersive media contribute to civic education not as uniform enrichment but as targeted compensation, and that they are best deployed where abstraction rather than information scarcity is the obstacle. A narrowing of score dispersion points the same way, indicating that the students who benefited most were those who had been furthest behind.

Two directions follow. Practitioners should treat immersive environments as instruments aimed at specific conceptual difficulties rather than as general engagement tools, and should pair them with conversational scaffolding configured to question rather than to answer. Researchers should test this design against a control condition, across schools with differing infrastructure, and with delayed post-testing to establish whether the gains reported here hold over time.

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