

**PENGEMBANGAN MEDIA *POP-UP BOOK* BERBANTUAN
AUGMENTED REALITY UNTUK MENINGKATKAN KEMAMPUAN
SPASIAL SISWA SMP**

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ABSTRAK

Pop-up book berbantuan *augmented reality* merupakan buku cetak tiga dimensi yang dipadukan dengan elemen visual interaktif. Media ini dikembangkan untuk menunjang pembelajaran matematika, khususnya pada materi bangun ruang sisi lengkung dan juga meningkatkan kemampuan spasial. Pengembangan dilakukan dengan menggunakan model Plomp yang meliputi lima tahap, yaitu *preliminary investigation, design, realization/construction, test, evaluation and revision*, serta *implementation*. Media mengintegrasikan visualisasi tiga dimensi pada *pop-up book* dengan aplikasi *augmented reality* berbasis *marker-based tracking* yang dikembangkan menggunakan Blender, Unity 3D, dan Vuforia Engine. Subjek penelitian adalah siswa SMP. Karakteristik media terletak pada integrasi visualisasi tiga dimensi dengan *augmented reality* yang memungkinkan siswa mengamati, memutar, serta mengeksplorasi objek geometri secara interaktif, membantu siswa mengonstruksi pemahamannya secara mandiri dan merepresentasikan bangun ruang dari berbagai sudut pandang. Hasil uji validitas menunjukkan rata-rata skor validitas materi sebesar 4,80 dan rata-rata validitas media sebesar 4,78 dengan kategori sangat valid. Berdasarkan hasil penelitian pada tiga sekolah dengan karakteristik yang berbeda, tingkat kepraktisan media berada pada kategori praktis hingga sangat praktis dengan hasil angket respon guru berada pada rentang 4,00 hingga 4,90 serta angket respon siswa pada rentang 4,30 hingga 4,77. Kemudian hasil uji efektivitas menggunakan uji t berpasangan pada seluruh sekolah memperoleh nilai Sig. < 0,001 sehingga terdapat perbedaan kemampuan spasial siswa sebelum dan sesudah penggunaan media *pop-up book* berbantuan *augmented reality*. Peningkatan tersebut diperkuat oleh nilai N_{Gain} pada ketiga sekolah sebesar 0,56; 0,74; dan 0,66 yang menunjukkan peningkatan kemampuan spasial siswa berada pada kategori sedang hingga tinggi.

Kata Kunci: *Pop-Up Book, Augmented Reality, Bangun Ruang Sisi Lengkung, Kemampuan Spasial*

**DEVELOPMENT OF AN AUGMENTED REALITY-ENHANCED POP-UP
BOOK TO IMPROVE THE SPATIAL SKILLS OF MIDDLE SCHOOL
STUDENTS**

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ABSTRACT

Augmented reality-enhanced pop-up books are three-dimensional printed books combined with interactive visual elements. This medium was developed to support mathematics learning, particularly regarding curved-sided three-dimensional shapes, and to enhance spatial skills. The development process followed the Plomp model, which consists of five stages: preliminary investigation, design, realization/construction, test, evaluation and revision, and implementation. The medium integrates three-dimensional visualization in the pop-up book with a marker-based tracking augmented reality application developed using Blender, Unity 3D, and the Vuforia Engine. The research subjects were middle school student. The media's key feature lies in the integration of three-dimensional visualization with AR, enabling students to observe, rotate, and explore geometric objects interactively. This helps students construct their understanding and visualize three-dimensional shapes from various perspectives. The validity test results showed an average material validity score of 4.80 and an average media validity score of 4.78, both falling into the highly valid category. Based on the results of the study at three schools with different characteristics, the media's practicality level falls into the practical to highly practical category, with teacher response questionnaire scores ranging from 4.00 to 4.90 and student response questionnaire scores ranging from 4.30 to 4.77. Then, the results of the effectiveness test using a paired t-test across all schools yielded a p-value of < 0.001 , indicating a significant difference in students' spatial abilities before and after the use of augmented reality-assisted pop-up books. This improvement was reinforced by the N_Gain values, which were 0.56, 0.74, and 0.66, indicating that the improvement in students' spatial abilities fell into the moderate to high categories.

Kata Kunci: *Pop-Up Book, Augmented Reality, Curved-Sided Shapes, Spatial Ability*