



## INTISARI

**Latar Belakang:** Pembelajaran anatomi jantung secara konvensional masih sangat bergantung pada preparat kadaver. Namun, keterbatasan jumlah kadaver, degradasi jaringan akibat proses fiksasi, serta kesulitan visualisasi struktur interna jantung sering menjadi kendala dalam pembelajaran. Jantung memiliki orientasi spasial tiga dimensi yang kompleks, terutama pada struktur internalnya, sehingga dapat meningkatkan beban kognitif mahasiswa preklinik. Teknologi *three-dimensional (3D) printing* berpotensi menjadi media pembelajaran alternatif dan pelengkap, namun bukti mengenai validitas anatomi, efektivitas pembelajaran, serta urutan penggunaan yang optimal dengan kadaver masih terbatas.

**Tujuan Penelitian:** Menilai validitas dan kelayakan model 3D printing cor sebagai media pembelajaran anatomi jantung, mengevaluasi efektivitasnya dalam meningkatkan hasil belajar mahasiswa, serta menentukan urutan penggunaan media yang paling optimal antara model 3D printing cor dan preparat kadaver.

**Metode:** Penelitian ini merupakan penelitian dan pengembangan (*research and development*) yang dilakukan dalam dua tahap. Tahap pertama adalah uji validitas dan kelayakan model 3D printing cor berbasis *fused deposition modeling* (FDM) oleh enam pakar anatomi menggunakan lembar penilaian terstruktur dan dianalisis dengan indeks Aiken's V serta kategori kelayakan. Tahap kedua adalah uji efektivitas menggunakan desain kuasi-eksperimental *pretest-posttest crossover* pada 42 mahasiswa semester I dari dua fakultas kedokteran. Kelompok A menggunakan model 3D terlebih dahulu sebelum pembelajaran kadaver (3D–kadaver), sedangkan Kelompok B menggunakan kadaver terlebih dahulu sebelum model 3D (kadaver–3D). Pemahaman anatomi diukur melalui pretest, posttest I, dan posttest II. Analisis hasil belajar meliputi skor tes, selisih skor (delta), tingkat kelulusan, serta data kualitatif dari *focus group discussion*.

**Hasil Penelitian:** Model 3D printing cor menunjukkan validitas isi tinggi (Aiken's V 0,78–0,94; rerata 0,89) dengan tingkat kelayakan sangat baik (91,67%), terutama pada struktur eksterna dan struktur interna mayor jantung. Beberapa detail struktur atrium menunjukkan validitas rendah dan tidak dilibatkan dalam uji efektivitas. Tidak terdapat perbedaan bermakna skor pretest antar kelompok ( $>0,05$ ). Pada evaluasi akhir, Kelompok A menunjukkan skor posttest II lebih tinggi dibandingkan Kelompok B ( $70,24 \pm 15,29$  vs  $50,00 \pm 24,85$ ;  $p=0,003$ ), peningkatan skor yang lebih besar ( $p=0,007$ ), serta tingkat kelulusan lebih tinggi (76,2% vs 33,3%;  $p=0,012$ ). Temuan kualitatif menunjukkan peningkatan orientasi spasial, penurunan beban kognitif, dan peningkatan kepercayaan diri mahasiswa.

**Kesimpulan:** Model 3D printing cor merupakan media pembelajaran anatomi jantung yang valid, layak, dan efektif. Penggunaan model 3D sebagai media awal sebelum pembelajaran berbasis kadaver direkomendasikan dalam pembelajaran anatomi multimodal.

**Kata Kunci:** *3D printing*, anatomi jantung, pembelajaran anatomi, kadaver, pembelajaran multimodal



## ABSTRACT

**Background:** Conventional cardiac anatomy education still relies heavily on cadaveric specimens. However, limited cadaver availability, tissue degradation due to fixation processes, and difficulties in visualizing internal cardiac structures often hinder the learning process. The heart has a complex three-dimensional spatial orientation, particularly in its internal structures, which may increase cognitive load among preclinical medical students. Three-dimensional (3D) printing technology has the potential to serve as an alternative and complementary learning medium; nevertheless, evidence regarding its anatomical validity, educational effectiveness, and optimal sequence of use in combination with cadaver-based learning remains limited.

**Objectives:** To assess the validity and feasibility of a 3D-printed cardiac model as a learning medium for cardiac anatomy, to evaluate its effectiveness in improving student learning outcomes, and to determine the most optimal sequence of media use between the 3D-printed cardiac model and cadaveric specimens.

**Methods:** This study employed a research and development design conducted in two stages. The first stage involved validity and feasibility testing of a fused deposition modeling (FDM)-based 3D-printed cardiac model by six anatomy experts using structured assessment forms, analyzed using Aiken's *V* index and feasibility categories. The second stage was an effectiveness study using a quasi-experimental pretest–posttest crossover design involving 42 first-semester students from two medical faculties. Group A used the 3D model before cadaver-based learning (3D–cadaver), whereas Group B used cadaveric specimens before the 3D model (cadaver–3D). Cardiac anatomy understanding was assessed using pretest, posttest I, and posttest II. Learning outcomes were analyzed using test scores, score differences (*delta*), pass rates, and qualitative data from focus group discussions.

**Results:** The 3D-printed cardiac model demonstrated high content validity (Aiken's *V* 0.78–0.94; mean 0.89) and excellent feasibility (91.67%), particularly for external structures and major internal cardiac structures. Several atrial details showed low validity and were excluded from the effectiveness phase. There were no significant differences in pretest scores between groups ( $p > 0.05$ ). At the final evaluation, Group A achieved significantly higher posttest II scores than Group B ( $70.24 \pm 15.29$  vs  $50.00 \pm 24.85$ ;  $p = 0.003$ ), greater score improvement ( $p = 0.007$ ), and higher pass rates (76.2% vs 33.3%;  $p = 0.012$ ). Qualitative findings indicated improved spatial orientation, reduced cognitive load, and increased student confidence.

**Conclusion:** The 3D-printed cardiac model is a valid, feasible, and effective learning medium for cardiac anatomy. Using the 3D model as an introductory learning tool before cadaver-based sessions is recommended to enhance learning outcomes within a multimodal anatomy education approach.

**Keywords:** 3D printing, cardiac anatomy, anatomy education, cadaver, multimodal learning