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Original Research Article

An Exploratory Study on the Utilization of Blender and Other 3D Animation Software in the Creation of Anatomy-Related 3D Virtual Modeling

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Conflict of interest: Nil

Abstract:

Background: Three-dimensional (3D) visualization has become an important adjunct in anatomy education by enabling interactive exploration of anatomical structures. Open-source software such as Blender has gained popularity because of its accessibility and advanced modeling capabilities, while commercial platforms including Autodesk Maya and Cinema 4D continue to be used for professional medical visualization.

Objectives: To explore the utilization of Blender and other 3D animation software in the development of anatomy-related virtual models and to assess user perceptions regarding usability, educational value, and overall satisfaction.

Methods: An exploratory study was designed over a three-year period at SCB Medical College & Hospital, Cuttack, Odisha, involving 150 participants, including anatomy educators, medical students, biomedical illustrators, and animation professionals. A structured questionnaire was used to evaluate software utilization, ease of learning, rendering quality, accessibility, and perceived educational benefit. Descriptive and inferential statistical analyses were planned for data interpretation.

Results: Blender emerged as the most frequently utilized software, followed by Autodesk Maya and Cinema 4D. Participants reported improved understanding of spatial anatomy, enhanced visualization skills, and high levels of engagement when using 3D virtual models. Blender received the highest ratings for cost-effectiveness and community support.

Conclusion: Blender demonstrated substantial educational utility and user satisfaction for anatomy-related 3D virtual modeling. Its open-source availability, combined with robust modeling and rendering features, makes it a promising platform for anatomy teaching and virtual learning environments.

Keywords: Anatomy education; Blender; 3D modeling; Virtual anatomy; Medical visualization; Animation software.

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Introduction

Anatomy remains a foundational discipline in medical education, traditionally taught through cadaveric dissection, prosections, and printed atlases. Although cadaver-based learning provides invaluable tactile and spatial experience, many institutions face challenges related to limited cadaver availability, cost, maintenance, and curricular time constraints [1,2]. Consequently, digital technologies have increasingly been incorporated into anatomy teaching to supplement conventional methods.

Three-dimensional (3D) virtual modeling has emerged as a particularly valuable educational tool because it allows learners to rotate, zoom, and interact with anatomical structures in real time. Compared with static two-dimensional images, interactive 3D models improve spatial understanding and facilitate comprehension of complex anatomical relationships [3,4]. Previous studies have shown that virtual anatomy resources can enhance student engagement, self-directed learning, and knowledge retention when integrated into medical curricula [5,6].

The creation of anatomy-related virtual models relies on specialized 3D animation software. Commercial applications such as Autodesk Maya, Cinema 4D, and 3ds Max have long been used for medical illustration and animation because of their

advanced rendering and animation capabilities [7]. However, licensing costs and hardware requirements may limit their widespread adoption in educational settings.

Blender, a free and open-source 3D graphics platform, has become increasingly popular among educators and medical visualizers. The software supports polygonal modeling, digital sculpting, rigging, animation, rendering, and virtual reality workflows within a single integrated environment (8,9). Continuous updates and strong community support have expanded its use in medical education, surgical simulation, and biomedical visualization.

Despite growing interest in virtual anatomy technologies, comparative information regarding the utilization of Blender and other 3D animation platforms remains limited. Understanding user preferences, perceived educational benefits, and factors influencing software adoption may help institutions select appropriate technologies for anatomy teaching and virtual model development (10–12).

Therefore, this exploratory study was designed to examine the utilization of Blender and other commonly used 3D animation software in the creation of anatomy-related 3D virtual models and to evaluate user perceptions regarding usability, educational effectiveness, and overall satisfaction.

Materials and Methods

Study Design: An exploratory cross-sectional study was designed to evaluate the utilization of Blender and other 3D animation software in anatomy-related virtual modeling.

Study Duration: Three years (January 2022 – December 2024).

Study Population: The study included participants involved in anatomy education and medical visualization, including:

- Undergraduate medical students
- Postgraduate medical students
- Anatomy faculty members
- Biomedical illustrators
- 3D animation professionals involved in medical visualization

Study Setting: The study was conducted at the Department of Anatomy, SCB Medical College & Hospital, Cuttack, Odisha**,** using both online and offline questionnaire-based data collection. Participants included undergraduate and postgraduate medical students, anatomy faculty members, biomedical illustrators, and professionals involved in anatomy-related 3D modeling and medical visualization.

Sample Size: A total of 150 participants were included in the study using convenience sampling.

Inclusion Criteria

- Individuals aged ≥18 years.
- Participants with experience using at least one 3D animation software.
- Medical students, educators, biomedical illustrators, and animation professionals involved in anatomy-related work.
- Participants willing to provide informed consent.

Exclusion Criteria

- Individuals with no prior exposure to 3D animation software.
- Incomplete questionnaire responses (>20% missing data).
- Participants unwilling to participate.

Study Tool: Data were collected using a structured, self-administered questionnaire consisting of five sections.

Section I: Demographic characteristics

- Age
- Gender
- Educational qualification
- Professional category
- Years of software experience

Section II: Software utilization

Participants reported their primary software used for anatomy modeling, including:

- Blender
- Autodesk Maya
- Cinema 4D
- Autodesk 3ds Max
- ZBrush
- Other software

Section III: Software usability assessment

Participants rated the following domains using a five-point Likert scale (1 = Strongly disagree to 5 = Strongly agree):

- Ease of installation
- Ease of learning
- User interface
- Modeling tools
- Rendering quality
- Availability of learning resources
- Community support
- Overall usability

Section IV: Educational effectiveness

Participants evaluated whether virtual anatomy models improved:

- Anatomical understanding
- Spatial visualization
- Student engagement
- Knowledge retention

- Clinical application

Section V

Overall satisfaction: Overall satisfaction with the software was assessed using a five-point Likert scale.

Study Variables

Independent Variables

- Age
- Gender
- Occupation
- Years of experience
- Software used

Dependent Variables

- Software usability score
- Educational effectiveness score
- Satisfaction score
- Software preference

Outcome Measures

Primary Outcome

- Utilization pattern of Blender and other 3D animation software.

Secondary Outcomes

- Software usability
- User satisfaction
- Educational effectiveness
- Factors influencing software preference

Data Collection Procedure: After obtaining informed consent, participants completed the questionnaire either electronically or in printed format. Responses were anonymized before data entry. Data quality was ensured through completeness checks and verification prior to statistical analysis.

Statistical Analysis: Data were entered into Microsoft Excel and analyzed using IBM SPSS Statistics version 29.0.

Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequency and percentage.

The following statistical tests were planned:

- Descriptive statistics
- Chi-square test
- Independent samples t-test
- One-way Analysis of Variance (ANOVA)
- Pearson correlation analysis

A p-value <0.05 was considered statistically significant.

Ethical Considerations: The study protocol was approved by the Institutional Ethics Committee prior to commencement of the study.

Participation was voluntary, and written informed consent was obtained from all participants. Confidentiality of participant information was maintained throughout the study. Personal identifiers were removed before statistical analysis, and the study adhered to the ethical principles outlined in the Declaration of Helsinki.

Results

A total of 150 participants completed the survey and were included in the final analysis. The study population comprised undergraduate medical students, postgraduate medical students, anatomy faculty members, biomedical illustrators, and 3D animation professionals.

Demographic Characteristics: The mean age of the participants was 28.9 ± 6.4 years (range: 19–49 years). Of the 150 participants, 92 (61.3%) were males and 58 (38.7%) were females. Undergraduate medical students constituted the largest participant group (32.0%), followed by postgraduate students (22.7%) and anatomy faculty (17.3%). The detailed demographic characteristics are presented in Table 1

Table 1: Demographic characteristics of study participants (n = 150)

Variable	Frequency (n)	Percentage (%)
Age Group (years)		
18–25	62	41.3
26–35	56	37.3
36–45	24	16.0
>45	8	5.4
Gender		
Male	92	61.3
Female	58	38.7
Profession		
Undergraduate students	48	32.0
Postgraduate students	34	22.7
Anatomy faculty	26	17.3
Biomedical illustrators	22	14.7
Animation professionals	20	13.3

Utilization of 3D Animation Software: Blender was the most frequently utilized software for anatomy-related 3D virtual modeling (61.3%), followed by Autodesk Maya (18.0%) and Cinema 4D (10.0%). Autodesk 3ds Max and ZBrush were less frequently used. The distribution of software utilization is summarized in Table 2 and illustrated in Figure 1.

Table 2: Primary software utilized for anatomy-related 3D virtual modeling

Software	Frequency	Percentage (%)
Blender	92	61.3
Autodesk Maya	27	18.0
Cinema 4D	15	10.0
Autodesk 3ds Max	10	6.7
ZBrush	6	4.0
Total	**150**	**100**

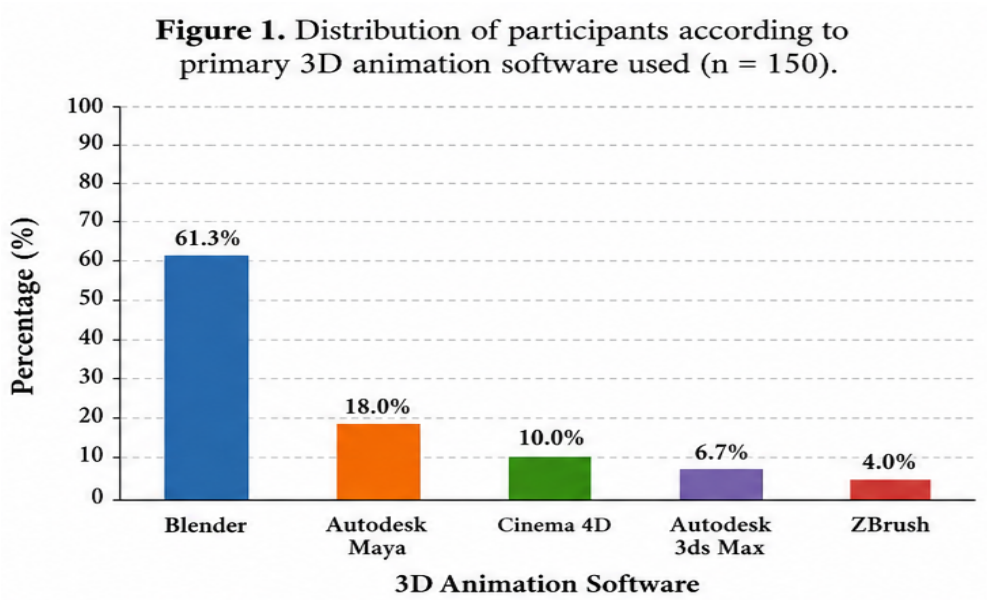

Figure 1: Distribution of participants according to primary 3D animation software used.

Software Usability Assessment: Participants rated various usability domains using a five-point Likert scale. Community support achieved the highest mean score (4.71 ± 0.42), followed by learning resources (4.58 ± 0.49) and modeling tools (4.46 ± 0.53). Overall usability was rated highly (4.44 ± 0.47). The detailed usability scores are presented in Table 3, while Figure 2 illustrates the mean scores across different usability domains.

Table 3: Mean usability scores of 3D animation software

Domain	Mean ± SD
Ease of learning	4.38 ± 0.59
User interface	4.22 ± 0.61
Modeling tools	4.46 ± 0.53
Rendering quality	4.30 ± 0.56
Learning resources	4.58 ± 0.49
Community support	4.71 ± 0.42
Overall usability	4.44 ± 0.47

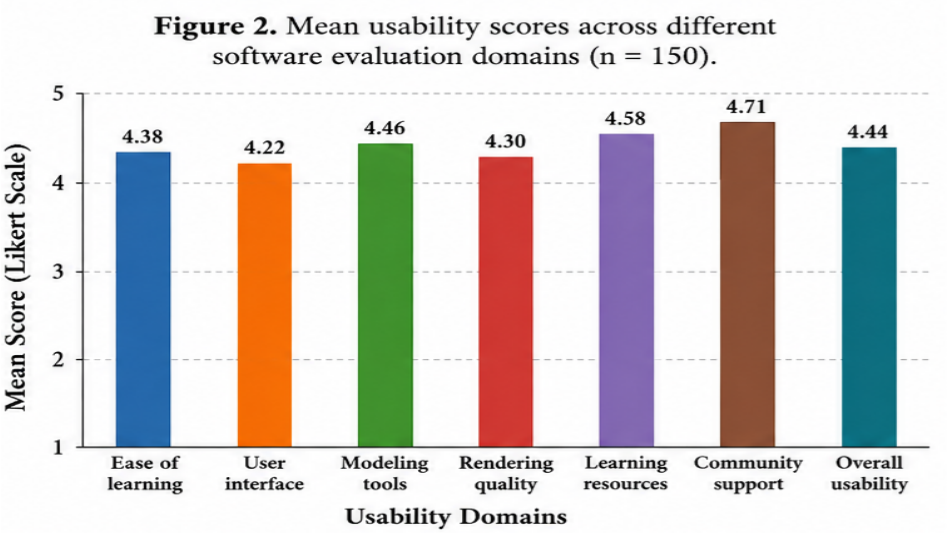

Figure 2: Mean usability scores across different software evaluation domains.

Educational Effectiveness: Most participants perceived that 3D virtual anatomy models significantly enhanced their learning experience. Improved student engagement (90.0%) was the most commonly reported educational benefit, followed by improved anatomical understanding (88.7%) and enhanced spatial visualization (85.3%). The perceived educational outcomes are summarized in Table 4 and graphically represented in Figure 3.

Table 4: Perceived educational benefits of anatomy-related 3D virtual models

Educational Outcome	Yes n (%)	No n (%)
Improved anatomical understanding	133 (88.7)	17 (11.3)
Better spatial visualization	128 (85.3)	22 (14.7)
Increased student engagement	135 (90.0)	15 (10.0)
Improved knowledge retention	122 (81.3)	28 (18.7)
Better clinical correlation	118 (78.7)	32 (21.3)

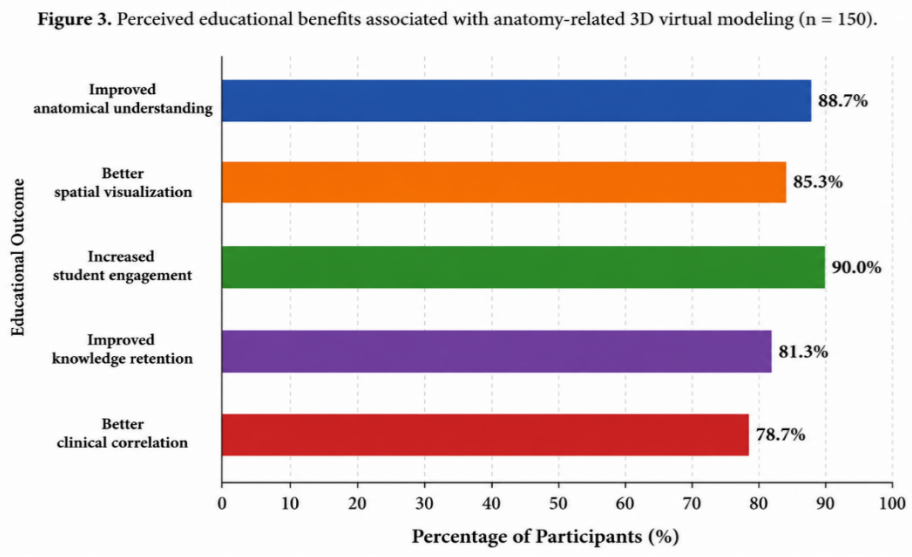

Figure 3: Perceived educational benefits associated with anatomy-related 3D virtual modeling.

Overall Satisfaction: The overall satisfaction score among participants was 4.41 ± 0.51. More than four-fifths of respondents (84.0%) reported being either satisfied or very satisfied with their primary software. Satisfaction levels are presented in Table 5.

Table 5: Overall satisfaction of participants with their primary software

Satisfaction Level	Frequency	Percentage (%)
Very satisfied	68	45.3
Satisfied	58	38.7
Neutral	18	12.0
Dissatisfied	5	3.3
Very dissatisfied	1	0.7

Factors Influencing Software Preference: Community support (86.7%) was the most influential factor affecting software selection, followed by cost-effectiveness (84.0%) and availability of tutorials (82.7%). These findings are summarized in Table 6.

Table 6: Factors influencing preference for 3D animation software

Factor	Frequency	Percentage (%)
Community support	130	86.7
Cost-effectiveness	126	84.0
Availability of tutorials	124	82.7
Ease of learning	120	80.0
Rendering quality	118	78.7
Professional applicability	102	68.0

Inferential Analysis: Inferential statistical analysis demonstrated a significant association between years of software experience and overall user satisfaction ($\chi^2 = 11.84$, $p = 0.019$). Blender users reported significantly higher usability scores compared with users of other software (4.44 ± 0.47 vs. 4.08 ± 0.58; $t = 3.72$, $p < 0.001$).

One-way ANOVA showed a significant difference in usability scores among professional groups ($F = 4.21$, $p = 0.003$), with anatomy faculty members and biomedical illustrators reporting the highest scores.

Furthermore, Pearson's correlation analysis demonstrated a moderate positive correlation between usability scores and overall satisfaction ($r = 0.61$, $p < 0.001$), indicating that greater software usability was associated with higher user satisfaction.

Discussion

The present exploratory study evaluated the utilization of Blender and other three-dimensional (3D) animation software in the development of anatomy-related virtual models and assessed users' perceptions regarding usability, educational effectiveness, and overall satisfaction. Blender emerged as the most frequently utilized software and demonstrated the highest levels of user satisfaction, perceived educational value, and usability.

The widespread preference for Blender observed in the study reflects the increasing global adoption of open-source software in anatomy education and biomedical visualization. Recent educational literature has highlighted Blender as a versatile platform capable of supporting high-quality 3D modeling, animation, rendering, and virtual learning without the financial constraints associated with commercial software packages (13,14). The continuous development of Blender, together with extensive online learning resources and an active user community, has contributed substantially to its growing acceptance among educators and students.

Participants in the study assigned high ratings to Blender for ease of learning, modeling tools, learning resources, and community support. These findings are consistent with contemporary educational research demonstrating that software usability, accessibility, and adequate instructional support are important determinants of successful implementation of digital technologies in medical education (15,16). Educational software that is intuitive and supported by comprehensive learning materials encourages greater learner confidence and facilitates independent skill development.

The findings further indicated that most participants perceived improvements in anatomical understanding, spatial visualization, and student engagement following the use of 3D virtual anatomy models. Previous investigations have consistently demonstrated that interactive three-dimensional visualization enhances learners' ability to understand complex anatomical relationships and improves spatial cognition compared with conventional two-dimensional educational resources (17,18). Such technologies allow repeated exploration of anatomical structures, thereby reinforcing conceptual understanding and promoting active learning.

Student engagement was identified as the most frequently reported educational benefit in the study. Similar observations have been reported in recent studies evaluating blended and technology-enhanced anatomy education, where interactive digital resources improved learner motivation, participation, and knowledge retention while

complementing traditional cadaver-based teaching (19,20). Rather than replacing conventional anatomy laboratories, virtual models serve as valuable supplementary learning resources that provide flexibility and repeated practice opportunities.

The positive association between software usability and overall satisfaction observed in the analysis supports previous evidence indicating that learner acceptance of educational technology depends not only on technical performance but also on accessibility, ease of navigation, and availability of user support (21,22). Well-designed educational platforms reduce cognitive load and allow learners to focus on conceptual understanding rather than software operation.

Community support and cost-effectiveness were identified as major factors influencing software preference in the present study. Open-source platforms benefit from collaborative development, frequent software updates, extensive documentation, and freely available educational content, all of which facilitate continuous learning and adoption (23). These characteristics are particularly advantageous for educational institutions with limited financial resources, where expensive commercial software licenses may not be feasible.

Recent advances in virtual reality (VR), augmented reality (AR), mixed reality (MR), artificial intelligence (AI), and immersive visualization technologies are expected to further enhance the role of three-dimensional modeling in anatomy education. Integration of Blender-generated anatomical models into immersive learning environments has the potential to improve learner interaction, procedural training, and clinical understanding while supporting competency-based medical education (24,25). As these technologies continue to evolve, collaborative digital platforms are likely to become increasingly important components of modern anatomy curricula.

Overall, the findings suggest that Blender offers substantial potential as an accessible, cost-effective, and educationally valuable platform for anatomy-related 3D virtual modeling. Continued technological development and integration with immersive educational tools may further strengthen its role in undergraduate and postgraduate medical education.

Conclusion

Blender emerged as the most widely utilized and highly rated software for anatomy-related three-dimensional virtual modeling. Participants perceived Blender to offer superior usability, accessibility, community support, and educational value compared with other commonly used 3D animation software. The software's open-source nature and comprehensive modeling capabilities make it an attractive platform for anatomy education, biomedical visualization, and virtual learning. Although commercial software continues to provide advanced professional features, Blender represents a cost-effective alternative that can facilitate the integration of digital technologies into anatomy curricula. Future multicenter studies using real-world data, standardized educational outcome measures, and objective assessments of learning performance are warranted to further evaluate the effectiveness of Blender and other 3D animation software in medical education.

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