# EXPLORING OPEN-SOURCE BLENDER'S IMPACT ON ADVANCING ACCESSIBLE AND INCLUSIVE EDUCATION IN DIGITAL CONTENT CREATION

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**Digital content creation skills are increasingly crucial in the modern workforce, yet commercial software costs and technical barriers limit educational access. This paper explores how integrating Blender, a free and open-source 3D creation suite, into educational workflows can help address these challenges. Blender provides cost-effective access to industry-relevant tools, making it a powerful platform for inclusive learning. The study investigates its potential to promote accessible, inclusive education in digital content creation. These objectives align with global sustainable development initiatives for quality education and digital inclusion while also supporting industry-relevant competencies needed in an evolving digital landscape. This study adopts a qualitative case study methodology, examining four scenarios: three final-year student projects, and a situation from the Animation, Games and Visual Effects course at Nanyang Polytechnic in Singapore where a raise in costs of commercial software impacted the learning experience of students. The student projects comprise a high-end animation for Suntec Convention Centre, the collaborative short film 'Spark' and selected high-performing projects from the Independent Work Project module. For these, the research draws on project documentation, students feedback, and production analysis as primary data sources. It combines descriptive analysis of feedback with technical workflow analysis to evaluate Blender's influence on accessibility, production efficiency, and skill development. Blender's open-source framework eliminates licensing costs, ensuring equitable access to cutting-edge tools for learners and educators across diverse socioeconomic contexts. The availability of extensive free online tutorials, community support, and open educational resources fosters independent learning and interdisciplinary collaboration. Blender's real-time rendering engine, EEVEE, significantly enhances educational experiences by providing immediate visual feedback. These features align with global educational frameworks promoting accessibility, digital literacy, and industry-relevant competencies. Blender exemplifies an inclusive approach to engineering education, bridging technical proficiency with global competencies. It enables students to address real-world challenges in the digital media industry, preparing them to navigate the complexities of a technology-driven global economy. Educational institutions should prioritize integrating open-source tools like Blender to foster pedagogical innovation, promote equitable access, and cultivate the transformative competencies necessary for the future workforce. This approach ensures education systems remain inclusive and responsive to evolving industry demands.**

***Keywords:*** *Inclusive Education, Blender (3D Software), Digital Content Creation, Sustainable Development Goals, Open-Source Tools.*

## Introduction

Digital content creation has become a cornerstone of modern professional competencies, transforming from a specialised skill to an essential requirement across numerous industries (National Skills Coalition, 2023). The increasing integration of digital technologies across various industries has significantly heightened the demand for professionals skilled in 3D modelling, animation, and visual effects. This surge is evident in the rapid growth of the 3D animation market, which was valued at $22.67 billion in 2023 and is projected to expand at a compound annual growth rate (CAGR) of 12.3% through 2030 (Grand View Research, 2024). However, this growing demand presents a significant challenge in educational contexts, where access to industry-standard tools often remains limited by prohibitive licensing costs and technical barriers (UNESCO, 2023; Schmitz, 2020).

This financial hurdle not only affects institutional capabilities but also impacts students' ability to practice and develop skills beyond classroom hours, potentially widening the digital divide and creating inequitable learning opportunities (Outreach International, 2024).

Blender, a free and open-source 3D creation suite, emerges as a compelling solution to these challenges. Unlike its commercial counterparts, Blender offers comprehensive functionality for 3D creation, animation, rendering, video editing, and game development without licensing fees (Blender Foundation, n.d.). This accessibility aligns directly with the United Nations'

Sustainable Development Goal 4, which emphasises ensuring inclusive and equitable quality education and promoting lifelong learning opportunities for all (United Nations, 2022).

The significance of exploring Blender's educational potential extends beyond mere cost considerations. As Industry 4.0 reshapes workplace requirements, educational institutions must adapt their approaches to develop students' technical proficiency while fostering critical thinking, creativity, and collaborative skills. These align with the OECD Learning Compass 2030's transformative competencies (OECD, 2019) and Industry 4.0's key components of agility and adaptability (World Economic Forum, 2019). This research investigates how Blender's integration into educational workflows can address these multifaceted demands.

This study specifically examined four distinct scenarios within Singapore's educational context at Nanyang Polytechnic, School of Design and Media: two final-year student projects, a high-end animation for Suntec Convention Centre and the collaborative short film 'Spark', selected high-performing Independent Work Projects (IWP) where students independently chose to implement Blender, and a broader case study of the Animation, Games and Visual Effects course's adaptation to software cost challenges. Through these cases, we explore how open-source tools can enhance educational accessibility while maintaining industry-relevant standards and examine the implications of different software adoption approaches in educational settings, from structured commercial projects to self-directed creative works.

The research aims to address one key question: how does Blender's open-source implementation advance accessible and inclusive education in digital content creation?

By examining this question, this study contributes to the broader discourse on educational technology and inclusive learning, offering insights for institutions seeking to balance educational quality with accessibility in an increasingly digital world.

## Materials and Methods

This study employed a qualitative case study methodology examining four distinct scenarios at Nanyang Polytechnic, School of Design and Media. The research investigated Blender's effectiveness in educational digital content creation, focusing on accessibility, technical capability, and skill development, while providing insights into the impact of software accessibility in educational settings.

Data collection encompassed multiple sources across these four scenarios. Primary data included feedback forms completed by 17 respondents who implemented Blender: a team leader from the Suntec Convention Centre project, four team members from the 'Spark' collaborative film, and 12 students from Independent Work Projects. The forms comprised open-ended questions covering technical implementation, workflow, and output assessment. Comparative data came from the Digital Sculpting unit Learning Unit Report, which captured feedback from 74 students affected by commercial software access limitations. Technical documentation included Discord server archives tracking render logs and iteration cycles across all implementation projects

The Suntec Convention Centre client project, running for 12 weeks from 29 May 2023, involved a six-member final-year team creating a 2 minutes Deepavali-themed animation for The Big Picture, the world's largest high-definition LED video wall. This project was one of four annual animation productions typically created for Suntec using commercial software. Under their team leader's decision to implement Blender as the main lighting and rendering software, the team used EEVEE real-time rendering engine to help produce 10K resolution outputs. Data collection included feedback form and Discord server archives containing render logs and iteration cycles.

The 'Spark' Collaborative Short Film project spanned three 12-week phases with different final-year teams, beginning 27 May 2024. Originally planned for two teams over 24 weeks, the project required a third team when the second team's output did not meet the targeted quality. The first and third teams implemented Blender as the main 3D application, while the second team used commercial software. The two-minute animation was submitted to two film festivals: Tiny Mountains Film Festival (Australia) and Voronezh International Animation Film Festival (Russia). Data collection included team feedback forms, festival selection documentation, and Discord server archives containing render logs and iteration cycles.

The Independent Work Project (IWP) was a self-directed third-year module where each cohort worked for 15 weeks. The module allowed students to conceptualize and execute projects of their own choice, working individually or in pairs. Each project was scoped for approximately 150 hours of work, representing a significant milestone where students demonstrated mastery of skills developed over their previous two years through independent project management and creative decision-making. From these cohorts, twelve high-performing students who independently chose to implement Blender as their primary tool were selected for this study, with academic achievements ranging from 75 to 95 out of 100. Their self-initiated projects encompassed diverse applications including mixed media animation, character modelling, commercial visualization, and 2D/3D hybrid works. Data collection included project documentation, feedback forms, and Discord server archives containing technical discussions.

The Digital Sculpting unit within the Diploma in Animation, Games and Visual Effects faced a sudden price increase for its primary commercial software student licenses, from approximately 20 to 100 SGD per student, just weeks before the semester's start in mid-April 2024. Due to the time-consuming nature of institutional purchase procedures and budget approval processes, new licenses could not be acquired at such short notice. With individual student licenses and laptop installations no longer feasible, and a proposal to adopt Blender as alternative software rejected, the unit

implemented existing legacy software licenses restricted to shared school laboratory facilities. This arrangement involved 81 students. Data collection consisted of the Learning Unit Report, which documented personal pen tablet compatibility issues across facilities and instances of private license purchase by some of the students, highlighting the impact of limited facility access hours on student work completion.

The study employed descriptive analysis to examine feedback data through two distinct analytical lenses. The first focused on documenting implementation experiences with open-source software in two animation projects and the IWP module, examining response frequencies and thematic patterns in learning resource utilization, technical performance feedback, and workflow adaptation. The second analysed the Digital Sculpting unit as a case study, examining how commercial software licensing changes impacted the learning experience, through documented student feedback. Areas of focus included facility access limitations, technical constraints, and resource availability challenges. Data processing involved extracting direct quotes from feedback forms, Learning Unit Report responses, and Discord archives, with responses grouped and categorized to clarify both successful open-source implementation patterns and the vulnerabilities of license-dependent educational systems.

## Results and Discussion

### Accessibility and Inclusivity

Both animation projects and IWP implementations demonstrated high accessibility, with all seventeen respondents specifically highlighting cost-free access. As shown in Figure 1, Accessibility & Inclusivity achieved 100% positive response, indicating unanimous recognition of Blender's accessible nature. "Blender's free and so are a lot of its plugins," noted one team member, while an IWP student emphasized the practical benefit: "easier to work with when switching between different workstations without having to deal with licensing issues." Another highlighted industry potential: "advocate everyone to use it and hope the industry moves closer to Blender."

Learning resource availability emerged as a critical factor across all projects. The community aspect particularly resonated, with one FYP member noting "having fresh daring views from casual artists really expanded my perspective," while IWP students highlighted diverse learning channels including "YouTube, Reddit, Instagram, Blender community." Several IWP students specifically mentioned the advantage of Blender's large user base for troubleshooting unique problems.

### Technical Performance and Production Efficiency

Technical performance data revealed strong satisfaction across both FYP and IWP projects. Figure 1 supports this finding with 82% positive response rate for Technical Performance and 76% for Production Efficiency. The Suntec project achieved 10K resolution outputs with 30-second render times, while IWP projects demonstrated diverse technical implementations from character modelling to commercial visualization. EEVEE's real-time rendering capabilities were particularly valued, with one FYP animator noting, "EEVEE made it a lot easier to visualise what was going on in the scene," while IWP students highlighted its benefits for "quick R&D to speed up my process and workflow."

Workflow advantages included comprehensive toolsets and efficient file sharing. Both FYP and IWP students praised the node system, with one IWP student noting it "felt more user friendly and less daunting." Project satisfaction ratings averaged 8/10 for FYP projects, while IWP projects consistently scored between 7-8/10, demonstrating consistent performance across different project scales.

### Skill Development

Learning curve data showed notably positive trends across both FYP and IWP implementations. Despite varying levels of prior experience (from none to basic knowledge), students demonstrated successful project completion across diverse applications. IWP students particularly noted the software's adaptability, with one stating "Being able to directly draw in the 3D space with Grease Pencil... gave a more hands-on experience in production making."

Learning resource utilization demonstrated consistent patterns, with all seventeen respondents actively engaging with online tutorials and communities. The self-directed nature of IWP projects particularly highlighted Blender's capacity to support independent learning, with students successfully navigating technical challenges through community resources and experimentation. As one IWP student noted, "Open-source software like Blender lowers the barrier of entry, allowing artists freedom to create and express their own styles."

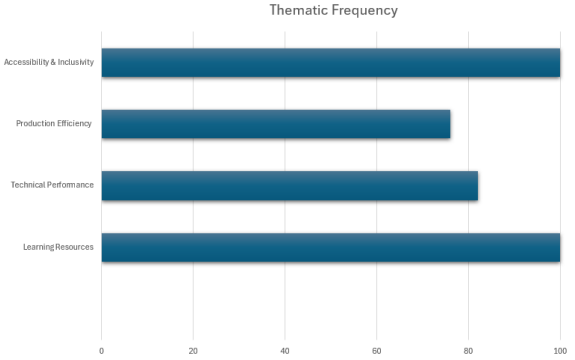


*Figure 1 Thematic Frequency Chart showing key implementation outcomes. Both Learning Resources and Accessibility & Inclusivity achieved 100% positive response, while Technical Performance (82%) and Production Efficiency (76%) also demonstrated strong positive results*

### Digital Sculpting Unit Software Access and Resource Considerations

The Digital Sculpting unit's Learning Unit Report (n=74, 92.50% response rate) revealed significant disruption following the license cost increase. Facility access limitations emerged as a primary concern, with students reporting restricted laboratory access and weekend attendance requirements. One student noted: "Make classrooms more readily available for Zbrush, I have to go to school in the weekends sometimes."

Technical constraints compounded these challenges, with tablet compatibility issues across facilities affecting work quality. Students reported driver update needs and inconsistent hardware performance, leading to additional time requirements for basic tasks. The situation particularly impacted those without personal licenses.

Resource access emerged as a significant factor, with fifteen students addressing availability concerns. Those relying on school facilities reported challenges, with one noting: "There is an unfair playing field in terms of resources. Those who bought Zbrush was allowed to spend less time in school." Time management became a critical issue, with students reporting diverted time from other modules and increased stress levels.

Study Limitations and Future Research Directions

While this research provides valuable insights into open-source software implementation in educational settings, a few considerations present opportunities for future expansion. The study's focus on Nanyang Polytechnic's implementations offers an understanding of effective practices, particularly through high-performing final year projects that demonstrated innovative applications of Blender. Additionally, the Digital Sculpting unit case involving 81 students provided insight into the vulnerabilities of commercial software dependency in educational settings, where a sudden license price increases revealed accessibility challenges. Building upon these findings, future research could benefit from multi-institutional studies, broader student sampling and the integration of quantitative metrics to complement the existing qualitative insights. These expansions would further strengthen the growing body of knowledge around open-source tools in digital content creation education.

## Conclusions

This study demonstrates how open-source software implementation in animation education supports broader educational and social objectives while meeting industry-standard technical requirements. Through examination of diverse project implementations, from high-end commercial work to independent student projects, several key conclusions emerge.

The elimination of licensing barriers through Blender's open-source framework has demonstrated tangible impacts on learning accessibility and educational equity. This becomes particularly significant considering the situation faced by the Animation, Games and Visual Effects course, where increased commercial software costs threatened to affect learning experiences. Students' ability to work seamlessly across different environments, coupled with access to extensive community resources, provides a sustainable choice while supporting continuous learning and skill development regardless of socioeconomic constraints. This aligns directly with SDG 4's objectives for inclusive and equitable quality education.

The development of transformative competencies, as outlined in the OECD Learning Compass 2030, is evidenced through students' demonstrated ability to solve complex technical challenges, collaborate across platforms, and adapt to evolving project requirements. The community-driven nature of open-source software appears to particularly enhance critical thinking and creative problem-solving capabilities.

Technical innovations, especially EEVEE's real-time rendering capabilities, have shown significant positive impact on learning experiences and workflow efficiency. This immediate visual feedback loop supports the development of agility and adaptability - crucial skills for Industry 4.0 readiness. The successful completion of professional-grade projects suggests that open-source implementation can effectively bridge educational and industry requirements while fostering these essential competencies.

These findings suggest that the integration of open-source software in animation education not only addresses immediate practical challenges but also contributes to broader educational objectives and future workforce preparation, while providing a sustainable solution to rising software costs in educational institutions.

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