VOLUME 4 NUMBER 3, NOVEMBER 2026
UNIVERSITAS AMIKOM YOGYAKARTA, INDONESIA
SWAGATI: Journal of Community Service
Journal homepage: https://jurnal.amikom.ac.id/index.php/swagati
P-ISSN 2986-7940 | E-ISSN 2986-7339

# Integrated Digital Workflow Training for Assistive Technology Development

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***Keywords:***
*Digital Fabrication,*
*Assistive Technology,*
*3D Scanning,*
*3D Printing,*
*Prosthetic Hand*

**ABSTRACT**

*People with disabilities continue to face barriers in accessing affordable and specialized assistive technologies. Digital fabrication offers a viable solution by combining three-dimensional (3D) scanning, digital modelling, and additive manufacturing into a single workflow. This community service program introduced an integrated digital workflow for assistive technology development, using prosthetic-hand fabrication as the application context. The training was held on 26–27 January 2026 at SMK TI Bali Global Badung, Bali, with 11 participants consisting of students, teachers, and school staff. Activities included workflow presentation, equipment demonstration, guided 3D scanning, scan visualization, mesh-quality discussion, and an introduction to CAD-based model preparation and 3D printing. Evaluation used an 11-item questionnaire on a 1–5 scale (Cronbach's α = 0.88) and two open-ended questions. The overall mean score was 4.12, with 87.6% of responses rated 4–5. Organizational aspects received the highest ratings, namely clarity of objectives (4.55), clarity of agenda (4.45), and instructor performance (4.36), whereas content, materials, resource persons, and activities were rated lowest (3.82–3.91). All participants reported being satisfied, and 8 of 11 (73%) reported gaining new knowledge, particularly on using 3D technology to help others, prosthetic-hand concepts, and 3D software. The program was well received and points to the need for deeper CAD practice, structured competency assessment, prototype verification, and user-centred validation in future activities.*

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https://doi.org/10.24076/swagati.2026v4i3.3015

## 1. Introduction

Access to appropriate assistive products affects how persons with disabilities participate in education, work, family life, and the wider community. The World Health Organization reports that about 1.3 billion people live with significant disability, while the WHO-UNICEF Global Report on Assistive Technology documents a persistent difference between the number of people who need assistive products and those who can obtain them [1], [2]. For people with upper-limb loss or functional limitation, a prosthesis may support everyday activity and social participation, but the value of the device depends on more than its manufacture. WHO standards place equal emphasis on service quality, competent personnel, appropriate product selection, and a user-centred process [3]. These considerations become especially important when low-cost fabrication methods are introduced in educational or community-based programs.

Digital fabrication offers one route for developing prosthetic components that can be adapted to individual requirements with shorter design-and-production cycles. Reviews of open-source and 3D-printed upper-limb prostheses describe potential advantages in affordability and iterative customization, while also noting unresolved issues involving standardization, durability, and clinical validation [4]–[7]. For this reason, 3D printing should not be treated as

a stand-alone solution. A usable prosthetic-development process begins with data capture, continues through mesh processing and computer-aided design (CAD), and only then moves to fabrication and evaluation. Work in Indonesia has followed this sequence. Kuswanto et al. combined measurement, 3D scanning, digital modelling, and 3D printing in a customizable upper-limb prosthesis workflow [8]. Subsequent collaborations by Kuswanto and Triandini have explored locally adaptable, lower-cost prosthetic development through circular-economy concepts and an affordable bionic-arm design [9], [10].

Within such a workflow, the quality of the digital model is established early. Three-dimensional scanning converts a physical surface into geometry that can be viewed, measured, corrected, and prepared for later design operations. A review of personalized prosthetic manufacturing identifies surface scanning as an increasingly practical option for capturing anatomy for patient-specific design [11]. The resulting model, however, is sensitive to the scanner used, the visibility of the surface, object or body positioning, movement during acquisition, and the way the data are processed. Comparative studies of residual-limb and hand scanning show that both acquisition technique and geometry processing influence completeness and dimensional accuracy [12], [13]. A study of personalized prosthetic liners in Indonesia similarly used 3D scanning before fused deposition modelling, demonstrating how the quality of captured geometry influences later fit-oriented fabrication [14]. Participants therefore need to understand scanning errors before they progress to CAD modelling or prototype production.

These technical dependencies also make digital fabrication suitable for practice-based learning. When learners can move from a digital model to a physical output, abstract design concepts become easier to connect with concrete fabrication decisions [15]. Studies of digital fabrication environments have reported improved self-perceived capability in modelling, prototyping, and machine operation after hands-on experience [16]. In Indonesian vocational teacher education, structured modules and collaboration between institutions have likewise been used to integrate 3D modelling and printing into applied learning [17]. For assistive-technology projects, however, technical competence is only one part of the process. Prosthetics research that adopts a user-centred approach stresses continued involvement of users and community stakeholders so that development is not confined to laboratory priorities [18].

Against this background, the Appropriate Technology program of Institut Teknologi dan Bisnis STIKOM Bali organized a community service activity on an integrated digital workflow for assistive-technology development. Prosthetic-hand development was used as the application case. The program took place on 26-27 January 2026 at SMK TI Bali Global Badung, Bali, with 11 participants. The learning sequence followed the path from 3D scanning and mesh inspection to CAD concepts and 3D printing, allowing participants to see how a physical object becomes editable digital geometry and, eventually, a manufacturable prototype. The activity had three practical objectives: to clarify the relationship among the stages of the workflow, to provide guided experience with 3D data acquisition, and to establish a basis for further collaborative development of assistive-technology prototypes.

## 2. Method

### 2.1. Activity design and participants

The activity was delivered over two days, 26–27 January 2026, at SMK TI Bali Global Badung, Bali. Eleven participants took part: six students, three teachers (including one vocational subject teacher), one administrative staff member, and one participant from the animation field. This composition brought together learners and educators with different levels of exposure to 3D technology. The program combined short technical explanations, equipment demonstrations, and guided practice so that concepts introduced by the facilitators could be examined immediately through observation and direct use of digital-fabrication tools. It was intended as introductory capacity building for assistive-technology development and was not designed as a clinical prosthetic service.

Program delivery relied on collaboration among Institut Teknologi dan Bisnis STIKOM Bali, SMK TI Bali Global Badung, the Denpasar City Disability Service Center, and resource persons from the Health Technology Laboratory, Faculty of Medicine and Health, Institut Teknologi Sepuluh Nopember. Each partner contributed a different perspective, spanning vocational learning, information technology, engineering, health technology, and community needs. The activity did not include prosthetic prescription, fitting, or delivery to a person with limb loss. Its scope remained educational and prototype-oriented, maintaining a clear distinction between early technical development and clinically validated prosthetic provision [3], [5].

### 2.2. Training stages and equipment

The program was organized into four linked phases: preparation, presentation of the workflow, guided practice, and evaluation. Before the training, the team coordinated partner roles and readied the learning materials, 3D scanner, computers, visualization or modelling software, 3D printer, and hand objects used for scanning. The presentation then mapped the full sequence from scan acquisition and mesh inspection to CAD-based model preparation and additive fabrication. Demonstrations focused on how scan data are acquired and visualized, how the model is inspected, and how the digital file is related to the later 3D-printing stage. The activities and expected outputs for each stage are presented in Table 1.

Most of the practical session was devoted to scanning a hand object and reviewing the resulting three-dimensional model. Participants were asked to look beyond whether a scan could simply be produced and instead consider whether the geometry was suitable for later design. Discussion covered scan coverage, object position, stability, lighting, surface continuity, mesh noise, and the need for cleaning or editing before CAD work begins. The 3D printer was introduced only after the digital-model discussion so that participants could see fabrication as the final part of a connected scan-to-design-to-fabrication process [8], [14]

**Table 1. Stages of the digital fabrication training activity**

| Stage | Main activity | Expected output |
|---|---|---|
| Preparation | Coordinate partner roles and ready the training materials, 3D scanner, 3D printer, computers, software, and hand objects. | A prepared venue, equipment set, schedule, learning materials, and practice sequence. |
| Material presentation | Explain the digital-fabrication workflow and the roles of scanning, modelling, and printing in prosthetic-hand development. | Participants can describe how scanning, modelling, and fabrication are linked in one workflow. |
| Hands-on practice | Guide hand-object scanning, model visualization, mesh inspection, and an introduction to digital-model processing. | Participants obtain direct experience with 3D data capture, model visualization, and basic mesh review. |
| Evaluation | Administer the post-training questionnaire, hold a question-and-answer session and technical reflection, and agree on follow-up activities. | Participant feedback, identified improvement needs, and an outline for advanced workflow training. |

### 2.3. Evaluation instrument and analysis

Participant perceptions were collected with a post-training questionnaire completed on 27 January 2026. The instrument contained 11 closed items rated on a 1–5 scale—relevance to partners, training content, training materials, resource persons, training activities, clarity of objectives, clarity of agenda, instructor performance, facilities, timeliness, and participant satisfaction—and two open-ended questions on perceived benefits and new knowledge. All 11 participants responded. The closed items showed good internal consistency (Cronbach's $\alpha = 0.88$). For each item, the mean, standard deviation (SD), and percentage of scores of 4–5 were calculated, while open-ended answers were grouped into categories of reported knowledge; a respondent could mention more than one category. Because the evaluation relied on self-report after the training and did not include a baseline test or an objective skills examination, the results are interpreted as perceived training quality and perceived benefit, not as direct evidence of competency gain.

## 3. Result and Discussion

### 3.1. Training Implementation and Participation Management

The training made the digital workflow visible by beginning with a tangible object and following its transformation into digital data. Participants first examined the overall sequence used in personalized fabrication: acquiring usable geometry, checking the data, developing the digital model, and preparing it for additive manufacturing. During the guided exercise, a hand object was scanned and the resulting three-dimensional model was displayed on a computer for inspection. Seeing the physical object and its digital representation side by side helped participants relate surface capture to the design data required in later stages [11]–[13].

The hands-on exercise also made common acquisition problems easier to recognize. Incomplete surface coverage, unstable positioning, variations in scanning distance, lighting conditions, and mesh noise were visible in the model and became points for discussion. Participants reviewed why a scan may require cleaning, continuity checks, and other preparation before it is useful for CAD or printing. The practical lesson was that errors introduced during data capture do not remain isolated at the scanning stage; they can carry forward into modelling and fabrication [12]–[14].

Treating the activity as a sequence rather than a set of separate equipment demonstrations was an important feature of the program. The participants could follow the same logic reported in customized orthotic and prosthetic workflows, where scanning is followed by data processing, design refinement, fabrication, and evaluation [8], [14], [19]. This made it possible to discuss not only how a scanner or printer operates, but also why the quality of one stage influences the next. The resulting digital model was therefore presented as an intermediate design asset that still requires verification and refinement before it can support a functional prototype. The integrated scan-to-design-to-fabrication sequence applied during the training is illustrated in Fig. 1.

The partnership structure added another dimension to the learning process. Vocational participants encountered digital-production tools in an applied health-technology context, university partners contributed design and research perspectives, and health-technology resource persons helped interpret technical and safety considerations. The involvement of the disability-service sector kept the discussion connected to community priorities rather than technology alone.

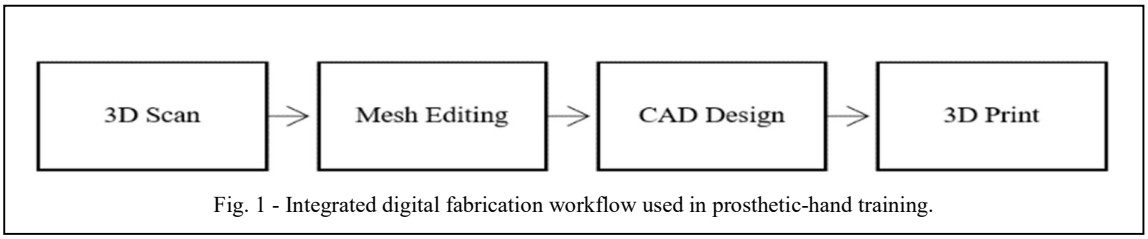



Fig. 1 - Integrated digital fabrication workflow used in prosthetic-hand training.

### 3.2. Participant Satisfaction

Participants rated the training positively. The overall mean across the 11 items was 4.12 out of 5, and 87.6% of all responses were scores of 4–5. Every respondent (100%)

rated the participant-satisfaction item 4 or 5, indicating that all participants were satisfied with the training. The detailed results, ordered from the highest to the lowest mean, are presented in Table 2.

**Table 2. Participant satisfaction ratings (n = 11)**

| Aspect assessed | Mean | SD | % 4–5 |
|---|---|---|---|
| Clarity of training objectives | 4.55 | 0.52 | 100% |
| Clarity of agenda | 4.45 | 0.52 | 100% |
| Instructor performance | 4.36 | 0.50 | 100% |
| Participant satisfaction | 4.36 | 0.50 | 100% |
| Relevance to partners | 4.09 | 0.54 | 91% |
| Timeliness | 4.09 | 0.54 | 91% |
| Facilities | 4.00 | 0.63 | 82% |
| Training content | 3.91 | 0.94 | 73% |
| Training materials | 3.82 | 0.75 | 82% |
| Resource persons | 3.82 | 0.87 | 73% |
| Training activities | 3.82 | 0.87 | 73% |
| **Overall** | **4.12** | **–** | **87.6%** |

The results show a clear pattern. Organizational aspects—clarity of objectives (4.55), clarity of agenda (4.45), and instructor performance (4.36)—received the highest scores, with all respondents rating them 4 or 5 and low dispersion (SD ≤ 0.52). Relevance to partners and timeliness (both 4.09) and facilities (4.00) were also rated favourably. In contrast, the substantive aspects were rated lowest and varied the most: training content (3.91; SD = 0.94), training materials (3.82; SD = 0.75), resource persons (3.82; SD = 0.87), and training activities (3.82; SD = 0.87). Part of this variation came from one respondent who gave a score of 2 on all four of these aspects. Although these values still indicate a broadly positive experience, they suggest that future sessions should offer more technical depth, clearer supporting materials, more consistent facilitation, and more time for interactive practice.

### 3.3. Perceived Benefits and Knowledge Gain

Responses to the open-ended questions indicate that the training was perceived as beneficial. Eight of the 11 respondents (73%) explicitly stated that they had gained new knowledge, insights, or skills. The reported knowledge covered prosthetic concepts, the use of 3D software, and the application of 3D technology in healthcare, as summarized in Table 3.

**Table 3. Types of knowledge reported by participants**

| Type of knowledge reported | Respondents |
|---|---|
| Using 3D technology to help others | 3 |
| Concepts and characteristics of prosthetic hands | 2 |
| Using software and developing 3D models | 2 |
| Insights into new fields (industry, health, and technology) | 2 |
| New knowledge or things in general | 2 |

*Note: a respondent could mention more than one type of knowledge.*

The most notable finding was a shift in perspective. Participants who had previously known 3D technology mainly through animation began to see it as a tool for helping people with disabilities, which was also the most frequently reported benefit. This perceived benefit is consistent with the ratings for relevance to partners (4.09) and clarity of objectives (4.55). One respondent also expressed a wish to learn more about Blender and 3D prosthetic fabrication, indicating interest in continued learning.

These findings are best interpreted together with what occurred during the sessions. Participants were able to follow the progression from scanning to model inspection and to discuss how the model would be used in CAD and 3D printing. However, both the ratings and the reported knowledge are self-reported perceptions; they do not demonstrate that participants reached a defined level of technical competence, and they provide no evidence of clinical readiness. The main outcome of the activity was therefore introductory capacity building and a platform for continued collaboration, not a clinically validated prosthetic device [3], [5].

### 3.4. Implications for Vocational Learning and Community Partnership

The value of the program is not limited to the two days of equipment practice. It also illustrates how a local network for health-related digital fabrication can be assembled from institutions with complementary functions. A vocational school offers a setting for repeated practice in scanning, modelling, and fabrication; a university can support design, research, evaluation, and interdisciplinary mentoring; a health-technology laboratory can contribute technical and safety guidance; and a disability-service organization can articulate community concerns and user priorities. When these roles remain connected, technology development can be refined through continuing exchange among developers, practitioners, and intended users, which is a central principle of user-centred prosthetics research [18].

For vocational learners, the integrated workflow places digital skills within a concrete and socially relevant problem rather than teaching them as isolated software or machine operations. Evidence from digital-fabrication education suggests that hands-on prototyping can strengthen understanding of design processes and increase confidence in using fabrication tools [15], [16], while research in vocational teacher education highlights the benefit of structured practice supported by institutional partnerships [17]. In this program, the strong ratings for objectives, agenda, instructor performance, and satisfaction, together with participants' shift from viewing 3D mainly as an animation tool to seeing it as a means of assisting people with disabilities, indicate that the format was well received and personally meaningful.

### 3.5. Sustainability Plan

Follow-up activities should extend the same workflow in progressively more demanding modules. A next stage could focus on advanced scanning and mesh repair, followed by CAD modelling, design for additive manufacturing, test printing, and iterative verification. A small collection of scan data could be prepared for design exercises before the team develops an initial prosthetic-hand model and prints selected trial components. Because content, materials, resource persons, and training activities were the lower-rated and most variable items, and because participants expressed interest in tools such as Blender, the follow-up should use step-by-step worksheets, guided practical assignments, and longer periods in which participants operate the software and equipment themselves. Consultation with prospective users or facilitators from

disability services should then be introduced before design decisions become fixed, so that preferences and functional priorities are considered early [9], [10], [18].

As the activity moves from education toward prototype development, governance and safety requirements will also become more important. Procedures are needed for informed consent, confidentiality, and secure handling of anatomical scan data. If future work reaches user testing, the team should evaluate material choice, mechanical strength, edge and surface safety, fit, comfort, durability, functional performance, and maintenance in a systematic way. Keeping these boundaries explicit will allow the collaboration to advance from training and prototyping toward assistive technology that is technically sound, user-centered, and appropriate for real-world use. Representative documentation from the training sessions and collaborative activities is shown in Fig. 2. (a,b,c)



Fig. 2. Documentation of the training activity at SMK TI Bali Global Badung



## 4. Conclusion

This community service activity introduced 11 participants at SMK TI Bali Global Badung to an integrated digital-fabrication workflow over two days, 26-27 January 2026. Using prosthetic-hand development as the learning case, the program connected 3D scanning, inspection of the digital model and mesh, basic CAD concepts, and 3D printing. The practical sequence enabled participants to observe how a physical surface is translated into editable digital geometry and why the quality of the initial scan matters for later modelling and fabrication.

Participant feedback was positive overall. The questionnaire showed good reliability (Cronbach's $\alpha = 0.88$), with an overall mean of 4.12 and 87.6% of ratings in the 4–5 range. All participants reported being satisfied, and 73% reported gaining new knowledge, particularly about using 3D technology to help others, prosthetic-hand concepts, and 3D software. The clearest strengths were the objectives, agenda, and instructor performance, while content depth, training materials, resource-person delivery, and the amount of practical activity were the main areas for refinement. Because the evaluation relied on self-reported perceptions, these results should not be read as measured competency improvement. Future programs should add pre/post assessment and performance-based evaluation, provide more extensive hands-on practice, including CAD tools such as Blender, and continue into iterative prototyping, technical and material verification, and user-centred validation.

## 5. Acknowledgements

The authors thank Institut Teknologi dan Bisnis STIKOM Bali for funding the Appropriate Technology community service program.

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