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Takashi Watanabe, Ph.D., *Nihon Fukushi University, Faculty of Health Sciences Department of Human Care Engineering*, Handa, Aichi, Japan, wata-t@n-fukushi.ac.jp

Michiko Tawara, B.A., *Nihon Fukushi University, Faculty of Health Sciences Department of Rehabilitation*, Handa, Aichi, Japan

Katsuhiro Kanamori, M.A., *Nihon Fukushi University, Faculty of Sport Sciences Department of Sport Sciences*, Handa, Aichi, Japan

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Takashi Watanabe, Ph.D.
Nihon Fukushi University, Faculty of Health Sciences Department of Human Care Engineering

Michiko Tawara, B.A.
Nihon Fukushi University, Faculty of Health Sciences Department of Rehabilitation

Katsuhiro Kanamori, M.A.
Nihon Fukushi University, Faculty of Sport Sciences Department of Sport Sciences
Handa, Aichi, Japan

Abstract: Three-dimensional (3D) printing technology has been widely known as a type of digital fabrication. Therefore, the development of human resources can take advantage of digital fabrication by providing better assistive technology services in local communities where users with disabilities live. In this study, we planned training programs to learn effective use of digital fabrication for assistive technology service, and then conducted experimental workshops. The workshops provided not only the opportunity for learning digital fabrication but also an opportunity to collaborate with the participants to improve assistive technology services.

Keywords: Assistive Technology; Digital Fabrication; 3D Printer; Community Welfare

Knowledge Focus: Best Practices Focus

Topic: Accessibility

Training Programs and Workshops for Assistive Devices Provision Using Digital Fabrication

Assistive technology (AT) services are essential for adapting assistive devices to the individual needs of users with disabilities. Assistive devices are included as environmental factors in the International Classification of Functioning, Disability and Health (ICF). The main method for assistive technology service is selecting or adjusting the devices. A good example is individually adjusting the size of a modular wheelchair or a cane. Other examples are to adapt the input devices—such as the keyboards and pointing devices—and to set accessibility features of the software for use with a personal computer. If neither selecting or adjusting assistive devices are suitable for individual needs, methods of production or remodeling can be applied. Those include making a seating system using casting techniques, remodeling switches, and devices that operate the communication equipment, nurse call, or environmental control system.

However, assistive technology services often depend on the empirical knowledge and experience-based skills of individuals or the regional community. Owing to the reliance on individuals, problems related to production and remodeling can arise. In addition, there are potential problems with the methods of production or remodeling, including:

- The continuity of the service is low because information related to production or remodeling is often not shared among the staff or not transmitted to incoming people.
- If the creation of devices takes too much time and the device cannot be provided to the user in a timely manner, it is possible that the user's quality of life or the ability to perform activities will worsen, particularly for people with progressive diseases or in children with disabilities.
- Methods of production or remodeling typically tend to be costly in terms of money, time, and human resources because they require individual handling or repeated trials.
- The reproducibility is extremely low in many cases, because actual adjustment or measurements need to be performed individually.

To overcome the problems mentioned above, we attempted to apply three-dimensional (3D) printing technology to some actual cases (Watanabe, Hatakeyama, & Tomiita, 2015) and proposed effective applications and an interactive community website (Watanabe, Iwabuchi, Ueda, & Tejima, 2018). The 3D printing technology is a well-known type of digital fabrication that is expected to result in new value creation. In the area of special needs education, case studies have reported use of 3D printing for supporting STEM applications or making prototypes of self-help devices for children with physical disabilities (Buehler, Comrie, Hofmann, McDonald, & Hurst, 2016). Moreover, there are also cases where 3D printing has been used in rehabilitation facilities (Matsuda, Ichiki, Okigawa, Tsujimura, & Murata, 2017). Accordingly, development of human resources that can take advantage of digital fabrication is required to perform better assistive technology services in local communities where users with disabilities live. To address problems associated with implementing the technology, a training program to learn effective use of digital fabrication for assistive technology services was planned and then experimental workshops were conducted.

Method

Contents of Training Program

To develop human resources that could take advantage of digital fabrication and perform better AT services, the contents of the training program shown in Table 1 were planned. The program could be classified in four categories: Technique of digital fabrication (T), Knowledge of disabilities (K), Manner of adaptation for an individual user (M), and Experience of a team approach for AT services with a user (E). As shown in Table 1, Category T has four subjects, including how to use 3D-CAD and methods to digitize any shape (e.g., 3D scanner); methods of data conversion depending on digital machine tools; how to use digital machine tools (e.g., how to 3D print using a 3D printer); and methods of handling and maintaining digital machine tools. Category K includes comprehension of impairment, disabilities, and handicaps for different types of users; sharing independent living conditions of users in their community and knowledge of the social welfare system. Category M includes the importance of providing suitable devices for users with disabilities, comprehension of functions, using of assistive devices (e.g., self-help devices); and ways to adapt. In addition, practice based on the experience of AT experts is very important for inexperienced supporters. Category E includes case studies, field work, and outreach activities of the AT services.

Table 1. The Contents of a Training Program to Learn Digital Fabrication for AT Service

Category		Contents
T:	Technique of digital fabrication	1. Design methods of assistive devices using 3D-CAD application software. 2. Methods of digitization for AT service and conversion methods of digital data. 3. Modeling methods of assistive devices using digital machine tools. 4. Methods of handling and maintenance of digital machine tools.
K:	Knowledge of disabilities	1. Comprehension of users with different types of disabilities. 2. Comprehension of independent living of users in their community.
M:	Manner of adaptation for an individual user	1. Comprehension of functions and utilization of assistive devices. 2. Skills to adapt the assistive device to individual user needs. 3. Comprehension of skills of AT experts and specialists.
E:	Experience of a team approach for AT service with a user	1. Brainstorming about AT and user needs. 2. Practice experience of assistive technology services.

Table 1 Image Description: Columns: Category; and Contents. Rows include: T: Technique of digital fabrication. 1) Design methods of assistive devices using 3D-CAD application software. 2) Methods of digitization for AT service and conversion methods of digital data. 3) Modeling methods of assistive devices using digital machine tools. 4) Methods of handling and maintenance of digital machine tools. K: Knowledge of disabilities, 1) Comprehension of users with different types of disabilities. 2) Comprehension of independent living of users in their community. M: Manner of adaptation for an individual user, 1) Comprehension of functions and utilization of assistive devices. 2) Skills to adapt the assistive device to individual user needs. 3) Comprehension of skills of AT experts and specialists. E: Experience of a team approach for AT service with a user, 1) Brainstorming about AT and user needs. 2) Practice experience of assistive technology services.

Conduct of the Experimental Workshops

According to the contents in Table 1, two types of workshops shown in Table 2 were conducted. The first workshop was intended for supporters, including physical therapists, occupational therapists, special needs education teachers, and local volunteers. In the second workshop, the main target was the AT users with disabilities. The workshops were programmed for five sessions, each in Table 2. In the first session of both workshops, the topic, "outline of technique of digital fabrication", was lectured on. Basic methods of 3D printing and how to use 3D printers were explained in detail. Then, in the first workshop, the participants experienced converting stereolithography (STL) formatted designs by 3D-CAD into a data format for 3D printers, and then printed sample data using 3D printers. The sample data was straw clips designed alphabetical characters. During the 3D printing of the straw clips, an occupational therapist who was on the workshop staff lectured about knowledge needed to customize AT devices and to adjust the AT devices to cater to individual users with disabilities. After the 3D printing was finished, the last session was facilitated by staff of the workshops so that the participants could discuss ideas regarding the AT devices while drinking soft drinks with the straw clips they printed.

Table 2. Program of the Experimental Workshops

	The first workshop		The second workshop	
Session	**Main target: Supporters**	**Category and content**	**Main target: AT users with disabilities**	**Category and content**
1	Introduction to the technique of digital fabrication.	T1, T2, T3	Introduction to the technique of digital fabrication.	T1, T2, T3
2	Converting 3D-CAD data into 3D printer data for 3D printing beginners.	T2	Trial 3D printing of an assistive device using a 3D printer with a sample data.	T3
3	Trial 3D printing of an assistive device using a 3D printer with a sample data.	T3	Designing an assistive device using 3D-CAD software for beginners.	T1
4	Knowledge to customize self-help devices suitable for the users.	M2	Trial use of the 3D printed assistive device.	M1, M2
5	Brainstorming about ideas of AT devices.	E1	Free discussion about assistive devices and user needs.	E1

Table 2 Image Description: Columns: The first workshop; The second workshop. Headers: Session; Main target: Supporters Category and content; Main target: AT users with disabilities; Category and content. Rows include: 1;

Introduction to the technique of digital fabrication.; T1, T2, T3; Introduction to the technique of digital fabrication.; T1, T2, T3. 2; Converting 3D-CAD data into 3D printer data for 3D printing beginners.; T2; Trial 3D printing of an assistive device using a 3D printer with a sample data.; T3. 3; Trial 3D printing of an assistive device using a 3D printer with a sample data.; T3; Designing an assistive device using 3D-CAD software for beginners.; T1. 4; Knowledge to customize self-help devices suitable for the users.; M2; Trial use of the 3D printed assistive device.; M1, M2. 5; Brainstorming about ideas of AT devices.; E1; Free discussion about assistive devices and user needs.; E1

In the second workshop, after the first session, the participants experienced the 3D printing of the straw clips they chose. Then, the participants were instructed to design the AT devices using 3D-CAD. They designed a bottle holder, which is a useful device for people with involuntary movements, such as cerebral palsy, because it can be difficult to hold the bottle steady. In the last session, the participants brainstormed self-help devices while drinking soft drinks with the 3D printed straw clips. The participants and staff of the workshops could share individual needs and their opinions at the workshop.

Results and Discussion

Participants

Figure 1. Percentage of Participants of the Workshops

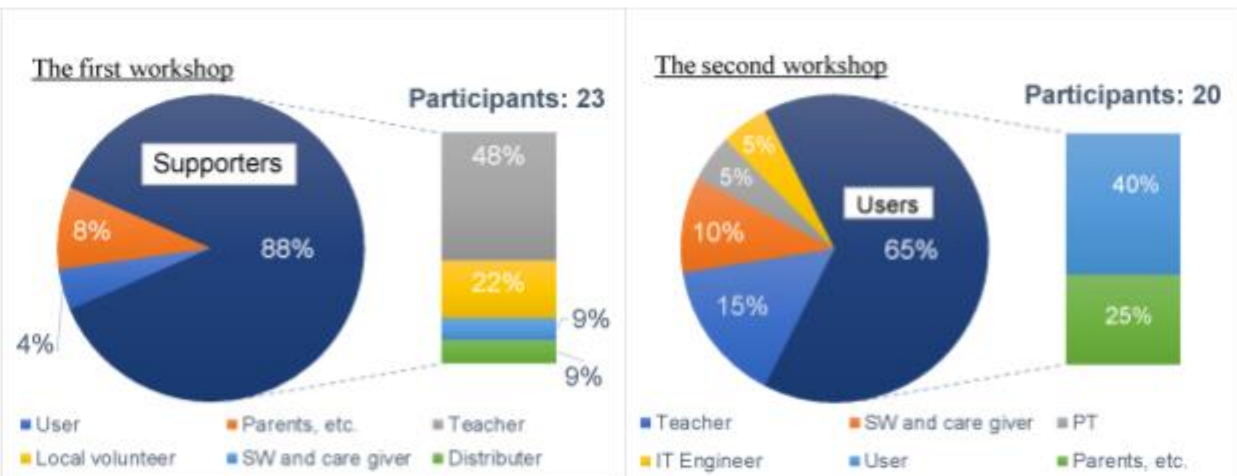

Figure 1 Image Description: Two pie charts titled, "The first workshop" and "The second workshop," reflects the percentage of participants of the workshops. In "The first workshop" there were 88% "Supporters," which includes 48% "Teacher;" 22% "Local volunteer;" 9% "SW and caregiver;" 9% "Distributor." "The first workshop" pie chart includes 8% "Parents, etc." and 4% "User." In "The second workshop" there were 65% "Users," which includes 40% "User" and 25% "Parents, etc." In addition, "The second workshop" pie chart includes 15% "Teacher," 10% "SW and caregiver," 5% "PT," and 5% "IT Engineer."

Figure 1 shows the percentage of participants in each workshop. In the first workshop, 88% of the participants were supporters. The defined groups of supporters divided in Figure 1 were teachers of special needs education, local volunteers, social workers, caregivers, distributors of the AT devices, and the others. In the second workshop, 65% of the participants were users with physical disabilities such as hemiplegia, cerebral palsy, and their parents, etc. The workshop could attract people from the local community we intended.

Interest in digital fabrication before and after the workshop and feedback

Figure 2. Percentage of Participants with Interest in Digital Fabrication Before and After Participating in the Workshops

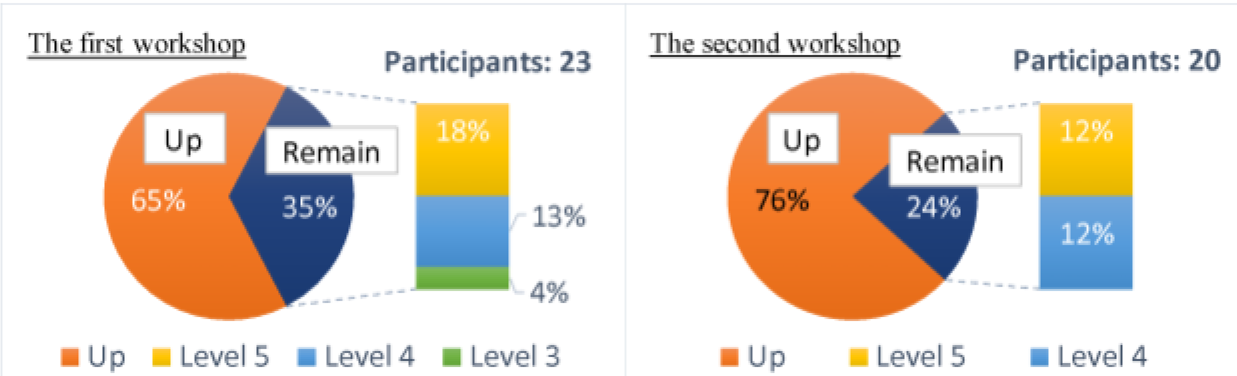

Figure 2 Image Description: Two pie charts titled "The first workshop" and "The second workshop," reflects the percentage of participants that had an increased interest in digital fabrication after participating in the workshops. In "The first workshop" there were 35% "Remain," which includes 18% "Level 5," 13% "Level 4" and 4% "Level 3." "The first workshop" pie chart includes 65% "Up." In "The second workshop" there were 24% "Remain," which includes 12% "Level 5" and 12% "Level 4." "The second workshop" pie chart includes 76% "Up."

After the workshops, the participants were asked how their level of interest in digital fabrication changed from before attending the workshop to after participating in the workshops, on a five-point scale. Figure 2 shows the percentage of participants that had an increased interest in digital fabrication after participating in the workshops. After the first workshop, 65% of the participants had increased interest in digital fabrication. After the second workshop, about 80% of the participants had increased interest in digital fabrication. The following are examples of feedback from the participants:

- "I was able to imagine 3D-printable assistive devices and grasp optimal shapes using a 3D printer. I will approach assistive devices for students with disabilities from a different perspective" (A teacher in special needs education).
- "The 3D printed straw clip made it easier for me to drink" (A user with cerebral palsy).
- "I want to design and print figures on my own" (A user with physical disabilities).
- "Thank you for useful workshops. I'd like to participate in them to step up the digital fabrication skills and to share with supporters" (A parent of a user with severe physical disabilities).

The results were promising for the development of human resources who perform AT services by remodeling and producing for users with disabilities in local communities. The workshop, using digital fabrication, brings an opportunity for users and supporters to create community activities in AT services.

Future Work

In this study, a training program to learn effective use of digital fabrication for AT services was planned and hands-on workshops were conducted on using 3D printers. In the future, we will conduct such workshops continuously and build a new AT service system using digital fabrication and information communication technology.

Author Note

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Correspondence concerning this article should be addressed to Takashi Watanabe, Faculty of Health Sciences, Nihon Fukushi University, 26-2 Higashihaemi-cho, Hanada, 4750012, Japan. Contact: wata-t@n-fukushi.ac.jp

Authors

Takashi Watanabe, Ph.D., is a professor at the Faculty of Health Sciences, Nihon Fukushi University, Japan. He is a rehabilitation engineer and specializes in assistive technology for people with disabilities. He has developed many commercial products and has also provided consultation to assistive technology users. *Image Description: Photo of Takashi Watanabe*

Michiko Tawara, B.A., is a professor at the Faculty of Health Sciences, Nihon Fukushi University, Japan. She is an occupational therapist and specializes in occupational therapy for physical disabilities.
Image Description: Photo of Michiko Tawara

Katsuhiro Kanamori, M.A., is a professor at the Faculty of Sport Sciences Department of Sport Sciences, Nihon Fukushi University, Japan. He specializes in special needs education and assistive technology.
Image Description: Photo of Katsuhiro Kanamori

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