The acceptance of 3D printing technology by occupational therapists: a qualitative study

Tereza Loucova | SNR 2019773 | ANR u732766

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Communication and Information Sciences
New Media Design
School of Humanities and Digital Sciences
Tilburg University, Tilburg

Supervisor: Karin Slegers, PhD
Second reader: Prof. Dr. Fons Maes

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ABSTRACT

Background: Three-dimensional (3D) printing technology offers possibilities for occupational therapists (OTs) to develop highly customized assistive technologies that fit clients’ unique needs. Such customization could possibly mitigate the abandonment rate of assistive devices. However, little is known about the stimulators and barriers affecting OTs’ decisions to use 3D printing technology in their profession.

Purpose: The purpose of this thesis is to (1) identify factors playing a relevant role in the acceptance of 3D printing technology by occupational therapist and to (2) investigate the effect of a hands-on experience with 3D modelling software on accepting 3D printing technology by OTs.

Design: 14 interviews with 17 Dutch OTs took place. Additionally, a workshop in Fusion 360 software with an authorised CAD trainer was organised. 6 OTs participated in pre and post-workshop focus groups and questionnaires and were observed during the workshop.

Findings: It seems to be the case that (1) personalisation options of the technology, (2) quality, durability of 3D printing materials, (3) possibility of cooperation with 3D designer, (4) 3D printing technology fit into occupational therapy, (5) organisational and colleagues’ incentives and (6) employers’ acknowledgment of the added value of the technology are the main stimulators for acceptance of 3D printing technology by OTs. On the other hand, (1) long development process, (2) small frequency of use, (3) not enough allotted time for training and (4) high investment costs could potentially halt OTs’ acceptance of 3D printing technology. Finally, a hands-on experience with 3D modelling software seems to affect OTs rather negatively regarding 3D printing technology usage in their profession.
**Implications:** Occupational therapy educational programmes should offer curriculum with a focus on 3D printing technologies. Next, in order to help overcome OTs’ time constraints and difficulty concerns, collaborations between OTs and 3D printing experts, and a shared international OT database with assistive technology templates should be set up. Finally, the technology designers should simplify and fasten 3D printing development process, and provide 3D modelling software that offers easily adjustable assistive technology templates.

**Keywords:** 3D printing technology, occupational therapy, assistive technology, 3D printed AT, technology acceptance, UTAUT
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1 INTRODUCTION

Occupational therapists (OTs) are professionals providing therapy and training individuals who cannot participate in specific everyday activities due to injury, illness, mental, emotional or developmental problems (Reed et al., 1980). Occupational therapists' objectives are to enable patients to participate in their most meaningful and purposeful occupations (Occupational Therapy Practice Framework: Domain and Process, 2017). To do so, OTs can provide their patients with assistive technologies (ATs) (Reed et al., 1980). Assistive technologies represent a wide range of products, e.g. splints, crutches, wheelchairs, or hearing aids. Their purpose is to enable patients to perform daily activities, such as dressing, eating, walking or typing independently and easy (Moraiti et al., 2015; Reed et al., 1980).

Occupational therapists usually provide patients with universally designed commercial assistive technologies, e.g. a utensil holder from an AT catalogue. Yet, such ATs are often abandoned for several reasons. For example, many commercial technologies focus on the physical needs but neglect the social and psychological ones, e.g. aesthetics that also play a role in patients’ integration in the society (Scherer, 1996). Among other reasons for abandonment belong changes in patients’ needs, i.e. improved or decreased abilities, patients’ overall perception of performance of the technology, i.e. reliability, safety, comfort, and also lack of patients’ involvement when selecting the assistive technology (Phillips & Zhao, 1993). The abandonment of AT has been a researched issue. Phillips and Zhao (1993) found that on average 29.3% of assistive technology is completely abandoned.

Scherer and Sax (2010) therefore highlighted the importance of shifting AT focus from universal solutions for “people” with disabilities to more customized solutions for a “person” with a unique set of skills and needs. There already exist professionally customized ATs, e.g. a professionally tailored crutch handle. Yet, such ATs must be bought from suppliers through insurance offering high-end tailored features, which often makes the AT
expensive (McDonald et al., 2016). Furthermore, its assortment is usually limited and its delivery time is slow (De Couvreur & Gooossens, 2011; McDonald et al., 2016).

Occupational therapists can customize commercial AT themselves as well, since they possess a certain creative skillset (Schmid, 2004). A typical adjusted AT is for example added padding on crutch grips for patients’ comfort. To customize AT, OTs usually use materials such as Velcro, tape or cardboard. However, these materials are not very durable (McDonald et al., 2016). Due to these reasons, there has been a growing interest in technological advancements that allow for optimal (Bagaria et al., 2015) and affordable customizations.

Emergent fabrication technologies such as 3D printing systems could allow occupational therapist to fabricate personalised and lasting AT (Hurst & Kane, 2013), which would result in reducing their abandonment (McDonald et al., 2016). Three-dimensional printing is “the process of making three dimensional physical models by using 3D software, computer, and printer” (Ganesan et al., 2016: 1). 3D printed ATs have certain potential, since they can be fully tailored to the individual user’s needs (e.g. McDonald et al., 2016). Moreover, the production of 3D printed AT is getting cheaper (Mertz, 2013; Lin et al., 2014), and they can be produced quickly. For example, 3D printed AT can be printed out within hours (Mertz, 2013) at any location that is equipped with a 3D printer (Lin et al., 2014; Ventola, 2014; McDonald et al., 2016). This means that patients do not have to wait long for the delivery (Banks, 2013; Buehler et al., 2016). Furthermore, 3D models of AT can be saved in the software library for future prints or necessary modifications.

Even though 3D printing has been widely used in various healthcare fields (Dodziuk, 2016), its clinical application is still in infancy stage when it comes to occupational therapy (Ganesan et al., 2016). Hence, the new technology could potentially represent some challenges for occupational therapists. Namely, in order to 3D print an object, it first must be modelled. Nonetheless, to independently model designs in 3D software it is necessary to
possess certain technological skills (Hurst & Tobias, 2011). Buehler et al. (2016) distinguished between two types of 3D software users: novice users, i.e. people with no or little prior training and expert users, i.e. people with engineering background. As the majority of traditionally educated occupational therapists do not have a technology background (Moraiti et al., 2015), in terms of 3D printing software they can be considered novice users.

The lack of OTs’ technical skills could halt the implementation of 3D printing technology into their profession, eventually diminishing the chances of patients to receive personalized, affordable and durable assistive devices. Some research already indicated that occupational therapists struggle with 3D printing technology in several areas, e.g. modelling in 3D software, lack of understanding 3D dimensions, and time management (Beuhler et al., 2016; Buehler et al., 2014; McDonald et al., 2016). However, obstacles such as technical skills and time management might represent only a fragment of factors that could discourage occupational therapist from accepting 3D printing technology into their profession.

It was found that OTs can be hesitant to accept new technologies to their profession, as they may intervene with their established ways of working (Anderson, 1997; Chau & Hu, 2002). According to technology acceptance theories, the acceptance of new technology depends on several factors, such as effort expectancy, efficiency, perceived usefulness, job fit, or self-efficacy (e.g. Venkatesh et al., 2003).

Several studies have already assessed the acceptance of 3D printing technology, yet in different domains, e.g. business, fashion, interior design or advertising, and by different target groups (Chatzoglou & Michailidou, 2019; Wang et al., 2016). Other studies investigated how OTs accept other technologies, e.g. rehabilitation (Liu et al., 2014) or information communication technology (Schaper & Pervan, 2007). The studies performed quantitative analyses, i.e. surveys, presenting statistical importance of certain factors that affect the technology acceptance. Yet, this method does not allow to thoroughly understand the reasons
why certain factors played a more important role than others - ‘the why’. What is more, to the best of my knowledge no study has yet directly investigated factors that play a relevant role in acceptance of 3D printing technology by occupational therapists.

The present study hopes to contribute to the current knowledge by offering a better understanding of factors that may withhold OTs from using 3D printing technology, and by additionally revealing new barriers/stimulants to 3D printing implementation into OTs’ profession.

The present study also hopes to aid clinics and OTs’ educational systems in decisions about training, educational programme and investment. For example, if OTs showed confidence in their learning capabilities to work in 3D software, clinics and schools could consider investing in 3D modelling courses or purchase 3D modelling software. On the other hand, if OTs showed that this technology does not fit their job, cooperation between OTs and 3D modelling designers or fabrication experts could be a better solution. Lastly, the factors hindering the acceptance could be directly addressed. To sum up, not knowing what factors are relevant for OTs to accept 3D printing technology may delay their adoption in OT profession and consequently suspend the opportunities for delivering highly customizable, affordable and more indispensable assistive technologies to people with unique impairments. Therefore, the first research question of the study is (1) "What factors play a relevant role in acceptance of 3D printing technology by occupational therapist?".

Furthermore, as it was already suggested by some studies, 3D modelling seems to represent a challenge in 3D printing process. Therefore, it is important to know if 3D modelling could indeed discourage inexperienced OTs from using the 3D printing technology in their profession. Hence, the second research question of this study is (2) “How does a hands-on experience with 3D modelling software affect occupational therapists’ acceptance of 3D printing technology?”. Based on the second study results, software designers could
learn more about OTs’ 3D modelling preferences and expectations. Those could be subsequently incorporated into the software interface or serve as a base for a new 3D modelling software designed specifically for occupational therapists.

The first chapter of the study will briefly introduce occupational therapy and 3D printing technology. Next, the technology acceptance theory serving as a framework for both studies will be introduced. Additionally, there will be an in depth assessment of literature studies that address acceptance of 3D printing technology in similar settings, and studies that address acceptance of new technologies by OTs. The second chapter will discuss methods chosen for the data collection, followed by results section, discussion and implications.
2 LITERATURE STUDY
In order to understand the main concepts of the thesis, a brief introduction to occupational therapy and 3D printing is provided.

2.1 What do occupational therapists do?
According to Canadian Model of Client Centered Enablement, OTs have a variety of tasks (Townsend et al., 2013). Namely, they adapt daily actions, whereby providing provisions and tools (e.g. AT). OTs also advocate with municipalities, for example, if a patient needs certain home modifications in a short term. OTs further consult, coach, educate and help clients engage in daily actions. Also collaborating with the clients and other teams or communities is one of their responsibilities. Besides, OTs coordinate activities between different parties (e.g. schools, health professionals) and use different specialised techniques e.g. neurorehabilitation techniques for people with brain damage or manufacturing splints techniques for people with hand injuries (Le Granse et al., 2017).

OTs can specialise in various domains, e.g. paediatric, geriatric, neurology or vision (“7 Most Popular Specialized Occupational Therapy Fields,” 2019). There is also a difference between first-line OTs who make appointments without referral from other medical specialists, and second-line OTs who are only accessible after being referred to by other medical specialists (”Ergotherapie” n.d.).

As aforementioned, OTs can thus provide assistive devices to their clients. An assistive device is “...any item, piece of equipment, or product system, whether acquired commercially, modified, or customized, that is used to increase, maintain, or improve the functional capabilities of individuals with disabilities” (Assistive Technology Act, 2004: 4). Types of assistive devices are for example sensory aids, e.g. alerting devices using light or vibration; mobility aids, e.g. wheelchairs; self-care aids, e.g. quad grip handles or zipper pulls; reading and writing aids, e.g. book holder or special purpose interface; and leisure time
aids, e.g modified grip scissors (Akyurek et al., 2017). When finding a suitable AT for a client, the OTs follow a process, namely they firstly evaluate client’s needs and acquire a device that matches client's skills and activities. If the device does not fit, OTs adapt or modify it, coordinate intervention plan and subsequently provide training and other technical support. Providing, fitting, customizing, adapting, and training with AT is thus a part of the occupational therapy process (American Occupational Therapy Association, 2010).

However, this process does not always allow OTs to provide each client with professionally customized ATs, as they are often too expensive (McDonald et al., 2016) when being ordered from specialized suppliers. Therefore, recent literature started to investigate if and how 3D printing technology could aid OTs in delivering professionally customized ATs (e.g. McDonald et al., 2016, Buehler et al., 2016).

2.2 What is three-dimensional printing?
Three-dimensional printing is a manufacturing process whereby materials are fused or deposited in layers producing 3D printed objects (Mertz, 2013, Schubert et al., 2013). In general, for one to be able to 3D print an object, 3D printing materials, a 3D printer, and 3D software is needed.

There are several types of 3D printers that differ from each other based on, for example, their printing speed or printing materials (Mertz, 2013). In terms the cost of printers, already at the end of 2014, the low cost 3D printers could be bought from €2480 (Paterson et al., 2014) and were judged to be good enough for printing comfortable assistive devices (Ganesan et al., 2016).

According to Mertz (2013), there are hundreds of 3D printing materials. The most 3D printing techniques work with three main material categories, namely wires (also referred to as filament), liquid or powder, usually resulting in plastic products. Nowadays materials such as metal and ceramic are becoming more common as well (“3D printen materialen,” n.d.).
The prices of materials vary based on their sort, from more expensive PVA that ranges from €70/kg, to cheaper and most popular PLA that ranges from €20/kg. It is estimated that prices of the material are expected to drop even lower in the future (“3D printen kosten,” n.d.). For example, as Hurst and Tobias (2011) indicated, a printer brand called MarketBot could 3D-print a hand splint using filament worth less than €0.90.

Next, the user can choose among a variety of 3D printing software. On the market there exists free software such as Blender or Google SketchUp. There are also commercial software packages that require yearly payment, such as AutoCAD software Fusion 360 that requires a yearly payment of approximately €500 (“Fusion 360,” 2019). The software offers parametric, a direct modelling style or both. The difference between the two types of modelling is that parametric modelling works with complex geometric relationships, whereas direct modelling does not, i.e. it allows for direct model manipulation, without the need to adjust the geometric relationships (“Parametric vs. Direct Modeling,” 2018).

Regarding 3D printing process itself, it generally includes designing a 3D model, which requires working in 3D work spaces. One can either 3D-model an object, save it in software and subsequently send it to the printer. One can also download an existing 3D object file from platforms for locating, making and sharing 3D models, e.g. Thingiverse. If necessary one can modify the downloaded 3D object in the software and print it out. Lastly, one can diminish the work in 3D modelling by opting for 3D scanning (Tanaka et al., 2013). OTs can then clay a play-dough object and 3D scan it. They could also 3D scan an existing object, e.g. a pencil grip, or part of a body, e.g. an injured finger that could serve as a starting point for 3D modelling.

However, the clinical application of 3D printing in occupational therapy is still in infancy stage (Ganesan et al., 2016). Moreover, the majority of OTs do not possess a
technology background (Moraiti et al., 2015) to work with 3D printing technology. OTs can therefore be considered as novice users of 3D printing technology.

2.3 Assessing technology acceptance: UTAUT theory

Recent research highlights struggles of novice users of 3D printing technology with its usage in certain areas, for example with 3D orientation and 3D modelling (Hudson et al., 2016). These factors could then affect novice users’ decision (not) to use the technology. Since most of the OTs are novice users of 3D printing technology it is important to identify all potential factors that could affect their decision (not) to use 3D printing technology in their job. For this purpose, a theory for assessing users’ acceptance of technologies will be used.

There are two leading/most cited theories (Mimpen, 2015). The first one is a theory of Davis et al. (1989) who established Technology Acceptance Model (TAM). TAM aims to clarify factors that affect computer acceptance (Davis et al., 1989). According to the authors, the variables that influence users to work with the new technology are users’ beliefs, attitudes and behavioural intentions. After the introduction of TAM in 1989, more researchers aimed to extend or adjust the model. Towards the end of the 20th century, more technology acceptance models were developed, often times overlapping each other. Therefore, Venkatesh et al. (2003) aimed to unify the theories by developing a Unified Theory of Acceptance and Use of Technology (UTAUT) model. This is the second leading model for technology acceptance. The UTAUT model summarized the theories into four main factors that affect users’ intention to use new technology, namely performance expectancy, effort expectancy, social influence, and facilitating conditions. Originally, the model aimed to clarify acceptance of information technologies, however, it has also been used to assess the acceptance of other technologies, such as social media adoption in PR (Curtis et al., 2010) or automated feedback system in educational environment (Debuse et al., 2008).
A few studies examined the acceptance of 3D printing technology by combining factors of various models. For example, Wang et al. (2016) combined several factors (perceived usefulness, perceived compatibility, perceived ease of use and perceived enjoyment) from TAM and Innovation Diffusion Theory (IDT). IDT deals with users’ adoption of innovations through diffusion (spread of new ideas) (Rogers, 1983). The authors found that all factors were positively influencing users’ intentions to accept 3D printing technology. Also, Chatzoglou and Michailidou (2019) combined several factors (compatibility, relative advantage, job relevance, output quality, output usability, experience, attitude, perceived usefulness, perceived ease of use, and intention to use) from TAM, IDT and Theory of Planned Behaviour (TBP). TBP explains how human’s behaviour and behavioural intentions depend on subjective norms, attitudes toward behaviour and perceived behavioural control (Ajzen, 1991). Chatzoglou and Michailidou (2019) found that perceived usefulness, output usability, compatibility and attitude are factors that allow comprehending users’ motives to utilize 3D printing technology. While Wang et al. (2016) did not explicitly explain why combining the two models suits assessment of 3D printing technology acceptance, Chatzoglou and Michailidou (2019) reasoned their choice of models by different fields they are developed from, i.e. psychology and sociology.

Due to several reasons, the present study will use UTAUT model to identify factors OTs consider relevant for adopting 3D printing technology into their profession. Firstly, the majority of factors used in Wang et al. (2016) and Chatzoglou and Michailidou (2019) studies are already incorporated in UTAUT model (i.e. perceived usefulness, perceived ease of use, compatibility, relative advantage, intention to use and output quality). This is due to the fact that UTAUT model is based on eight technology acceptance models, namely: TAM, IDT, TBP, Motivational Model, Theory of Reasoned Action, a model integrating TAM and TPB, Model of PC Utilization, and Social Cognitive Theory. Secondly, UTAUT model
accounts for more variance in behavioural intention to use new technology (70% based on adjusted R²) than Wang et al. (2016) and Chatzoglou and Michailidou’s (2019) models (57% and 56% based on adjusted R², respectively) (Venkatesh et al., 2003; Wang et al., 2016; Chatzoglou and Michailidou, 2019, respectively). Lastly, UTAUT was already applied in occupational therapy domain. For instance, Liu et al. (2014) conducted a paper-based survey to assess the acceptance of new rehabilitation technologies by Canadian physical and occupational therapists. Also, Schaper and Pervan (2007) conducted focus groups and survey to assess the adoption of new information technologies by Australian occupational therapists where it proved to be valid. Hence, this study will be the first exploratory study using UTAUT model to investigate which factors are important for OTs to accept 3D printing technology. To the best of my knowledge, there is only limited literature on OTs perception of 3D printing technology. Therefore, literature about OTs’ and physical therapists’ (PTs’) acceptance of other technologies, and novice users’ acceptance of 3D printing technology will be used to contemplate the literature review (see Appendix 1). Both PTs’ and OTs’ opinions are considered relevant for this study, as both specialists’ work overlap, i.e. both aim to improve patients' mobility, prevent injuries and pain (St. Catharine University, 2017). Moreover, literature on how OTs react to other technologies will help to understand their general attitudes towards (new) technologies. Likewise, novice users’ perceptions of 3D printing technology are relevant too, as they can be similar to those of OTs who are also novice users. The following section presents findings from related literature and is structured in four subchapters mirroring four factors of UTAUT model.

**2.4. Acceptance of 3D printing technology and other technologies**

**2.4.1 Performance expectancy (PE)**
Performance expectancy is “the degree to which an individual believes that using the system will help him or her to attain gains in job performance” (Venkatesh et al., 2003: 447). This
factor deals with relative advantage, job fit, extrinsic motivation and perceived usefulness of the technology. It also considers the degree the technology influences outcome expectations. Performance expectancy is, according to Venkatesh et al. (2003), the strongest factor influencing behavioural intention to use new technologies. In OTs’ context, performance expectancy may include expected patients’ outcomes or expected quality and safety of 3D printed AT.

Table 1. UTAUT model, PE factors and constructs (Venkatesh et al., 2003)

<table>
<thead>
<tr>
<th>Factor</th>
<th>Constructs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance expectancy</td>
<td>Perceived Usefulness</td>
<td>“The degree to which a person believes that using a particular system would enhance his or her job performance” (Venkatesh et al., 2003: 448)</td>
</tr>
<tr>
<td></td>
<td>Extrinsic Motivation</td>
<td>“The perception that users will want to perform an activity because it is perceived to be instrumental in achieving valued outcomes that are distinct from the activity itself…” (Venkatesh et al., 2003: 448)</td>
</tr>
<tr>
<td></td>
<td>Job-fit</td>
<td>“How the capabilities of a system enhance an individual’s job performance” (Venkatesh et al., 2003: 448)</td>
</tr>
<tr>
<td></td>
<td>Relative Advantage</td>
<td>“The degree to which using an innovation is perceived as being better than using its precursor” (Venkatesh et al., 2003: 449)</td>
</tr>
<tr>
<td></td>
<td>Outcome Expectations</td>
<td>“Outcome expectations relate to the consequences of the behaviour…” (Venkatesh et al., 2003: 449)</td>
</tr>
</tbody>
</table>

PE: Acceptance of other technologies by OTs and PTs

Liu et al. (2014) conducted a survey using UTAUT to determine which factors influence PTs’ and OTs’ acceptance of new rehabilitation technologies, such as neuromuscular electrical stimulation (Chen & Bode, 2011). The paper-based survey with 40 participants indicated that the degree to which new rehabilitation technologies enhanced therapists’ work or clients’ results was considered the most salient construct influencing therapists’ intention to use the technologies. Similar results were found by Seifert et al. (2016) who researched OTs’ perception of smart device applications (apps) for therapeutic purposes by conducting a
survey with 620 OTs. The research showed that the OTs who did not use apps in their work did so mainly due to their negative perception of the apps usefulness, effectiveness and clients’ outcomes. This study implies that OTs need to positively perceive 3D printing technology usefulness and effectiveness in order to incorporate it at work.

**PE: Acceptance of 3D printing technology by novice users**

Consistent trends were found by novice users of 3D printing technology. Wang et al. (2016) conducted a survey with 256 Chinese novice users of 3D printing technology to measure the acceptance of home 3D printing systems in several domains, e.g. fashion, interior design and advertising. The authors found that perceived usefulness of the systems had a positive effect on participants’ intention to use them. Likewise, Chatzoglou and Michailidou (2019) who surveyed the readiness of 258 people from different business sectors, e.g. manufacturing, commercial, IT, or services, to use 3D printing technology found that users’ intention to utilize 3D printing technology was directly enhanced when the technology was perceived useful. Both studies suggest that if novice users, including OTs, perceive 3D printing technology as useful in their job, the likelihood of its usage will be enhanced.

**PE: OTs, PTs and 3D printing technology**

Regarding OTs specifically, one study indicates that OTs perceive 3D printing technology useful. Buehler et al. (2016) conducted special education classroom, observations and interviews with 5 OTs who had limited exposure to 3D printing technology. After being introduced to the 3D printer and its capabilities, the OTs working in special education saw many opportunities of its usage, e.g. modifying or replacing standard AT. This suggests that OTs specialised in children with special needs perceived 3D technology useful.
As aforementioned, the expected outcome expectations influence the adoption of technology as well (Venkatesh et al., 2003). In OTs’ context, the outcome expectations can relate to the quality and safety of 3D printed AT. Buehler et al. (2016) found the safety of 3D printer and 3D printed objects did not represent a major concern for the interviewed OTs. Their judgment was based on student observations and existing safety protocols for new AT. However, the OTs were unaware that some printers, such as ZPrinter 4508 resin composite machine, sometimes provide less durable prints that cannot endure extensive usage and are subject to break. Moreover, the OTs were designing AT for special educational purposes, e.g. grips or screen guards, for visually impaired students. It would be interesting to know if their concerns changed after being familiar with all safety risks and if they were designing ATs serving purposes with bigger safety risks. For example, a 3D printed AT for walking support that needs to uphold more load/restrictive force than screen guards or tactile graphics aids.

The material from which the 3D printed device is made of influences the quality of the device and thus its safety. Buehler et al. (2016) found that not all 3D printing materials necessarily fit OTs’ needs. Some OTs were more interested in alternative, less hard materials such as soft textiles, rubber and foam fiber that offer more flexible, easy-to-grip solutions. Similarly, McDonald et al. (2016) who conducted three classroom sessions with PT students found that 3D printed solid plastic materials were evaluated as too hard for direct hand contact. Therefore, the students wanted to adjust the 3D printed AT with softer materials. This suggests that OTs need to have access to a wide variety of 3D printing materials that meet their professional needs.

Lastly, even though Venkatesh et al. (2003) does not directly deal with responsibility as a performance expectancy factor, the present study includes responsibility in the research. This is due to the fact that the lower expected quality of the output, the lower the safety and the higher OTs’ responsibility. The increased responsibility could subsequently discourage
OTs from using 3D printing technology. Regarding both safety and responsibility, an online questionnaire with 4 PTs conducted by McDonald et al. (2016) revealed that two PTs did not think the responsibility would increase when manufacturing their own ATs since all ATs must be checked for proper fit. Nonetheless, the other two PTs thought their responsibility would grow. McDonald et al. (2016) expects that unregulated, non-medically tested 3D printed AT might represent concerns for both PTs and patients. This study implies that OTs might be hesitant to use unregulated 3D printed ATs, i.e. ATs without CE\(^1\) marking, as they might cause patient’s irritations. Yet, these results are not generalizable to OT population and hence more input is required to know if safety and responsibility play an important role in acceptance of 3D printing technology by OTs.

To sum up, the consulted literature indicates that OTs care about enhanced job performance and patients’ outcomes when deciding to accept a new technology. Furthermore, it seems to be the case that 3D printing technology is strongly accepted by novice users if perceived useful. Finally, 3D printing materials, safety of 3D printed devices and increased responsibility might represent other important factors that could influence adoption of 3D printing technology into occupational therapy, yet more investigation is needed to assess these assumptions.

### 2.4.2 Effort expectancy (EE)

Effort expectancy is “the degree of ease associated with the use of the system” (Venkatesh et al., 2003: 450). This factor covers topics such as perceived ease of use, actual ease of use, and complexity. According to Venkatesh et al. (2003), effort expectancy directly influences behavioural intention to use new technology and is less significant with more exposure to new technology. In OTs’ context, effort expectancy assesses how much effort

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\(^1\) CE marking is a certification that assures that a product is in accordance with European Economic Area health, safety and environmental protection standards. (eur-lex.europa.eu, n.d.)
(easy/difficult/time consuming) OTs perceive learning to work/working with 3D printing technology.

**Table 2. UTAUT model, EE factors and constructs (Venkatesh et al., 2003)**

<table>
<thead>
<tr>
<th>Factor</th>
<th>Constructs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effort expectancy</td>
<td>Perceived Ease of Use</td>
<td>“The degree to which a person believes that using a system would be free of effort” (Venkatesh et al., 2003: 451)</td>
</tr>
<tr>
<td></td>
<td>Complexity</td>
<td>“The degree to which a system is perceived as relatively difficult to understand and use” (Venkatesh et al., 2003: 451)</td>
</tr>
<tr>
<td></td>
<td>Ease of Use</td>
<td>“The degree to which using an innovation is perceived as being difficult to use” (Venkatesh et al., 2003: 451)</td>
</tr>
</tbody>
</table>

**EE: Acceptance of other technologies by OTs and PTs**

The survey of Liu et al. (2014) revealed that effort expectancy does not affect PTs’ behavioural intention to use new rehabilitation technology. The authors explain this may be due to the fact that “the expectation of better patient outcomes and therapists’ job performance overcomes the hurdles of learning to use new challenging technologies” (Liu et al., 2014: 453). However, Schaper and Pervan (2007) conducted a national survey with 6453 Australian OTs to assess their behavioural intention to use existing and emerging information technologies (ICTs), e.g. clinical information systems, telemedicine or personal digital assistants. In this study, the effort expectancy influenced OTs’ behavioural intention to use ICTs. Namely, if technologies were perceived as easy and uncomplicated to use, they positively affected OTs’ behavioural intention to use them. These two contradicting research results suggest that the type and purpose of the technology may influence the role that effort expectancy plays in technology adoption by OTs, yet more research is needed to test this assumption.

Furthermore, the study of Atwa et al. (2012) indicates, time effort could play a relevant role in technology adoption as well. Namely, the authors conducted three focus
groups with 25 English OTs and assessed their attitudes towards 3D interior design software (3DIDS). The OTs did not have previous experience with this technology, but were introduced to the software for better understanding. The research showed that OTs had concerns about their capabilities and the time they would have to invest in learning to work with the 3D software, which may influence technology acceptance as well.

EE: Acceptance of 3D printing technology by novice users

Regarding novice users of 3D printing technology, the survey of Wang et al. (2016) found that the easier 3D printing technology was perceived by Chinese novice users, the more intentions they had to actually use it. However, novice users seem to perceive 3D printing technology as rather complex, as found by Hudson et al. (2016). The authors conducted 32 semi-structured interviews with casual users of 3D printing technology to examine their barriers and motivations to use 3D printing technology. As the results showed, the casual users had usability issues due to complex 3D modelling software and 3D dimensions. For example, a few casual users failed to customize a downloaded 3D model since they “were confused by the geometry produced” (p.7). Hudson et al.’s (2016) research therefore suggests that complexity of the 3D modelling software and orientation in 3D dimensions might negatively influence novice users’ perception of 3D printing technology and potentially its acceptance.

EE: OTs, PTs and 3D printing technology

A research conducted by Buehler et al. (2016) revealed similar results as Hudson et al. (2016). Namely, the authors collaborated with two OTs to design a prototype of an AT and additionally interviewed three other OTs. All OTs had limited previous experience with 3D printing technology. The study revealed the OTs were worried about the steep learning curve
and time commitment to design and print. Similarly as novice users from Hudson et al. (2016) study, the OTs were intimidated by the complexity of the 3D software, e.g. confusion by CAD (computer-aided design) vocabulary and by the high number of programmes needed for interaction. Even working with 3D scanners that diminish modelling work in the software was perceived too timely for OTs, since it still required some degree of adjustments. These results are also closely aligned with Buehler, Hurs and Hofmann’s (2014) study where OTs collaborated with researchers on a special AT for a student with disabilities. The OTs did not think they had the time in their schedules to experience or train with the 3D software. Hence, OTs believed that somebody else (not specified) should work with 3D modelling software and 3D printers, i.e. the OTs currently did not consider the work with the technology to be their job. These studies suggest that OTs would rather avoid learning working/working with 3D printing technology as it requires too much time investment.

As another study showed, even PT students perceived 3D modelling challenging and frustrating due to inexperience working in 3D software. In this study, McDonald et al. (2016) conducted pre and post-classroom session surveys with 65 students of physical therapy who had little to no background experience with 3D designing, printing or AT designing. The students received three class sessions on 3D printing. The results found that the students preferred 3D scanning of clayed play-dough objects to modelling objects in 3D software, possibly due to the familiarity with claying with play-dough. This indicates that the PT students perceived 3D scanning as less effortful and more familiar than 3D modelling. In terms of 3D modelling, McDonald et al. (2016) further found that both practicing PTs and PT students preferred to customize existing 3D AT models to creating novel 3D AT ones. The reasons varied for each participant, yet these study results indicate that in terms of 3D modelling, creating novel 3D AT models might represent too much effort for OTs.
To sum up, time effort, a steep learning curve, 3D modelling difficulty (especially modelling novel ATs), and the complexity of the 3D modelling software, e.g. CAD vocabulary and understanding 3D dimension are important factors with the potential to affect OTs’ behavioural intention to use 3D printing technology.

2.4.3 Social influence (SI)

Social influence is “the degree to which an individual perceives that important others believe he or she should use the new system” (Venkatesh et al., 2003: 451). Social influence deals with social factors, subjective norms and status/image that the usage of technology would give to the user. The factor directly determinates behavioural intention to use new technology (Venkatesh et al., 2003). In OTs’ context, social influence may include for example OTs’ perception of their job status among their colleagues, or co-workers’ influence on OTs’ decision to use 3D printing technology.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Constructs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Influence</td>
<td>Subjective Norm</td>
<td>“The person’s perception that most people who are important to him think he should or should not perform the behavior in question” (Venkatesh et al., 2003: 452)</td>
</tr>
<tr>
<td></td>
<td>Social Factors</td>
<td>“The individual’s internalization of the reference group’s subjective culture, and specific interpersonal agreements that the individual has made with others, in specific social situations” (Venkatesh et al., 2003: 452)</td>
</tr>
<tr>
<td></td>
<td>Image</td>
<td>“The degree to which use of an innovation is perceived to enhance one’s image or status in one’s social system” (Venkatesh et al., 2003: 452)</td>
</tr>
</tbody>
</table>

**SI: Acceptance of other technologies by OTs and PTs**

There seem to be mixed findings about the role of social influence on usage of technologies by OTs. Namely, Atwa et al. (2012), found that 25 English OTs, who had no experience with 3D interior design software (3DIDS), thought that working with such software would
improve their status. Namely, the OTs felt that their job was not always valued by other members in the medical field and believed that working with such complex technology might improve their image and impress their colleagues. Even though these findings were not directly linked to the intention to use 3DIDS, according to the authors, OTs’ overall positive attitudes towards the software imply they would be open to try it at work.

Nevertheless, this does not seem to apply for all therapists and technologies. Schaper and Pervan (2007) found that social factors such as peer pressure did not affect therapists’ decisions to use ICT technologies. Even though ICTs such as telemedicine or Internet require certain computer skills, generally they are not as technical as 3D printing technology, e.g. they do not require 3D orientation. Owing to the technical difference, it could be the case that OTs’ decisions to use 3D printing technology are, contrary to ICT technology, affected by peer pressure, yet more research is needed to test this assumption.

Similarly, the survey of Liu et al. (2014) found that social influence did not affect PTs’ behavioural intention to use new rehabilitation technologies. The author explained this was possibly due to the fact that it was not used in obligatory context. Namely, social influence is insignificant in voluntary context (e.g. PTs do not perceive the use of rehabilitation technology organisationally mandated) but is significant in mandatory contexts (e.g. PTs perceive the use of rehabilitation technology organisationally mandated) (Venkatesh & Davis, 2000). Since the usage of 3D printing technology in occupational therapy is still a voluntary choice, it might be the case that OTs will not perceive social factors of particular relevance when deciding to use 3D printing technology.

The usage of rehabilitation technologies in Liu et al. (2014) and the usage of 3DIDS in Atwa et al. (2012) research were both voluntary and ended up yielding contradictory results. This implies there could be more social variables influencing OTs’ decision to use
technologies. To sum up, the role of social influence in therapists’ decisions on adopting technologies is therefore still ambiguous and more research needs to be conducted.

2.4.4 Facilitating conditions (FC)

Facilitating conditions are “the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system” (Venkatesh et al., 2003: 453). This factor deals with topics such as perceived behavioural control; compatibility, i.e. the fit of the technology into users’ values, needs and standard way of working; and facilitating conditions, e.g. guidance, special instructions or assistance. All constructs assess potential organisational and technological barriers that could hinder the usage of new technology. According to the authors, facilitating conditions directly affect the actual usage of a new technology. In OTs’ context, facilitating conditions may include for example clinics’/hospitals’ financial or educational support as well as OTs’ perception of 3D printing technology fit into their work style.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Constructs</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facilitating</td>
<td>Perceived Behavioural Control</td>
<td>“Reflects perceptions of internal and external constraints on behaviour and encompasses self-efficacy, resource facilitating conditions, and technology facilitating conditions” (Venkatesh et al., 2003: 454)</td>
</tr>
<tr>
<td>Conditions</td>
<td>Facilitating Conditions</td>
<td>“Objective factors in the environment that observes agree make an act easy to do, including the provision of computer support” (Venkatesh et al., 2003: 454)</td>
</tr>
<tr>
<td></td>
<td>Compatibility</td>
<td>“The degree to which an innovation is perceived as being consistent with existing values, needs, and experiences of potential adopters” (Venkatesh et al., 2003: 454)</td>
</tr>
</tbody>
</table>

FC: Acceptance of other new technologies by OTs and PTs

Liu et al. (2014) found that facilitating conditions were directly influencing PTs’ current use of new rehabilitation technologies. Particularly, if good facilitating conditions, e.g.
scheduling, support and favourable environment are provided, the more likely PTs use the technology. More examples of favourable facilitating conditions were obtained in the following studies.

Chen and Bode (2011) conducted a survey with 736 OTs to identify factors and barriers playing a role in OTs’ decision to acquire new technology devices, e.g. prostheses with electrical muscle stimulation, cognitive aids or Wii-Sports a VR sport game. The availability of pre-service, research information and the space requirements were important acquisition factors for OTs. Logistics, e.g. time to set up new technology devices, and the fit of the devices to the setting were perceived as important use factors while the lack of technical support represented a barrier to use new technology devices.

Similarly, a study investigating OTs adoption of assisted living technology, e.g. alarms or sensors, found that if time for proper assisted living technology assessment and prescription process was constrained, it represented barriers to its adoption (McGrath et al., 2017). Finally, likewise was found by Wherton et al. (2015). The authors organized workshops where telecare and te-health customers cooperated with health carers and other parties. The research revealed that health carers needed organisational support, e.g. allotted time for training, information sharing and better financial incentives to enhance telecare/te-health usage.

**FC: Acceptance of 3D printing technology by novice users**

In terms of compatibility, two studies assessing the adoption of 3D printing technology by novice users found that perceived compatibility had a positive impact on the intention to use 3D printing technology. Namely, when novice users perceived 3D technology to be compatible with technologies they currently use at work, with their needs and past working experience, their intention to use 3D printing technology was positively stimulated (Wang et
al., 2016; Chatzoglou & Michailidou, 2019). This implies that if OTs perceive the use of 3D printing technology in the organisation as fitting into their working style and needs, its usage will be facilitated and enhanced.

**FC: Financial Investment**

Moreover, the implementation of 3D printing technology is dependent on other factors as well. As Chen and Bode (2011) found in their surveys with OTs, initial financial costs represented a significant factor in decisions about acquiring new technologies. The same was found by Seifert et al. (2016), namely OTs selected apps based on (among others, e.g. operating system) their prices. Price of the technology may thus influence the adoption of 3D printing technology into occupational therapy.

Not only the price of the printer itself, but also the price of the material could be an important decisive factor for OTs. Buehler et al. (2016) shed a light on OTs’ attitudes towards the prices of 3D printing material. In this study, OTs co-created a hand grip with researchers. From what they understood about the 3D printing material expenses, the OTs did not seem to show a great financial concern, on the contrary; they believed the 3D printed grips would be cost-effective. Nevertheless, it would be interesting to know OTs’ attitudes towards prices of other 3D printed AT as well.

Furthermore, the prices of 3D modelling software and 3D printer represent additional investments. Besides, OTs would most likely have to undergo a training and be provided with further technical assistance (Buehler et al., 2016), which also represents financial investments and potential financial barriers for the clinics and first-line OTs.

To sum up, the consulted literature suggests that compatibility of 3D printing technology with OTs’ current working style has a positive effect on its acceptance. Also, the OTs need organisational and technical support, information, favourable environment and
allotted time for training. Despite the general price overview, there seems to be little literature that captures OTs’ attitudes towards 3D printing investment costs. Hence, more research is needed to investigate this topic.

2.5 Conclusion

The consulted literature suggests that factors such as job performance (effectiveness, clients’ outcomes), usefulness, effort expectancy (complexity of software, 3D modelling, 3D dimensions, a steep learning curve, time effort), facilitating conditions (favourable environment, organisational support, allotted time for usage and training, information sharing and compatibility) will play a relevant role in OTs’ decision to use 3D printing technology. However, more research needs to be done about the role of safety, OTs’ perception of 3D printing materials (quality and price) and responsibility. Also, there are some contradictory findings about social factors and little is known about OTs’ attitudes towards 3D printing expenses.

By qualitatively assessing all four factors from UTAUT model, more attitudes towards social influence and financial expenses should be provided. Moreover, some consulted literature studied these factors in slightly different settings, i.e. either different technology or different user group that has different motivations and needs. These studies are also often quantitative studies, i.e. missing the explanations of OTs’/novice users’ opinions. Hence, the current study will be of a qualitative nature, with focus solely on OTs and 3D printing technology. Also, the existing literature about OTs and 3D printing technology used small samples (e.g. 5 or 4 OTs) that provide only narrow insights into the topic. To provide more insights, the current study will aim to use a larger sample size. Furthermore, two studies (Buehler et al., 2016 and McDonald et al., 2016) suggested that some OTs’ 3D printing technology perceptions might be influenced by their inexperience with the technology. To
observe whether this is true, the effect of hands-on experience with the technology on OTs perceptions of 3D printing technology will be studied.

These methods, also a bigger sample size and a hands-on experience will (1) help to assess factors that might play a relevant role in 3D printing technology acceptance by OTs and (2) help to understand how hands-on experience with 3D modelling software affects OTs’ acceptance of 3D printing technology.
3 METHODS
In order to answer both research questions, the research is divided into two studies: (1) interview study, answering the first research question and (2) hands-on experience study, answering the second research question. The following Figure 1. demonstrates a visual representation of the methods used in both studies.

3.1 Study 1: Interview study
To answer the first research question, i.e. to assess all possible factors influencing OTs’ acceptance of 3D printing technology, 14 semi-structured interviews with 17 OTs were conducted (12 with one OT, one with two OTs and one with three OTs). This number allowed for in depth understanding while not producing huge volume of superficial data. The concept ‘acceptance of 3D printing technology’ was operationalized by assessing four factors from UTAUT model. The interviews allowed to assess factors playing a role in OTs’ readiness to adopt 3D printing technology and also helped to understand why some do/do not play a role. Additionally, this method helped to identify other factors that were not anticipated by the theories of technology acceptance or from the consulted literature.

Participants
The participants were recruited by convenience sampling with the help of Zuyd Hogeschool occupational therapist team. An email was sent to the team’s and researcher’s network. The interview participants were 17 Dutch professional occupational therapists. The participants had no to little hands-on experience with 3D printing technology or 3D modelling.

**Materials**

An audio recorder was utilized to record the interviews and a printed material (Appendix 2) was used to demonstrate a few images showing examples of DIY fabricated technology. An interview protocol (Appendix 3) was used to guide the semi-structured interviews. The interview protocol had a broader focus as it covered two related studies. The questions that were relevant for the present study are questions 6a, 6c - 6e, 7c - 7f.

In the original survey, Venkatesh et al. (2003) uses the constructs definitions (see Table 1-4) to create scale items for survey purposes. In this research, the same constructs definitions were used to create interview questions (and focus group topics that will be described in Study 2). The interview questions aimed to cover all the elements that were part of the original construct definitions. Three constructs were not used to create interview questions i.e. extrinsic motivation (PE), social factor (SI), and social norm (SI), as they were not considered relevant for the current research. Table 5 demonstrates the relation between UTAUT constructs and interview questions followed by prompting questions based on literature review.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Constructs</th>
<th>Definition</th>
<th>Interview questions</th>
<th>Literature based prompting questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Performance</td>
<td>Percieved</td>
<td>“The degree to which a</td>
<td>7c. What impact do you</td>
<td>Usefulness</td>
</tr>
</tbody>
</table>

Table 5. UTAUT model, factors, constructs (Venkatesh et al., 2003), interview questions and prompting questions
<table>
<thead>
<tr>
<th>Expectancy</th>
<th>Usefulness</th>
<th>Person believes that using a particular system would enhance his or her job performance&quot; (Venkatesh et al., 2003: 448)</th>
<th>Think using 3D printing would have on your job performance?</th>
<th>Job effectiveness/Clinet’s outcomes/Materials/Safety/Quality/Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Job-fit</td>
<td>‘How the capabilities of a system enhance an individual’s job performance” (Venkatesh et al., 2003: 448)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative Advantage</td>
<td>‘The degree to which using an innovation is perceived as being better than using its precursor” (Venkatesh et al., 2003: 449)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outcome Expectations</td>
<td>‘Outcome expectations relate to the consequences of the behaviour…” (Venkatesh et al., 2003: 449)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Effort expectancy</td>
<td>Perceived Ease of Use</td>
<td>‘The degree to which a person believes that using a system would be free of effort” (Venkatesh et al., 2003: 451)</td>
<td>6c. To what extent do you expect that you would be able to use the software for 3D printing?</td>
<td>Time effort to learn/work with the technology/Confidence to learn/Perceived 3D modelling difficulty and software complexity</td>
</tr>
<tr>
<td>Complexity</td>
<td>‘The degree to which a system is perceived as relatively difficult to understand and use” (Venkatesh et al., 2003: 451)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Use</td>
<td>‘The degree to which using an innovation is perceived as being difficult to use” (Venkatesh et al., 2003: 451)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Influence</td>
<td>Image</td>
<td>‘The degree to which use of an innovation is perceived to enhance one’s image or status in one’s social system” (Venkatesh et al., 2003: 452)</td>
<td>7d. Imagine that you would be able to work with 3D printing technology. What impact would it have on your reputation as an OT?</td>
<td>Reputation of OTs among colleagues and other medical staff</td>
</tr>
<tr>
<td>Facilitating conditions</td>
<td>Perceived Behavioral Control</td>
<td>‘Reflects perceptions of internal and external constraints on behaviour and encompasses self-efficacy, resource facilitating conditions, and technology facilitating conditions” (Venkatesh et al., 2003: 454)</td>
<td>7f. Do you think it would be easy to incorporate 3D printing technology into your current work?</td>
<td>Organisational and technical support/Information support/Allotted time for training/Costs of technology implementation</td>
</tr>
</tbody>
</table>
Question 7c “What impact do you think using 3D printing would have on your job performance?” focused on first UTAUT factor, performance expectancy. The question was important as it gave insights into how OTs believe 3D printing technology would change their job performance. As the literature review revealed, variables that might be of importance are for example usefulness, job effectiveness, client’s outcomes, perception of materials, safety, quality and OTs’ responsibility. Therefore, these variables served as prompting questions.

Question 6c “To what extent do you expect that you would be able to use the software for 3D printing?” focused on the second UTAUT factor, effort expectancy. This question meant to analyse OTs’ perception of 3D printing technology difficulty. Variables based on literature research, such as time effort to learn/work with the technology, confidence to learn, perceived 3D modelling difficulty, and software complexity served as prompting questions.

Subsequently, question 7d “Imagine that you would be able to work with 3D printing technology. What impact would it have on your reputation as an OT?” aimed to provide insights into the third UTAUT factor, social influence. More specifically, OTs opinions about the impact of 3D printing technology usage on their image/job reputation were discussed.

Next, questions 7e “Do you think that 3D printing fits in your profession? Is this
compatible with your values and needs as an OT?” and 7f “Do you think it would be easy to incorporate 3D printing technology into your current work?“ were meant to analyse the last UTAUT factor, facilitating conditions. The questions meant to find obstacles and drivers of 3D printing technology implementation into OTs’ job and to provide information about technology fit into OTs’ work style.

Finally, question 6a, 6d and 6e (questions about added value, benefits and concerns of 3D printing technology usage) helped to analyse OTs’ general perceptions of 3D printing technology. These broader questions allowed OTs to come up with other factors that might influence the usage of the technology.

Procedure

After registering for the interviews, the OTs were contacted via phone by four interviewers and were fully informed about the purpose of the study and the procedure of the interview. An appointment for an interview at the work location of the OT or via Skype was made. The interview settings varied according to the agreed location with the participants.

At the day of the interview, the interviewees were first asked to sign an informed consent in which they agreed the interviews would be recorded. Seven of the participants were informed that the face-to-face interviews would take place in English, however they were ensured that it was possible to express some words in native language. The participants were also ensured that their identity would be protected and that any quotes used in the study would be anonymous. The participants were further informed that they could stop participating in the interview whenever they felt suitable. After the interview, the interviewees were debriefed about the study and were offered to receive the study results.

Data analysis
The audio recordings were transcribed and hand coded by one researcher using ATLAS.ti programme. The first step in the coding procedure was to code all excerpts directly related to the predefined categories, i.e. UTAUT constructs and literature-based variables (e.g. usefulness, safety, effectiveness, software complexity, compatibility). These codes were then organised into four main categories ‘performance expectancy’, ‘effort expectancy’, ‘social influence’, ‘facilitating conditions’ as subcategories.

Next, excerpts not directly related to predefined categories (e.g. excerpts about insurance, education, collaboration with specialist) were coded using inductive coding approach. This approach yielded new codes. The inductive analysis revealed that some of the new codes were to some extent related to the four main categories (e.g. education including 3D printing technology classes would result in less effort expectancy in the future). Therefore, codes that were to some extent related to the four main categories were additionally added into the four main categories as subcategories. The inductive analysis also revealed codes that were not related to the four main categories. These codes then created three separate categories (‘Current situation in OT’, ‘DIY approach’ and ‘AT development process’).

The coding procedure resulted in 7 coding categories and 30 codes (see Appendix 4). The coding structure (categories 1-4) is followed in the discussion of the findings in the result section. Insights that that were relevant according to the UTAUT model and the reviewed literature were discussed. Additionally, insights that were repeatedly said or that were very apparent in the majority of the interviews were discussed.

3.2 Study 2: Hands-on-experience study
The objective of the second study was to give OTs a realistic experience with 3D modelling software and to assess how this experience affects their acceptance of 3D printing technology. In order to achieve this objective, 6 OTs attended 2,5 hours workshop in 3D
modelling software Fusion 360. This workshop was provided by an authorized CAD trainer from Kaatsheuvel-based firm. Three methods were used to collect the necessary data.

(1) Single focus groups: In order to assess the change in attitudes, two 60 minutes focus group sessions with 6 OTs were held. One session was held before the workshop and one session was held after the workshop. The aim of the pre-workshop focus group session was to establish OTs’ attitudes towards 3D printing before the hands-on experience. The post-workshop focus group session enabled comparing post-experience attitudes to prior-experience attitudes.

(2) Questionnaires: Additionally, the OTs filled in a pre and post-workshop online questionnaire. The questionnaire covered the topics that were covered in the focus group, yet in more detail. The questionnaires allowed the OTs to answer the questions individually without peer influence and to compare participants’ pre-post attitudes complementary to the focus group session. The questionnaire did not serve any statistical measurements rather as a complementary method to quantify and visualise the findings on an individual participant level to illustrate the focus group findings.

(3) Observation: To complement the data generated from the focus group sessions, an observation took place while the OTs were modelling in the software. The observation was done by two researchers. The observation helped capture first impressions, attitudes and potential struggles OTs experience with 3D modelling software. Types of questions that participants asked the CAD trainer, e.g. software related or technically related, and types of comments and emotions e.g. positive or negative were noted.

Participants

The participants were recruited by convenience sampling, via LinkedIn, email and Facebook. A total of 6 Dutch professional occupational therapists that were able and willing to speak
English were recruited. This requirement was necessary as the researcher was not Dutch herself. The number of participants was based on the maximum training capacities in Kaatsheuvel studio, namely only 6 people could be trained during one training session. Five participants were female and one participant was male. Four participants had no experience with 3D printing technology while two of them had little hands-on experience with 3D printing technology. None of the participants had experience with 3D modelling before the workshop took place.

Materials

Six computers with Fusion 360 software were provided in the CAD training office in Kaatsheuvel. An audio recorder was used to record the focus group sessions. A video recorder was used to film the workshop.

The topics of the focus group sessions (Appendix 5 & 6) were based on Venkatesh et al.’s (2003) UTAUT construct definitions, similarly as interview questions in Study 1. These topics served as a structure for the discussions.

The first focus group covered seven topics. The first topic “What benefits and concerns, if any, do you see related to 3D printing for OTs?” served as an opening question and meant to let OTs express their initial opinions. The second topic “How do you think that 3D printing technology may change your job performance?” was related to performance expectancy factor. The third topic “Do you think using 3D printing technology will be easy or difficult for you?” covered effort expectancy factor. The four topic “Imagine you would be able to work with 3D printing technology, to what extent would it have an impact on your ‘imago’ among your colleagues/organisation?” was related to social influence factor. The fifth and sixth topic “Do you think it would be easy or difficult to incorporate 3D printing technology into your job?” and “To what extent do you think that 3D printing technology fits
into your work style/way of working?” covered the last UTAUT factor, facilitating conditions. The seventh topic was meant to let OTs come up with other factors that might influence their intention to use the technology “Apart from what we’ve already discussed, are there some factors that would stimulate and discourage you from using 3D printing technology?”

The second focus group covered 11 topics. The first four topics evaluated the workshop and aimed to capture OTs’ pre and post-workshop opinions. The seven remaining topics were identical to the seven pre-workshop focus group topics.

Both questionnaires (Appendix 7 & 8) used Venkatesh et al. (2003) UTAUT survey questions. Out of the original UTAUT 64 item questions, 39 questions rated on 5-point Likert scale (1- Strongly Disagree, 2 – Somewhat Disagree, 3 – Neither agree/disagree, 4 – Somewhat Agree, 5 – Strongly Agree) were selected. The item questions most relevant for this research were selected. The phrasing of the questions was slightly adjusted to the present study topic, e.g. “new system” was adjusted to “3D printing technology”. Also, the tense was changed from the present tense to the future or conditional tense, as the OTs had not worked with the technologies yet.

The pre-workshop questionnaire contained a total of 41 questions (name, experience with 3D printing technology and 39 UTAUT item scale questions). The post-workshop questionnaire contained a total of 42 questions (from which name and 39 UTAUT item scale questions were identical to pre-workshop questions. A question related to OTs’ experience with 3D printing technology was not included and two questions evaluating the workshop itself were added).

Procedure
Upon recruitment, a letter containing the purpose of the study and the procedure of the day was sent via email to the participants. A week before the day of the workshop a questionnaire was sent to the 6 OTs. Before filling in the questionnaire, the participants were informed about how the data would be used and were given the opportunity to withdraw from participation. By participating in the survey, the OTs gave consent to use their data. On the day of the workshop, the participants arrived to the office in Kaatsheuvel. Upon arrival, the purpose of the study, the procedure of the day and participant’s rights were explained personally again. The participants could then ask additional questions and signed the informed consent form related to the focus groups and observation.

Next, a pre-workshop focus group took place. Firstly, the researcher, the researcher’s assistant, the CAD instructor, and the goal of the focus groups were introduced. The agenda of the day was then presented to manage participants’ expectations. Subsequently, rules of the focus group were explained. Next, the prepared topics were discussed in a chronological order. The OTs were instructed to share their opinions freely. The researcher was a moderator, meaning she posed the questions, asked follow up questions, watched the time, made sure the participants stayed on topic and made sure everyone was included in the discussion. The researcher’s assistant helped making notes. After the pre-workshop focus group, the participants engaged in Fusion 360 workshop that was led by the CAD trainer.

During the workshop, the CAD trainer introduced and demonstrated how Fusion 360 software works, explained the difference between parametric and direct modelling, and how various types of 3D printers and 3D scanners work. He further explained the different types of materials, provided current prices of the technology, and demonstrated a few examples of 3D printed objects and how Ultimaker printer works. The trainer also demonstrated how to download a model from platforms as Thingiverse and explained the difference between various 3D files, e.g. STL. file and STEP. file. The participants then practiced orientation in
3D space, followed by both parametric and direct modelling of a couple of simple 3D forms. During the workshop, participants were observed.

Following the lunch break, the participants were asked to fill in a second online questionnaire. Finally, the participants were gathered for the post-workshop focus group session. The post-workshop focus group was semi-structured and followed the same procedure as the pre-workshop focus group. The researcher was a moderator while the research assistant was taking notes. The CAD trainer joined the post-workshop focus group and had a role of a specialist in the field, who could, in case of need, answer technical (e.g. software) and practical (e.g. prices) questions OTs posed.

Data analysis

The audio recordings were transcribed and hand coded with ATLAS.ti programme. The coding procedure started with dividing transcripts into pre and post-workshop data. Next, the coding procedure followed the same steps as the coding procedure in Study 1. The deductive and inductive coding methods yielded 13 categories and 27 codes (see Appendix 9). Insights that that were relevant according to the UTAUT model and the reviewed literature were discussed. Additionally, insights that were repeatedly said or that were very apparent in the majority of the interviews were discussed.

The questionnaire provided descriptive statistics, i.e. mean and median per person. No statistical analysis was further conducted as the sample was not meant for generalization of the data.
4 RESULTS
The following chapter is structured in two parts; the first part discusses the main factors that might be important for OTs’ acceptance of 3D printing technology. This section is mainly based on interview findings, additionally indicating if these are consistent with the pre-workshop focus group findings. The second part discusses solely workshop findings, addressing the change of OTs’ perception of 3D printing technology stimulated by the workshop.

4.1. Factors important for OTs’ acceptance of 3D printing technology
Both the interview and workshop participants had no to little experience with 3D printing technology. Therefore, a few OTs had difficulties to imagine how 3D printing technology works, how much it costs and could not estimate its impact on their profession. Despite the occasional difficulties, the following factors were identified as playing a role in OTs decision to use 3D printing technology.

4.1.1 Factors within Performance expectancy
*Usefulness: Better fit & Improved client satisfaction*
All interviewed OTs perceived several relative advantages of 3D printing technology. The most common advantage was a precise fit between 3D printed AT and clients’ needs. The interviewed OTs thought that 3D printing technology would allow for a better fitting, personalized ATs compared to the commercial ATs. This is due to the fact that the commercial ATs do not always fit to all clients, as one OT explained every patient is unique:

“I do think it is an advantage that it then fits exactly. If you have a knife for example, that someone needs to use for cutting that you can then make a grip that fits in his hand exactly instead of a standard grip.” Two OTs noted that due to the personal fit, clients would
diminish the risk of getting pressure spots that are common with commercial ATs. All workshop participants had very similar views, anticipating an added value of a personal fit.

Next, 14 OTs voiced that client’s satisfaction would improve not only due to precise fit but also due to other reasons. Namely, eight interview participants and all workshop participants were convinced that 3D printed AT would be more aesthetically appealing, subtler, professional-looking, fun and colourful, which could potentially encourage clients to use it. For instance, one OT noted some clients need a special fork to eat with; however, they can be hesitant to bring the special fork to public places, such as restaurants. The OT expected that a subtler-looking 3D printed AT would stand out less and would make the AT faster acceptable.

Materials

Another discussed factor was the material of the 3D printed AT. Seven interview participants anticipated better quality of 3D printed AT. For example, one OT believed that the wide material assortment would ensure better quality of AT materials. Also, three OTs assumed 3D printing material is more durable. Namely, one OT pointed out some of the current materials tend to discolour relatively quickly, e.g. foam, wherefore the OT thought the 3D printing material is more durable and easier to keep clean. Also, two OTs saw an advantage of the weight of the 3D printed AT, e.g. compared to leather or wooden AT, as 3D printed material would offer a lighter solution.

Safety and responsibility

With reference to safety and responsibility, the participants showed mixed opinions. Five interviewed OTs were not preoccupied about these factors. For example, according to one OT, the on-going adjustments made on current AT do not have to be approved by CE either.
Another OT believed the 3D printing material would represent the same risks as the current materials: “*When we make splints and we do it from the wrong material then you also have risks (...) so I don’t see much risk in this. Or different than the risks you have now.*”

Nevertheless, a total of six OTs expressed concerns related to 3D printing materials. Namely, two interviewed OTs were worried that the material could be too sharp and too hard for certain purposes, e.g. a hand splint. One OT noted: “*Like I said, a key, perhaps it’s not a problem that is very hard. You can polish a key. But no one will wear a very sharp splint.*” Similarly, four workshop participants were concerned about the material. For example, one OT worried about the consequences of a broken 3D printed AT and the injuries it could cause to the patient. Furthermore, two interviewed and three workshop participants showed slight worries as the current AT is being tested and self-developed 3D printed AT would miss a safety label.

As for the responsibility, the majority of interview and workshop participants realized they would become responsible for any issues related to 3D printed AT, yet did not explicitly remarked worries about this factor.

*Productivity & Efficiency*

In total nine OTs expected the technology to make their work more productive and efficient. More specifically, two interviewed OTs expected to decrease the number of clients’ visits. During these visits the clients try out the prototyped AT and OTs make adjustments to the prototype if necessary. The OTs anticipated that with 3D printed AT that offers a precise fit, less visits would be necessary, one OT noted: “*[Now], I have to come three times back to customize, but with the 3D printer you can really do it a little bit better, a little bit more precise, so I think you don’t have to go 3x back to customize it.*”. Furthermore, one interviewed OT thought the process of delivering AT would become quicker. As he
explained, the current AT delivery time can sometimes take too long due to a lengthy back-and-forth communication with AT suppliers, which is also believed to be perceived as annoying by clients. Similarly, three workshop participants expected the technology to deliver AT faster. For example, one OT believed that working independently on the 3D AT without any external help would diminish number of meetings with specialists. Also, one interviewed OT and one workshop participant believed that keeping a 3D model copy for new prints would speed up the AT developing process. Lastly, one interviewed OT saw benefit of that the 3D printer can print without the need of her presence, allowing her to attend clients or work on other tasks while the 3D object is being printed out.

*Concern: Time constraint & Extra clients’ demands*

Nonetheless, other OTs believed that the development time of 3D printed AT and extra client demands might affect their productivity. Namely, eight interviewed OTs were concerned about the time it would take to develop the 3D printed AT. The interviews revealed that OTs have only a certain amount of time, i.e. usually 25 minutes up to a maximum of 60 minutes per patient visit, during which they often have to develop the AT. This time limit created some concerns. One OT noted: “How long it takes before something like that comes out. How long it takes before you’ve measured something like that, because you only have a maximum time slot of 25 minutes, right. And by then we must have realized this.” This concern was related to insurance. Namely, the OTs explained that the work on AT they do outside of the client hours is not declarable. If the AT is not declared, it then becomes too expensive for the client. One OT noted: “But yes, I only have an hour. I need to make everything in that time (...) because you can only declare the time you spend with a client.” Hence, if the development process took too long, the 3D printed AT would become unaffordable for the clients. Consistent remarks were found in the workshop where four OTs voiced worries about
the time spent on developing the 3D printed AT, i.e. if this time outside of the clients’ hours would be declared by insurance.

Moreover, two interviewed OTs were concerned about the time it would take to adjust the 3D printed AT (e.g. tweak the 3D printed AT after first fitting sessions or based on the client’s future needs). For example, one OT noted: “...you have to bring all that data into your 3D model before you print it. And if it is printed, it is hard to alter because of the material (...). So you can alter it and reprint it but that is tedious and expensive process instead of just altering it the way we do that now, which is - use a heat gun and you are done in 2 minutes.” The other OT explained that the fine tuning of AT currently takes approximately up to 60 minutes, and anticipated that to tune the 3D printed AT would take from 2 up to 4 hours, which was seen as a drawback.

Lastly, two workshop participants showed worries that the wide range of options would create (extra) demands from clients, which would result in less productive work. One of the OTs explained: “I think when people are really used that you make something especially for them then you will be less productive because you will have to spend time for every patient to make something exactly as they wish for.”

Concern: Number of caseloads

Finally, the frequency with which the technology would be used seems to be of importance as well. Four OTs anticipated the technology to provide solutions to a relatively small number of their clients. Namely, 5%-30% of clients are estimated to need special solutions whereby 3D printing technology could be of help. The relatively small proportion of clients using the technology indicates that the technology might not be used that often. Yet, the small frequency of 3D printing technology utilization might not be sufficient for all clinics to be worth the purchase. Namely, eight OTs expressed their opinion to make the 3D printing
technology efficient/worthy, especially in smaller centres, it would have to be used frequently, i.e. on a large percentage of clients.

4.1.2 Factors within Effort expectancy

Need for education

The research revealed the OTs’ need for education in new technologies. All interview and workshop participants were willing to learn and work with 3D printing technology, yet they realized that it is a new technical skill they would firstly have to acquire. Namely, five interviewed OTs explained that their education did not prepare them for similar work and expressed the need to be professionally trained or educated in order to work with the technology. Besides, one interviewed OT explained, the majority of occupational therapists do not standardly have a natural technical ability: “You need to make technical drawings for this I think, but that isn’t a standard skill of an OT and most of them don’t have a natural technical ability.”

Regarding education, an interesting fact was repeated. Namely in the past, OT education encouraged OT students to create and adapt AT themselves, yet the current OT education lacks this feature, mostly due to a wider range of AT ready-made options on the market. One OT noted: “I learned a wee bit of adapting and materials but so little, so enormously little of the time of the education was spent on learning making adaptations and learning materials (...) so it is something we probably lost.”

Lastly, four interview participants and two workshop participants had slight concerns about when they would be able to invest time into learning the technology, as their days are full with patients and other clinical duties. One OT explained: “I have to learn it and it takes time, and I do not have a lot of time. I am completely full with patients, I have clinic duties and there is not a lot of time to invest in this technology.”
Confidence to learn & difficulty of the software

A stimulating factor for the technology usage was OTs’ confidence to learn working with the technology. Even though nine interview and all workshop participants believed that working with 3D printing technology would be very technical and/or difficult, all participants demonstrated general confidence in learning to 3D model. This was due to a few reasons. First, two OTs pointed out that most of the OTs have a HBO\textsuperscript{2} background, which, the two OTs believed, should make it easier to learn working with new technologies and programmes. Second, one OT explained that if there is a need for such technologies or enjoyment while working with them, the complexity should not represent an obstacle. She also believed that over time it is possible to learn it, as any other systems/programmes: “With word and excel and mail, you learn naturally how to work with that over the years. And if you have a new declaration system or a registration system or you are on a new working place, you also have to learn new things. So I don’t think this will be totally different.” Third, one OT was confident that the technologies would become even more user-friendly in the future and hence easier to work with.

Nevertheless, four interviewed OTs voiced that when the design would become too complex, they would prefer to delegate the job or to cooperate with a specialist e.g. instrument maker or 3D modelling designer. One OT explained: “So like the simple things and like the splinting, yes. That is very useful. But very difficult, complicated things that use a lot of effort to put into the computer in the right way, I don’t think we are going to do that. We’ll use specialised persons for that.”

Cooperation with specialists

\textsuperscript{2} HBO - Dutch university of applied sciences. A degree that is professionally oriented.
The possibility of cooperation with specialists was favoured among the majority of OTs. Namely, only one interviewed OT mentioned that due to his enthusiasm and interest, he would find it a shame not to work with the 3D printing technology himself. However, the rest of the interviewed OTs preferred working with a specialist to working alone. Mainly since letting someone help to design and print AT would save time and provide support, as one OT noted: “I think it’s easier to involve someone who will do that for you, than for me to become able to do all of that myself.” Also, seven interviewed OTs believed that the specialists have more knowledge of the technology or/and experience. For example, one OT believed that the specialist utilizes the technology more often and hence has more equipment and experience than she would have: “But to do it, again, I would do it too infrequently to do it well. So I’d be crazy not to involve a specialist who can do that easily.” Another interviewed OT mentioned that cooperation with specialists from other fields would offer fresh ideas. Additionally, three OTs remarked that delegating the work to instrument makers would offer cheaper ATs, as the working hours of OTs are more expensive than working hours of instrument makers.

Nevertheless, four interviewed OTs showed concerns about such cooperation. More specifically, two OTs believed it would cost more money to let two people work on the AT. One OT remarked: “But I’m also not sure whether it is cost-effective to have two people working on the same thing.” What is more, one first line OT believed she would have to pay for such cooperation herself since insurance companies do not cover these expenses, e.g. salary of a specialist. The OT believed this makes the cooperation between first line OTs and specialists unfeasible. Lastly, one OTs was worried that the cooperation would prolong AT delivery time due to communication lags between the two parties.
4.1.3 Factors within Social influence
The impact of 3D printing skills on job status evoked mixed opinions among the OTs. Six interview and four workshop participants did not believe the ability to work with 3D printing technology would have a dramatic impact on their image and/or that it was important. For example, one OT noted: “I don’t think it really matters to be honest. That it changes my reputation, I don’t think so. No.”

Nonetheless, ten interviewed OTs thought the new skill would have a positive impact on their reputation/image, mostly because they could deliver more professional, more durable and higher quality AT. One OT reasoned it by the fact that nowadays the proactive approach to learning new skills already gives a better image. Another OT remarked that the occupational therapist are seen as “soft” compared to other healthcare providers and this skill would allow them to deliver more factual, tangible products, which was believed to have a positive impact on OTs’ image: “...so I think that we’re always seen as soft and that this would allow us to do more concrete things. So you could just say ‘I can do this’. It makes it more concrete. So it would be good for our reputation I think.” Furthermore, two interviewed OTs believed that the reputation of the company would prosper and expressed their enthusiasm and desire to be among the first ones to use the new technology.

Lastly, none of the interview or workshop participants thought OTs’ salaries would increase after being able to work with the technology. This was due to the fact that they perceived it as any other OT specialisation, and as one OT explained, OTs’ salaries belong to a fixed salary group in the Netherlands.

4.1.4 Factors within Facilitating conditions
Compatibility
Overall, the technology seems to fit into OTs’ work style, which creates a facilitating condition for the technology implementation. Solely one interviewed OT noted that the
technology would be a partial help as customizing/creating AT is only a small part of her job: “But it’s [creating and customizing AT] still only a small part of our job I think like observing, watching, talking, advising, coaching that will always be the main part, and this helps us.” Similarly, only one workshop participant, who is working predominantly with adults, providing cognitive rehabilitation, noted that 3D printing technology fitted little into her work style. However, 15 interviewed OTs thought that 3D printing technology fitted into their current job as it would aid them to provide even better solutions to clients. Similar situation was echoed by five workshop participants who work with children with various handicaps, elderly, or in the first line. These participants believed that the technology fit well into their work style, as it enhances the work they perform.

Potential obstacles for 3D printing technology implementation

The integration of the technology seems to depend on several factors. Namely, five interview and three workshop participants believed that the integration depended on investment costs, e.g. costs of equipment and training. The cost factor was mainly important for OTs working in small practices or in the first line. One OT from a small practice noted: “… that’s a smaller practice there the issue of cost will be a big thing when making it.” Additionally, four workshop participants were rather sceptical about receiving allotted time for 3D modelling courses from the organisation. As one OT explained, the organisations would perhaps provide finances for the courses, but the OTs would have to attend the course outside of their working hours3: “…we had 8 hours in a year, or something like that, that we get from the organisation and the other courses you have to do in your own time. You get the money for the courses, that’s what you get, but the time you have to do on your own.”

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3 Note that a full 3D modelling course in Fusion 360 takes 4 days (29 hours) (Basiskursus Inventor, n.d.)
Favourable conditions for 3D printing technology implementation

A few favourable conditions for the technology implementation were identified as well. Four interviewed OTs noted it would be possible for bigger institutions, such as revalidation centres to purchase the technology, as those already have employees specialized in customization of ATs, e.g. instrument makers. Also, four OTs working in organizations that aim to be leaders in innovation believed they would be supported in implementing the technology into their jobs.

Next, one interviewed OT believed that if there were some initiators among the OTs themselves, who would strive to have the technology at their organisation, it would stimulate the implementation. This idea was repeated during the workshop, where four OTs believed that if more colleagues in the organisation would show interest and initiatives, the organisation would be quicker open to experience the new technology. What is more, the workshop participants believed that if none of their colleagues would show interest and initiatives for 3D printing technology, it would be nearly unfeasible to integrate it into their jobs.

Lastly, three interviewed OTs thought that if the technology would clearly prove its value, i.e. that the OTs could create ATs in an easier, faster and cheaper manner and that the clients would benefit from it as well, employers might not be as hesitant to invest money in it. One OT explained: “Yes. If it makes you much faster, or if it provides people with lots of benefits, or uh... Then the added value should be very clear, then I guess you would be willing to buy something or to invest in it or something like that.” The same idea was voiced by five workshop participants who believed they would firstly have to demonstrate the technology value to the organisation. Only if the organisation would see the added value, the OTs believed they would receive support in its use.
4.2 The impact of hands-on experience with 3D printing technology on OTs attitudes

4.2.1 The impact of hands-on experience on PE
Before the workshop, all six participants anticipated an added value of the technology, namely the possibility of personalisation, e.g. a personal fit or personal colour. This anticipated added value was confirmed with the workshop.

However, the major part of discussion in the post-workshop focus group shifted predominantly towards concerns. First, before the workshop, four OTs had concerns about the 3D printing material. This safety concern remained after the workshop, especially when considering children, one OT noted: “Yeah maybe the safety of the plastic. When you work with small children is it safe when they chew on it or put the thing in their mouth?”

Second, before the workshop, the group of OTs’ were unsure how adjusting of 3D printed AT would work in practice. For example, one OT assumed it would be possible to add extra 3D layers on an already 3D printed AT: “I thought you could print this and then say oh I need two more layers on top of it...I figured that would be possible, but yeah...that’s not.” After learning that these options were not feasible, four OTs showed signs of disappointment, perceiving the 3D printed AT as a definite product that is hard to adjust. Already during the workshop one OT responded “that is a shame” as a reaction to this realization. Furthermore, after the workshop, three OTs became unsure if they would be able to adjust the 3D printed AT without knowing the material characteristics. Namely, they started seeing issues with changing the AT’s dimensions e.g. from children to adult size, as the new length would need to correspond to the new width of the AT to remain stable.

Third, before the workshop, four OTs voiced doubts about whether it was feasible to fit the development process of 3D printed AT into the clients’ hours. During the workshop itself, four OTs started explicitly voicing a worry about the lengthy development. After the workshop, a total of five OTs realized the development process would take significantly
longer than they thought before the workshop. The finding is supported by the questionnaire results, showing that four of the six participants had less positive views on the task accomplishment speed after the workshop (see Figure 2).

The time it would take to develop the 3D printed AT was also the reason why, after the workshop, all participants became sceptical about using the technology at work. One OT noted: “Also the drawing costs time. When you are drawing 8 hours for some very difficult thing, you can see seven patients.” Even a 3D scanning scenario, e.g. creating the AT form from play dough, 3D scanning it, printing it and finally adjusting it seemed to be lengthy for the OTs. As one OT explained, she has too many patients to invest more than 30 minutes to 60 minutes to each of them for these purposes: ”...but now it takes too long to say ‘oh I make something for one client’ because I have like 40 clients every week and it is not possible.” A half of the OTs, perhaps also therefore, had sceptical thoughts about increased productivity. As the questionnaire results demonstrate, three OTs were more negative after the workshop concerning their productivity (see Figure 3).
Four OT mentioned that if the technology offered fast and easy 3D scanning or if they could use a template to which the software adapts measurements automatically, it would offer more acceptable prospects to OTs’ busy schedule. For example, one OT noted: “…like you have a prototype and you can just fill in the measurements from this specific client and then you have it adapted in the right size. Then that would be ok.”

4.2.2 The impact of hands-on experience on EE
Before the workshop, all six OTs believed 3D modelling would be complex. After the workshop, four OTs realized 3D modelling was more difficult and took more time to learn than anticipated. This was partly reasoned by the newness of the technique, i.e. working in a software to which OTs have to insert exact measurements differs from their current working techniques where they create ATs from materials such as clay or play dough. One OT noted: “Because you can’t do it hands on...because you have to do it on the screen and you are not used to it in your daily life in your daily profession.” The results are captured in the questionnaire where four out of six OTs perceived learning to work with 3D printing technology harder after the workshop (see Figure 4).
Furthermore, before the hands-on experience, the workshop participants did not explicitly express the need to be educated to work with the technology. Yet, after the workshop, four OTs expressed a strong need to be professionally trained and to practice thoroughly before offering 3D printed solutions to their clients. As one OT noted: “...and that the programme you have to use it needs a lot of schooling because you won’t figure it out yourself.” One OT came up with an idea for a special minor or a whole education programme for OTs that would specialize in 3D printing and other emergent technologies: “I think as long as the OT education is just this (...) for elderly people or children and for all the different settings (...) it won’t work. I think when you have more specialization in you education it would be more possible.” The rest of the OTs agreed that such educational preparation would make it easier for OTs to work with new technologies.

What was not anticipated: Both before and after the workshop, all OTs believed they would be able to learn to work with the technology. However, the option of working with a specialist who would create 3D drawings started becoming preferred during the workshop, when one OT remarked that cooperation would be the best solution. After the workshop, the
cooperation was preferred by all OTs, especially for more complicated designs. One OT remarked: “Before [the workshop] I thought maybe I can do it by myself, now I think I need somebody to do it, yeah not only if you need something.” Interestingly, two OTs believed that the orthopaedic instrument maker would be the most suitable person to develop 3D modelling and printing skills in order to collaborate with the OTs: “…they [orthopaedic instrument makers] already have those kinds of skills…they are more technical maybe then I am as an OT.”

Lastly, after the workshop, five OTs realized developing 3D printed AT would take too much time from other duties. As one OT noted: “…it is a small part of what you are doing during the day, because you also do a lot of advisement, training…” These findings are captured in the questionnaires too; where five out of six OTs agree that the use of the technology would leave less time for other OTs’ tasks (see Figure 5).

4.2.3 The impact of hands-on experience on SI

Before the workshop, four OTs thought their job status would not necessarily change. This opinion remained stable in the post-workshop focus group. Two reasons for this opinion were
given. First, one OT explained OTs’ job status is not as important in occupational therapy:

“The world where we are working, the medical world, it is not like doctors have - if you are a surgeon you have more status. In the rehabilitation centre even the doctors and therapists are even.” Second, the post-workshop revealed that the four OTs did not see 3D modelling as an extra skill but as any other OT specialisation, which also partly explains why some OTs did not explicitly agree the job status would improve. These findings can be seen in the questionnaire results where only two OTs explicitly think the job status would improve (see Figure 6).

![Graph showing attitudes towards 3D printing technology and job status](image)

Figure 6. 3D printing technology and job status

**What was not anticipated:** After participating in the workshop, five OTs realized the status of their organization would increase. This was due to the fact that the organisation would become an expert in 3D printed AT potentially attracting new clients. This was especially the case if the organisation would be one of the few in the region. One OT believed that the organisation could therefore become a “stronger player” when dealing with insurance companies.
4.2.4 The impact of hands-on experience on FC

Before the workshop, only one OT did not think the technology fitted into her work style. In the post-workshop focus group, still solely two OTs thought the technology did not fit into their work style, as they believed the task of creating 3D printed AT should be a task of a rehabilitation technician or it should be a new type of OT specialisation. Yet, four OTs believed that the technology fit into their work style. For example one OT noted: “*That you want to adapt something specially for one person that really fits in how OTs work.*” This pattern is clearly captured in the questionnaire (see figure 7).

![Bar chart showing the fit of 3D printing technology into OTs' work style](image)

**Figure 7.** 3D printing technology and its fit into OTs’ work style

*What was not anticipated:* After the workshop, all OTs believed it would be more difficult to integrate 3D printing into occupational therapy than they had thought before the workshop. This was due to the learned financial costs, the perceived difficulty of the software, time investment, and little expected organisational support. The only exception regarding positively perceived organisational support was one OT (Participant C) working within a company that already has an innovation management, investigating possibilities of other technologies (see figure 8).
4.2.5 Other Factors

The workshop participants came up with an idea of a ‘data bank’, where they could share each other’s designs to save time, work and to help each other: "If you can...umm...use designs from other people as well that would also be nice. So if I invented this special thing for the knife it would be nice that you could use it too and you don’t have to do it all over again." One OT was positive that designs from other countries, that are believed to be further in OT development, could be prosperous for the Dutch occupational therapy. The OTs were not concerned about copyrights, perhaps only if the design took several months, they would consider asking a little fee.
5 CONCLUSION & DISCUSSION

5.1. Relevant factors for 3D printing technology acceptance in occupational therapy

The first aim of the study was to investigate factors that play an important role in OTs’ acceptance of 3D printing technology. The purpose was to identify stimulating factors and factors that may prevent OTs from accepting the technology, halting the opportunities of delivering customizable, affordable and more indispensable assistive technologies to people with unique impairments.

This research confirms findings from previous studies and contributes with new insights. Namely, the study revealed that OTs have certain expectations about the technology that should be met in order to stimulate its acceptance and usage. Firstly, as was indicated by related literature about PTs, OTs and novice users, (Liu et al., 2014, Seifert et al., 2016, Wang et al., 2016 and Chatzoglou and Michailidou 2019), usefulness, clients’ outcomes, and the technology’s impact on job performance are important factors in 3D printing technology acceptance by OTs. This research contributes to previous findings, more specifically, OTs anticipate 3D printing technology to provide a precise fit of 3D printed AT and improved clients’ satisfaction in terms of colours, faster delivery process and professional, aesthetically appealing, personalized look, which should stimulate AT usage.

What is more, OTs also expect the technology to make their work more productive and efficient. Therefore, it is crucial for OTs to develop and adjust 3D printed AT fast enough, i.e. in the allotted client hours; else the 3D printed AT will not be declarable by insurance.

Moving forward, the study revealed that the technology should be utilized frequently to be cost-efficient by providing solutions for ideally larger number of patients. Similar results were found by Chen and Bode (2011) where therapists’ decisions to acquire new
technology devices for stroke rehabilitation depended on, amongst others, sufficient number of caseloads that would use the technology device.

Furthermore, despite their overall learning confidence, OTs desire to be professionally trained or educated in order to work with the technology. However, concerns about the learning hours and their busy schedules are strongly present, similarly as in related studies, e.g. Atwa et al. (2012), Buehler et al. (2016), Buehler et al. (2014). Not enough allotted time for training may therefore halt OTs from learning to use the technology.

Interestingly, the OTs seem to be willing to work with the designs that are simple, yet with more complex designs delegating the job to a specialist, such as an instrument maker, or 3D designer is preferred. According to the current study, the cooperation with 3D designer should be both efficient and financially feasible. These results are consistent with Buehler et al. (2016) whose study pointed at a new job specialisation, i.e. somebody between an AT expert and an OT, who would be educated to solely work with 3D printers and 3D modelling software.

According to the majority of the interviewed OTs, 3D printing technology fits into their job and thus increases the likelihood of technology acceptance. Yet, it seems to be the case that the fit of the technology depends on the OT specialisation and the extent to which OTs currently create/adapt AT.

Regarding investments, small practices and first line OTs may have difficulties implementing the new technology due to its costs. Moreover, organisational/colleagues’ incentives and organisational acknowledgment of the added value of 3D printing technology are important factors contributing on the technology implementation. These findings align closely with Dijkers et al. (1991) research, where OTs required a proof of cost-effectiveness of robotic technology, for it to operate in the clinics.
Additionally, the present study provides new insights into the role of safety of 3D printing technology, 3D printing materials, OTs’ responsibility and social factors. Namely, OTs anticipate, compared to the current AT, the 3D printed AT to provide longer durability, e.g. easily cleanable materials, and better quality of the 3D printing materials. Despite the mixed opinions about the material safety, the increased responsibility does not preoccupy the majority of the OTs and thus does not seem to be a threat to 3D printing technology acceptance. In terms of salary prospects, OTs do not foresee any financial remuneration for the newly acquired skill. Hence it seems to be the case that their interest in 3D printing technology is not driven by any financial rewards and those seem therefore insignificant regarding 3D printing technology acceptance. Lastly, social factor remains a subject of mixed opinions, since some OTs believed their image was not important, while others believed they could prove their professional worth with the newly acquired skill. To conclude, the answer to the first research question is summed up in the following table overview.

*Table 2. Factors playing a relevant role in acceptance of 3D printing technology in occupational therapy.*

<table>
<thead>
<tr>
<th>Factor</th>
<th>Description of factor</th>
<th>Stimulator/Barrier</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>Usefulness, i.e. high personalisation options of 3D printed AT</td>
<td>Stimulator</td>
</tr>
<tr>
<td></td>
<td>The quality and durability of 3D printed AT</td>
<td>Stimulator</td>
</tr>
<tr>
<td></td>
<td>Long development process</td>
<td>Barrier</td>
</tr>
<tr>
<td></td>
<td>Small frequency use of the technology/ small number of caseloads profiting from the technology</td>
<td>Barrier</td>
</tr>
<tr>
<td>EE</td>
<td>Not enough allotted time for training</td>
<td>Barrier</td>
</tr>
<tr>
<td></td>
<td>Possibility of cooperation with 3D designer</td>
<td>Stimulator</td>
</tr>
<tr>
<td>FC</td>
<td>Fit of the technology to occupational therapy</td>
<td>Stimulator</td>
</tr>
</tbody>
</table>
High investment costs (especially applies to small practices and first line OTs) | Barrier
---|---
Organisational and colleagues’ incentives | Stimulator
Employers’ acknowledgment of the added value 3D printing technology represents for occupational therapy | Stimulator

5.2. The effect of a hands-on experience with 3D modelling software on OTs’ acceptance of 3D printing technology

The second aim of this study was to investigate how a hands-on experience with 3D modelling software (Fusion 360) influences OTs’ acceptance of the technology, i.e. the perception of UTAUT factors. The workshop strengthened OTs’ views about the usefulness, more specifically personalization possibilities of 3D printed AT. The personalisation possibilities of 3D printed AT thus indeed stimulate the technology acceptance.

Furthermore, while OTs’ social image does not seem to be a relevant decision maker in 3D printing technology acceptance, the OTs realized the organisational image could prosper from the technology usage and might thus encourage 3D printing technology acceptance.

The workshop also confirmed several issues OTs encounter with the technology. Namely, the hands-on experience strengthened the safety concern of 3D printed AT, especially regarding children, supporting McDonald et al.’s (2016) expectations about unregulated and non-medically tested 3D printed AT representing concerns for therapists. These findings indicate the importance of safety of 3D printed AT to some OTs. It could be the case that the safety of 3D printed AT is more important to OTs working with children rather than adults.

Moreover, learning to develop, developing and adjusting 3D printed AT seems to affect OTs’ decisions to accept 3D printing technology, it is namely longer than the therapists
expected. These perceived drawbacks could explain OTs’ strong post-workshop preference for cooperation with specialists, e.g. a 3D designer.

The workshop also evoked OTs’ need for professional training and/or education. This need can be explained by the perceived difficulty of the software which was also found in similar studies (e.g. Hudson et al., 2016, and McDonald et al., 2016). Namely, even though the OTs anticipated the technology to be difficult to learn, their expectations were exceeded.

Lastly, while the workshop validated generally positive opinions about the technology fit into occupational therapy, it also confirmed that the technology would be difficult to integrate due to little expected organisational support, investment costs and the technology difficulty. All in all, the 3D modelling hands-on experience generated more negative than positive reactions of occupational therapist towards 3D printing technology usage in their profession. The following table sums up the effect of the hands-on experience.

Table 3. Hands-on experience with 3D modelling software effect on occupational therapists’ acceptance of 3D printing technology.

<table>
<thead>
<tr>
<th>Factor</th>
<th>Effect of hands-on experience on OTs</th>
</tr>
</thead>
<tbody>
<tr>
<td>PE</td>
<td>Affirms positive opinions about personalisation possibilities that 3D printing technology offers</td>
</tr>
<tr>
<td></td>
<td>Affirms concerns regarding safety and the lengthy development process</td>
</tr>
<tr>
<td></td>
<td>Evokes disappointment regarding adjustment of 3D printed AT</td>
</tr>
<tr>
<td>EE</td>
<td>Increases perception of 3D modelling difficulty</td>
</tr>
<tr>
<td></td>
<td>Evokes concerns regarding required learning time</td>
</tr>
<tr>
<td></td>
<td>Creates a need for professional education</td>
</tr>
<tr>
<td></td>
<td>Creates a preference for collaboration with 3D printing specialists</td>
</tr>
<tr>
<td>SI</td>
<td>Evokes positive opinions regarding beneficial influence of technology usage on organisational image</td>
</tr>
</tbody>
</table>
5.3 Implications

This study is a first exploratory study addressing 3D printing technology acceptance by OTs. The UTAUT-based framework helped to provide a systematic, qualitative analysis, presenting findings that contribute to a better understanding of the potential stimulants and obstacles to the usage of 3D printing technology in occupational therapy.

Additionally, the present study yielded several practical implications. First, in order for the technology to fit into OTs’ tight schedules, the technology/software designers should offer fast and easy 3D scanning options and/or provide 3D model templates of AT that would be automatically adapted based on clients’ measurements. This proposition is in line with McDonald et al. (2016) who recommended (automated) 3D modelling software that would offer standard AT measurements and AT items.

Besides, based on OTs’ preferences, the present study suggests setting up collaborations between OTs and 3D printing experts who would draw 3D models in the software. This collaboration seems to be more suitable for OTs especially when it comes to more complex 3D designs.

Next, to avoid the issue with steep learning curve of 3D printing technology and deficient time for training, OTs should be educated about the technology preferably already at schools. Similar was demonstrated by Seifert et al. (2016) and Verdonck et al. (2011), who both found that OTs would prosper from an undergraduate, postgraduate and professional education about new technologies, i.e. smart device applications and electronic AT. In this case, OT students would benefit from an education (re)incorporating not only adaptation techniques and materials, but also new technologies, e.g. 3D printing technology. The
curriculum could have topics whereby the OTs could learn for example, design in 3D modelling software, understand the difference among various 3D modelling formats, be able to download and customize existing 3D designs, be able to operate 3D printers, 3D scanners or be able to choose appropriate materials. In this manner, OTs would already have a basic knowledge, experience and confidence when they would start working, mitigating the steep learning curve that 3D printing technology entails.

Furthermore, to stimulate the technology implementation, the present study suggests creating a shared international OT database with a library full of 3D AT templates. This database would reduce the amount of work on each model and speed up the development process. Moreover, the database could encourage OTs’ initiatives for working with 3D printing technology and could connect OTs so they could exchange their knowledge. The OTs’ desire for a database is echoed in the study of Buehler et al. (2016) and the need for such database for novice users of 3D printing technology is also mentioned by Wang et al. (2016).

Finally, regarding investments, the implementation of 3D printing technology would be more feasible by bigger institutions and/or organisations with already existing innovation initiatives. Those practices would simultaneously provide a higher chance for a sufficient number of caseloads for the technology to be cost-efficient. For small practices and first-line OTs governmental or insurance support is necessary.

5.4 Limitations
The study has several limitations. Firstly, the study was a small-scale exploratory study. Thus, the results serve as initial insights into the topic and are not generalizable to the Dutch occupational therapist population. It could be the case that additional relevant factors would be identified having had a larger sample size.
Another limitation of the present research is that only one interpreter (the researcher) coded the transcript data and hence calculation of inter-rater reliability was not possible. Having had a second interpreter could have provided more validity to the codes and interpretations of the data.

Next, despite providing visual images and brief explanations of 3D printing technology to the interviewed OTs, due to their inexperience and lack of knowledge about the technology, it was challenging for some (8/17 OTs) to assess the impact of the technology, the prices or the development process. Hence, it seems to be the case that a primary thorough introduction to the technology and/or primary hands-on experience would yield more accurate estimation of the technology acceptance.

Moreover, the workshop took 2.5 hours. It could be the case that a longer training could have a different effect on changes in technology perception. For example, according to Venkatesh et al. (2003), effort expectancy is less significant with more exposure to the new technology, suggesting that the bigger the experience the OTs would gain with 3D printing technology, the smaller the role effort expectancy would play in their decision to accept the technology. It would be interesting to explore how and if a longer training, e.g. 4 days, influence the results.

Finally, it is important to note that the participants in the workshop study worked in one of the many 3D modelling software, i.e. Fusion 360. It could be the case that a workshop in a different software with a different trainer could yield different results, e.g. even more novice user-friendly software could increase OTs’ confidence to work with the technology independently, diminishing the need for cooperation with specialist or vice versa.
5.5 Future research

Future research could validate the present findings with a larger sample size to provide quantitative results generalizable to the Dutch OT community. Such study could also allow understanding the strength of the relationships between the found factors and OTs’ intentions to use 3D printing technology.

Furthermore, the present study did not investigate the impact of moderating variables such as age, gender, or experience on OTs’ intention to use 3D printing technology, owing to the exploratory nature of the research. Besides, the current sample size would not allow for any statistical measurements of the moderating impact of these variables on the intention to use the technology. Hence, future studies could investigate how these variables influence the relationship between the discussed factors and the intention to use 3D printing technology. For example, according to Venkatesh (2003), it could be the case that the usefulness and efficiency of 3D printing technology will be more important for male and younger OTs, whereas organisational support will be more important for older OTs.

As the results showed, OTs have a strong preference to work with a specialist that would help them to create 3D printed AT. Future studies should therefore provide more insights into the collaboration possibilities among OTs and 3D technology specialists, e.g. the role of the OTs in this collaboration, the degree of involvement of the specialist, or the desired frequency/manner of the communication between the two parties.

The research demonstrated that OTs perceive Fusion 360 difficult to use, partly due to the fact that it represents a different way of working compared to the current way of working, i.e. 3D models vs. actual models from play dough/wood. Therefore, different ways to make the software easier to use for OTs should be researched as well.

Besides, the workshop gave insights into the mixed opinions about the fit of the technology into occupational therapy. Namely, it seems to be the case that the technology fit
depends on the specialisation of an OT, e.g. hand therapy, first-line, neurology, etc. It would therefore be interesting to conduct research with OTs who have different specialisations to better understand which OTs specialisations benefit from 3D printing technology usage the most.

Similarly, the present research indicates the extent of the safety concern might depend on OTs’ specialisations, e.g. children specialisation. Hence, more research is needed to clarify the relationship among 3D printed AT safety, OT specialisations and OTs’ intentions to use 3D printing technology.

Also, the study was exploring a (still) voluntary usage of 3D printing technology in occupational therapy. However, as Venkatesh et al. (2003) pointed out, there is a difference in voluntary usage context and mandatory usage context. It would be interesting to know if the same results were found once OTs are obliged to use the technology in their practice. For example, a future research could compare data from two OT groups. One OT group that uses the technology only as an optional method and one OT group that is required using the technology whenever deemed necessary.

Finally, the results of the present study showed that OTs are interested in educational programme that includes specialisation in 3D printing technology. Therefore, future research could investigate how to incorporate 3D printing technology into OT educational curriculum. For example, future research could interview 3D printing specialists and OT teachers in order to specify and establish new curriculum requirements.

5.6 Conclusion

Three dimensional printing could aid OTs in developing highly customized assistive devices. Despite identifying several stimulants that encourage OTs’ interest and willingness to use 3D printing technology, there clearly exist obstacles that might prevent OTs from developing customized solutions for their patients. It is therefore of utmost importance that future
research continues examining these obstacles to mitigate their effect. Additionally, to create favourable conditions for OTs, educational institutions should consider updating OTs’ curriculum with a focus on 3D printing technologies, and 3D printing technology designers should look into fastening/simplifying the 3D printing development process. Last but not least, it would be beneficial if 3D modelling designers, together with OTs, specified optimal conditions for mutual collaboration.
REFERENCES


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## APPENDIX

### Appendix 1: Overview of the literature reviewed in the literature study

<table>
<thead>
<tr>
<th>Author</th>
<th>Topic</th>
<th>Method</th>
<th>In which Subchapter(s)?</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Acceptance of new technologies by OTs</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Schaper and Pervan (2007)</td>
<td>ICT and OTs: A model of information and communication technology acceptance and utilisation by occupational therapists</td>
<td>Focus groups &amp; Survey</td>
<td>Effort expectancy Social influence</td>
</tr>
<tr>
<td>Atwa et al. (2012)</td>
<td>Occupational therapists’ perceptions about the clinical utility of the 3D interior design software</td>
<td>Focus groups</td>
<td>Effort expectancy Social influence Facilitating conditions</td>
</tr>
<tr>
<td>Seifert et al. (2016)</td>
<td>Apps in therapy: occupational therapists’ use and opinions</td>
<td>Survey</td>
<td>Performance expectancy Facilitating conditions</td>
</tr>
<tr>
<td>McGrath et al. (2017)</td>
<td>Investigating the enabling factors influencing occupational therapists’ adoption of assisted living technology</td>
<td>Interviews &amp; Focus groups</td>
<td>Facilitating conditions</td>
</tr>
<tr>
<td>Wherton et al. (2015)</td>
<td>Co-production in practice: how people with assisted living needs can help design and evolve technologies and services</td>
<td>Co-designs</td>
<td>Facilitating conditions</td>
</tr>
<tr>
<td><strong>Acceptance of 3D printing technologies by novice users</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Authors and Year</td>
<td>Study Title</td>
<td>Methodology</td>
<td>Key Factors</td>
</tr>
<tr>
<td>-----------------------</td>
<td>-----------------------------------------------------------------------------</td>
<td>------------------------------------</td>
<td>----------------------</td>
</tr>
<tr>
<td>Chatzoglou and Michailidou (2019)</td>
<td>A survey on the 3D printing technology readiness to use</td>
<td>Survey</td>
<td>Performance expectancy, Facilitating conditions</td>
</tr>
<tr>
<td>Hudson, Alcock and Chilana (2016)</td>
<td>Understanding Newcomers to 3D Printing: Motivations, Workflows, and Barriers of Casual Makers</td>
<td>Interviews</td>
<td>Effort expectancy</td>
</tr>
<tr>
<td>Buehler et al. (2016)</td>
<td>Investigating the Implications of 3D Printing in Special Education</td>
<td>Interviews &amp; Observations</td>
<td>Performance expectancy, Effort expectancy, Facilitating conditions</td>
</tr>
<tr>
<td>Buehler, Hurs and Hofmann (2014)</td>
<td>Coming to Grips: 3D Printing for Accessibility</td>
<td>Case study</td>
<td>Effort expectancy</td>
</tr>
<tr>
<td>McDonald et al. (2016)</td>
<td>Uncovering Challenges and Opportunities for 3D Printing Assistive Technology with Physical Therapists</td>
<td>Online survey, Collaborative Design Sessions with Instructors of physical therapy, and three classroom sessions with physical therapy students</td>
<td>Performance expectancy, Effort expectancy, Facilitating conditions</td>
</tr>
</tbody>
</table>

**Appendix 2: Visual materials used in the interview**

Examples of 3D printed assistive devices:

1 - 3D printed hand grip (Retrieved from: https://3dprint.com/126214/103dp-devices-for-the-disabled/)

3 - 3D printed “Niagara” foot (Retrieved from: http://protosthetics.com/niagara-foot/)

4 - 3D printed shoe sole used for bicycle (left: a 3D model; right: an actual product)
(Retrieved from: https://www.thingiverse.com/thing:1560036)
**Appendix 3: Interview protocol**

<table>
<thead>
<tr>
<th>1. CURRENT PROFESSION OF OCCUPATIONAL THERAPISTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1a. How would you describe the job of an occupational therapist?</td>
</tr>
<tr>
<td>1b. Can you tell me about the different kind of problems/needs you help your clients with? Note down the problems/needs the OT mentions</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. OT PROBLEM SOLVING PROCESS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Show interviewees the AT Care Process (printed) and refer to the 8 stages</td>
</tr>
<tr>
<td>2a. Are you familiar with this AT care process? Does this model represent the approach you take for assistive technology care? Go through the process step-by-step and annotate the AT Care Process with the participant: Cross out steps the participant does not apply Add steps the participant does apply but that is not in the AT Care process</td>
</tr>
<tr>
<td>2b. With whom do you collaborate in the process of finding a solution? In which steps of the process do you collaborate? Again annotate the AT Care Process with the participant: 1. Add persons the participant collaborates with ○ Think about: clients, manufacturers, engineers, colleagues, other health care professionals, informal caregivers, etc.</td>
</tr>
</tbody>
</table>
Indicate in which steps of the process (including steps that were added in Q2a) the participant collaborates with these persons (e.g. by drawing lines from the persons to each step) For each collaboration, indicate how the participant communicates with the other person (phone, voicemail, chat, email, F2F meetings, collaboration systems, ...)

<table>
<thead>
<tr>
<th>3. FIT BETWEEN CLIENTS' PROBLEMS/NEEDS AND EXISTING OT SOLUTIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3a. Do you sometimes encounter problems/needs of your clients for which you find that existing ATs offer insufficient solutions? What kind of problems/needs are these?</td>
</tr>
<tr>
<td>3b. What, in your opinion, seems to be the main reason why existing ATs sometimes offer an insufficient solution?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. CURRENT MAKING PRACTICES IN OCCUPATIONAL THERAPY</th>
</tr>
</thead>
<tbody>
<tr>
<td>4a. Do you sometimes make or adapt ATs for your clients yourself (either from scratch or by adapting existing ATs/situations)?</td>
</tr>
</tbody>
</table>
| 4b. How do you make or adapt such an AT? | ● Tools  
● Materials  
● ... Do you involve the client in this making/adapting process? How? Do you collaborate with others than your client to make/adapt an AT? Who? How? |
| 4c. How do you refer to such self-made ATs? What terminology do you use? | Think about: personalising, customizing, hacking, adjusting, making, creating, ... |

<table>
<thead>
<tr>
<th>5. ATTITUDES AND NEEDS REGARDING MAKING ATs</th>
</tr>
</thead>
<tbody>
<tr>
<td>5a. To what extent do you think that occupational therapists in general experience a need for being able to make/adapt ATs for their clients themselves?</td>
</tr>
<tr>
<td>5b. To what extent would you say occupational therapists in general are willing to make ATs for their clients themselves?</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. ATTITUDES TOWARDS DIY TECHNOLOGIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Explain 3D printing (or fabrication technologies)</td>
</tr>
</tbody>
</table>

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3D printing and other "fabrication technologies" such as laser cutting make it possible to fabricate physical products yourself, without having to rely on manufacturers. Show interviewees examples of 3D printing, laser cutting

Explain IoT

IoT enables us to add sensors to physical products. Imagine that you could add sensors to the ATs your clients use. This would enable the assistive devices to artificially perceive, hear, feel, taste or smell things that happen to or near the assistive device. Show interviewees the examples of IoT-enabled assistive devices. Explain that users and OTs can receive information about data the assistive devices collect over time.

<table>
<thead>
<tr>
<th>6a. What, if any, added value of 3D printing (or other technologies for creating physical products) do you see for OTs? Same question for IoT: What, if any, added value of adding sensors to ATs do you see for OTs?</th>
<th>If none: why not?</th>
</tr>
</thead>
<tbody>
<tr>
<td>6b. To what extent would you be willing to learn to use fabrication technologies to make solutions for your own clients? Same question for IoT: To what extent would you be willing to learn about ATs with sensors?</td>
<td></td>
</tr>
<tr>
<td>6c. To what extent do you expect that you would be able to use the software for 3D printing? Same question for IoT: To what extent do you expect that you would be able to use ATs with sensors with your clients?</td>
<td>Why (not)? Do you expect 3D printing software to be as easy/difficult to use as the software you already use today (like Word or a mail program)?</td>
</tr>
<tr>
<td>6d. What benefits, if any, do you see related to 3D printing for OTs? Same question for IoT: What benefits, if any, do you see related to ATs with sensors?</td>
<td></td>
</tr>
<tr>
<td>6e. What concerns, if any, do you have related to 3D printing for OTs? Same question for IoT: what concerns, if any, do you have related to ATs with sensors?</td>
<td></td>
</tr>
</tbody>
</table>

Imagine you would be able to create your own ATs with sensors, or to add sensors to existing ATs yourself. Show interviewee examples of Skweezees.

| 6f. To what extent do you see yourself create ATs with sensors, or add sensors to existing ATs? | Why (not)? |

7. EXPECTED IMPACT
Show interviewees the (annotated) AT Care Process again

7a. Which parts in the Assistive Technology Care Process would change if you would use fabrication technologies (3D printing) to create solutions for your clients?

Go through the process step-by-step and annotate the AT Care Process with the participant:
3. Mark steps in the process that would change. Would anything change about the process if you would use IoT technology? (only not annotate in the process)

7b. Imagine you would be making an AT for a client using fabrication technologies together with someone who has lots of experience with these technologies (a Computer-Aided Designer). How would you think/ feel about that? How would you like this collaboration to be like?
Same question for IoT: Imagine you would think of an idea for an AT with sensors for a client and someone with experience in this technology can make the AT for you. How would you think / feel about that? How would you like this collaboration to be like?

● Advantages ● Disadvantages
● OT's role ● Designer's role

7c. What impact do you think using 3D printing would have on your job performance?
Same question for IoT: What impact do you think using ATs with sensors would have on your job performance?

● Effectiveness ● Quality of solutions ● Time (quicker/slower) ● ...

7d. Imagine that you would be able to work with 3D printing technology. What impact would it have on your reputation as an OT?
Same question for IoT: Imagine that you would be able to work with ATs with sensors. What impact would it have on your reputation as an OT?

E.g. within the organisation you work for? E.g. from the viewpoint of other OTs?

7e. Do you think that 3D printing fits in your profession? Is this compatible with your values and needs as an OT?
Same question for IoT: Do you think that ATs with sensors fit in your profession? Are they compatible with your values and needs as an OT?

Why (not)?
Can ATs with sensors support you in what you find important? Can ATs with sensors make your job easier?
Do you think it would be easy to incorporate 3D printing technology into your current work? Same question for IoT: do you think it would be easy to incorporate ATs with sensors into your current work? Would your employer be willing to provide the technology? Do you think you would be able to afford the technology yourself?

Appendix 4: Interview codes

<table>
<thead>
<tr>
<th>Nr</th>
<th>Categories</th>
<th>Subcategory</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Performance expectancy</td>
<td>a factor PE (usefulness, impact on job performance, outcome expectations, safety, responsibility)</td>
<td>98</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b factor PE (relative advantages of 3D printing technology, i.e. client satisfaction)</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c materials</td>
<td>58</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d concerns 3D printing technology</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e insurance</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>f general attitudes towards 3D printing technology</td>
<td>39</td>
</tr>
<tr>
<td>2</td>
<td>Effort expectancy</td>
<td>a education</td>
<td>11</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b factor EE (ease of use, complexity, perceived ease of use - confidence)</td>
<td>55</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c attitudes towards collaboration with designer</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d perception collaboration with designer</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td></td>
<td>e willingness to use/learn to use 3D printing technology</td>
<td>15</td>
</tr>
<tr>
<td>3</td>
<td>Social influence</td>
<td>a factor SI (image)</td>
<td>33</td>
</tr>
<tr>
<td>4</td>
<td>Facilitating condition</td>
<td>a factor FC (compatibility)</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td></td>
<td>b factor FC (perceived behavioural control)</td>
<td>41</td>
</tr>
<tr>
<td></td>
<td></td>
<td>c finance</td>
<td>15</td>
</tr>
<tr>
<td></td>
<td></td>
<td>d time</td>
<td>9</td>
</tr>
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<td>AT development process</td>
<td>a process changes</td>
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<tr>
<td></td>
<td></td>
<td>b process changes (who pays the AT?)</td>
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</table>

Appendix 5: Topics discussed during pre-workshop focus group

1. What benefits and concerns, if any, do you see related to 3D printing for OTs?
2. Why else do you consider using it?
   - safety of 3D printed AT
   - responsibility
   - price of 3D printed AT
   - learning time
   - skills needed

2. How do you think that 3D printing technology may change your job performance?
   - faster/slower
   - quality
   - easier/more difficult
   - more productive/less productive
   - on what does it depend?

3. Do you think using 3D printing technology will be easy or difficult for you?
   - software modelling
   - printers managing
   - learning time
   - becoming skilful
   - intimidating
   - cannot control

4. Imagine you would be able to work with 3D printing technology, to what extent would it have an impact on your ‘imago’ among your colleagues/organisation?
   - why?
   - how exactly?
   - would it be important/stimulating for you?

5. Do you think it would be easy or difficult to incorporate 3D printing technology into your job?
   - on what does it depend do you think? - BARRIERS
     - instructions (instructor)
     - workshops

6. To what extent do you think that 3D printing technology fits into your work style/way of working?
   - why? (not)
   - values
   - needs
7. Apart from what we’ve already discussed, are there some factors that would stimulate AND discourage you from using 3D printing technology?

- prices
- courses
- education
- library - customising 3D models only, not modelling from scratch
- 3D scanning option

**Appendix 6: Topics discussed during post-workshop focus group**

1. How did you experience 3D modelling (working in Fusion360)?

- easier/more difficult than expected
- enjoyable/frustrating
- difficulties with what?

2. What was your perception of 3D printing technology before and after the workshop? Did it change?

- if yes how
- if not why not

3. What were the most important things that you have learned?

4. Would 3D modelling discourage you from including 3D printing technologies at your work?
   - what other ideas do you prefer/do you think are better (e.g. 3D scanning)

5. What benefits and concerns, if any, do you see related to 3D printing for OTs?
   - why else do you consider using it?

- safety of 3D printed AT
- responsibility
- price of 3D printed AT
- learning time
- skills

6. How do you think that 3D printing technology may change your job performance?

- faster/slower
- quality
- easier/more difficult
- more productive/less productive
- on what does it depend?
7. Do you think using 3D printing technology will be easy or difficult for you?

- software modelling
- printers managing
- learning time
- becoming skilful
- intimidating
- cannot control

8. Imagine you would be able to work with 3D printing technology, to what extent would it have an impact on your ‘imago’ among your colleagues?

- why?
- how exactly?
- would it be important for you?

9. Do you think it would be easy or difficult to incorporate 3D printing technology into your job?

- on what does it depend do you think?
- instructions (instructor)
- workshops

10. To what extent do you think that 3D printing technology fits into your work style/way of working?

- why? (not)
- values
- needs

11. Apart from what we’ve already discussed, are there some factors that would stimulate AND discourage you from using 3D printing technology?

- prices
- courses
- education
- library - customising 3D models only, not modelling from scratch
- 3D scanning option

Appendix 7: Pre-workshop questionnaire

1. What is your first name?
2. Have you ever worked with 3D printing technology before?

All following questions are answered using the following Likert-scale:
1- Strongly Disagree, 2 – Disagree, 3 – Neutral/Unsure, 4 – Agree, 5 – Strongly Agree
Performance Expectancy (PE)
3. I would find 3D printing technology useful in my job.
4. Using 3D printing technology in my job would enable me to accomplish tasks more quickly.
5. Using 3D printing technology in my job would increase my productivity.
6. Using 3D printing technology would make it easier to do my job.
7. If I used 3D printing technology I would increase my chances of getting a raise.
8. Use of the 3D printing technology could significantly increase the quality of output on my job.
9. Use of 3D printing technology could increase the effectiveness of performing job tasks.
10. Considering all tasks, the general extent to which use of 3D printing technology could assist on the job. (different scale used for this item).
11. Using 3D printing technology would improve the quality of the work I do.

Effort Expectancy (EE)
12. Learning how to use 3D printing technology would be easy for me.
13. I expect that my interaction with 3D printing technology would be clear and understandable.
14. I expect that it would be easy for me to become skilful at using 3D printing technology.
15. I would find 3D printing technology easy to use.
16. Using 3D printing technology would take too much time from my normal duties.
17. Working with 3D printing technology would be so complicated; it would be difficult to understand what is going on.
18. Using 3D printing technology would involve too much time doing mechanical operations (e.g., data input).
19. It would take too long to learn how to use 3D printing technology to make it worth the effort.

Social Influence (SI)
20. People who are important to me think that I should use 3D printing technology.
21. I would use 3D printing technology because of the proportion of co-workers who use the system.
22. In general, I believe that the organisation I work in would support the use of 3D printing technology.
23. I believe that people in my field who would use 3D printing technology would have more prestige than those who would not.

Facilitating Conditions (FC)
24. I believe I would have control over using 3D printing technology.
25. I believe I would have the resources necessary to use 3D printing technology.
26. I believe I would have the knowledge necessary to use 3D printing technology.
27. A specific person (or group) would be available for assistance with 3D printing technology difficulties.
28. Specialised instruction concerning 3D printing technology would be available to me.
29. Using 3D printing technology is compatible with all aspects of my work.
30. Using 3D printing technology fits into my work style.

Anxiety
31. I would hesitate to use 3D printing technology for fear of making mistakes I could not correct.
32. I expect 3D printing technology to be somewhat intimidating to me.

Attitude
33. Using 3D printing technology is a good idea.
34. I expect using 3D printing technology to be enjoyable.
35. 3D printing technology would make my work more interesting.
36. 3D printing technology is okay for some jobs, but not the kind of job I do (R).
37. I look forward to those aspects of my job that require me to use 3D printing technology.
38. I expect that using 3D printing technology will be frustrating for me (R).

Behavioural Intention to use the system (BIU)
39. I plan to use or intensify the use of 3D printing technology in the future.
40. I intend to encourage others to use 3D printing technology.
41. I intend to be informed about 3D printing technology and use it in the future.

Appendix 8: Post-workshop questionnaire

1. What is your first name?

All following questions are answered using the following Likert-scale:
1- Strongly Disagree, 2 – Disagree, 3 – Neutral/Unsure, 4 – Agree, 5 – Strongly Agree

Performance Expectancy (PE)
2. I would find 3D printing technology useful in my job.
3. Using 3D printing technology in my job would enable me to accomplish tasks more quickly.
4. Using 3D printing technology in my job would increase my productivity.
5. Using 3D printing technology would make it easier to do my job.
6. If I used 3D printing technology I would increase my chances of getting a raise.
7. Use of the 3D printing technology could significantly increase the quality of output on my job.
8. Use of 3D printing technology could increase the effectiveness of performing job tasks.
9. Considering all tasks, the general extent to which use of 3D printing technology could assist on the job. (Different scale used for this item).
10. Using 3D printing technology would improve the quality of the work I do.
Effort Expectancy (EE)
11. Learning how to use 3D printing technology would be easy for me.
12. I expect that my interaction with 3D printing technology would be clear and understandable.
13. I expect that it would be easy for me to become skilled at using 3D printing technology.
14. I would find 3D printing technology easy to use.
15. Using 3D printing technology would take too much time from my normal duties.
16. Working with 3D printing technology would be so complicated; it would be difficult to understand what is going on.
17. Using 3D printing technology would involve too much time doing mechanical operations (e.g., data input).
18. It would take too long to learn how to use 3D printing technology to make it worth the effort.

Social Influence (SI)
19. People who are important to me think that I should use 3D printing technology.
20. I would use 3D printing technology because of the proportion of co-workers who use the system.
21. In general, I believe that the organisation I work in would support the use of 3D printing technology.
22. I believe that people in my field who would use 3D printing technology would have more prestige than those who would not.

Facilitating Conditions (FC)
23. I believe I would have control over using 3D printing technology.
24. I believe I would have the resources necessary to use 3D printing technology.
25. I believe I would have the knowledge necessary to use 3D printing technology.
26. A specific person (or group) would be available for assistance with 3D printing technology difficulties.
27. Specialised instruction concerning 3D printing technology would be available to me.
28. Using 3D printing technology is compatible with all aspects of my work.
29. Using 3D printing technology fits into my work style.

Anxiety
30. I would hesitate to use 3D printing technology for fear of making mistakes I could not correct.
31. I expect 3D printing technology to be somewhat intimidating to me.

Attitude
32. Using 3D printing technology is a good idea.
33. I expect using 3D printing technology to be enjoyable.
34. 3D printing technology would make my work more interesting.
35. 3D printing technology is okay for some jobs, but not the kind of job I do (R).
36. I look forward to those aspects of my job that require me to use 3D printing technology.
37. I expect that using 3D printing technology will be frustrating for me (R).

Behavioural Intention to use the system (BIU)
38. I plan to use or intensify the use of 3D printing technology in the future.
39. I intend to encourage others to use 3D printing technology.
40. I intend to be informed about 3D printing technology and use it in the future.

Evaluating workshop (different scale used for these two items)
41. To what extent did 3D modelling at Fusion 360 stimulate you to use 3D printing technology at your work?
42. To what extent did 3D modelling at Fusion 360 discourage you from using 3D printing technology at your work?

Appendix 9: Focus group codes

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<thead>
<tr>
<th>Nr</th>
<th>Main categories</th>
<th>Sub categories</th>
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