User Perception of Wearables in Everyday Learning Contexts: The Impact of Prior Device Experience

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Abstract. Wearable devices are ubiquitous technology, which is attached to the user itself, allowing it to be available in various everyday life settings. With the growing popularity and increasing affordability of smart wearables devices, their uses are also growing. Traditionally wearables have been used for health and fitness tracking, but now wearable are used for various educational purposes as well. Wearable devices can take the form of daily use accessories like a watch, glasses, clip, necklace, etc. The abundance of form factors brings the question of what preferences people have for these form factors and how prior experience shapes these preferences. In this paper, we explore peoples' attitudes towards different wearable form factors and their preferences of wearable form factors in an everyday learning context. We conducted a survey-based study to find differences between users with and without prior experience with wearable devices. This study will help designers understand why certain wearable devices are preferred and the role of prior experience. In the survey, nine different fictional scenarios of daily life were presented, and participants were asked to imagine themselves using a wearable for learning in those scenarios. Results show a significant relationship between users' prior device experience and which form factor of wearable device they prefer to use for learning. Also, participants with prior experience with fitness trackers rated the social influence of wearable devices significantly lower compared to participants without wearable experience.

Keywords: Smart wearables · Education · Survey · User attitude · Wearable experience

1 Introduction

With technological advancement, smart wearable devices are becoming increasingly embedded in daily lives with more and more features at the same time becoming more affordable. This technological advancement has also made technology compact and smaller in size, which had led to the availability of wearables in a variety of form factors ranging from head-mounted devices to smart

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footwear. Health monitoring has been one big area explored for wearable applications. While smart wearables are commonly used for fitness and health tracking [4], they also have untapped potential to support learning processes. Wearables have been explored to support learning in various educational contexts, but mostly in formal settings like in a lab [9], in a classroom [11], etc. Some of the past research work shows that wearables have the potential for informal learning in daily life as well. For example research by Huang et al. explore the use of wearable technology for piano skill learning [6]. Another paper by Shadiev et al. explores smartwatch as a tool for language learning and also coupled language learning with physical activity [15]. However, exploration in that space of wearables for informal or everyday learning has so far been exclusively conducted in research contexts. Hence, our work seeks to advance understanding of the potential of wearable use for learning among general users.

Wearable devices are typically strapped on the body of users and allow the user to have the devices available constantly to assist in a variety of situations in daily life. While in formal education the type of wearable to be used is mostly the decision of the instructor, school administrators, and other school management stakeholders, for informal learning, it is not the case. The choice of wearable type for informal everyday learning is solely dependent on users' preferences. The choice of users depend primarily on their perception and attitude towards technology, wearable cost and their experience [8]. This makes the investigation of people's attitude towards wearable devices and their preferences for wearable form factors to support informal learning in daily life an important question. Exploring differences between users with and without wearable experience will help designers understand why certain wearable devices are more preferred and the role of experience in people's attitudes.

We hypothesize that in the case of informal learning through wearables in daily life the choice of wearable type is heavily impacted by the person's prior experience with existing wearable devices in general. In this paper, we present our survey-based exploration to understand people's attitudes towards wearable for everyday learning in the context of prior experience. We conducted a survey-based study with 70 participants with 38 female and 32 male population. Through our analysis, we found that there is a significant relationship between the choice of wearable type for learning purposes and prior experience.

In the next section i.e. background, we discuss wearable capabilities and form factors. Followed by that, in the related work section, we talk about wearable exploration done in the past for learning purposes. We then state the research question that we are attempting to answer through this study. In the study section, we describe the participants, study procedure, and structure of the survey. Further, we describe the data gathering, filtering and statistical tests used. Finally, we describe the results and discuss the implication of our findings.

2 Background

Wearables that are commonly aimed for a specific task like health tracking and step tracking, now integrating seamlessly into our lives and can be used for more purposes than we can list. For example, wearable devices are now capable of biometric authentication, have virtual and augmented reality, allow for quick payments, have integrated virtual personal assistant, health monitoring through monitoring body vitals, activity tracking, stress tracking, etc. This became possible due to increased computational capacity, advanced sensors, and smaller chips. *Apple SE* watch is one of the latest smartwatches which has built-in sensors like accelerometer, gyroscope, GPS, Siri, etc. [7]. It has multiple functions like calling, texting, voice-based interaction, music, podcast, touchscreen, fall detection, activity tracking, contactless payments, weather forecast, etc. Further, these devices are more affordable than ever and are available in a wide variety of forms. Wearable devices come in multiple form factors, for example, smartwatch, wristband, smart glasses, smart ring, smart clip, smart necklace, smart bracelet, smart shoes, smart clothes, etc. These forms are inspired by the everyday accessory traditionally worn by people, and each form has its own aesthetic, function, and use requirements. Among all these form factors, a wrist-worn wearable device is the most popular and commonly used [1]. A possible reason for this popularity is the early presence in the market and ease of use for fitness purposes. In our study, we consider five major wearable form factors i.e. watch/wristband, glasses, clip, necklace, ring. Table 1 lists all the wearable form factors explored in this study along with a description and an example device.

Table 1. This table describes the five wearable form factors along with examples.

Form factor	Description	Example
Watch/Wristband	A wearable device which is wrapped around wrist of the wearer	Apple watch SE [7]
Glasses	Glasses that are smart and equipped with technology to play sounds or even display screen	Snapchat Spectacles 3 [17]
Clip	A wearable device that is clipped to any part of the clothing like clipped to pocket or to shirt neck	Ditto clip [16]
Necklace	A wearable device that is hanging around neck. It may or may not add to aesthetics	Bellabeat urban leaf [2]
Ring	A wearable device that is shaped like a ring and can be worn on fingers	NFC Ring [13]

3 Related Work

The use of wearables for learning is an emerging area of exploration with a lot of recent research. Wearables have been explored in the past for insitu science reflection in daily life [5]. In another paper, researcher explored smart glasses as a tool for providing a step-wise guide for science experiments in lab settings [11]. Another paper explored the use of smart glasses as an AR tool for everyday informal learning through supporting information gain in meaningful real-life context [14]. In yet another paper, smart glasses were explored for distance learning by facilitating live streaming sessions where the instructor can review students performing the task and provide real-time feedback [18]. Another researcher investigated the use of google glasses in art galleries for facilitating learning through a real-time projection of information related to the art being viewed [10]. Further, Bower and Sturman in his research explored the educational affordances of wearable devices [3]. This brought into light all the main ways of using wearable for learning-based activities as reported by the educators. Through analyzing the perception of educators with a good understanding of wearables, fourteen educational affordances were found. Some of these educational affordances of wearable were, providing insitu contextual information, recording educational events such as class, simulating educational procedures, communication in an educational context, etc. Clearly, we can see that there is an established potential of wearable for learning. Wearable explorations in the past, for understanding users' attitude, are mainly done in the context of fitness, and health care [12,21]. Despite this established potential, there is a lack of understanding of people's attitudes towards wearable for everyday learning. Although many people already have experience of using wearable for the regular purpose of health and fitness tracking, when the purpose transitions to educational use, the preferences of form factor may change. With multiple form factors available, choosing wearable type can be influenced by prior experience. Understanding how prior experience with wearable shapes users current preferences for educational use of wearable will provide researchers insights into prior experience as a factor in general.

4 Research Question

With more and more wearables available in the market, there is a plethora of options to choose from. Understanding how prior experience with wearable devices influence the choice of wearable type will guide wearable designers regarding the form of wearable devices meant for education and exploration purposes.

Our research question was as follows: **Do people's attitudes towards using wearables for learning in everyday life differ if they have actually used a wearable before as opposed to if they have not?**

5 Study

5.1 Study Design and Structure

We conducted a survey-based study to understand people's attitudes towards the use of wearables for everyday learning and to explore the relationship between prior experience and preference of wearable form factor. The survey consisted of 4 Major sections. First section aimed at collecting demographic information of the participants. Then different wearable types were demonstrated through images and example. These wearable devices were demonstrated through images in the survey to familiarize participants with wearable form factors and to understand what is referred to in the later part of the survey. In the study protocol, 5 different major wearable form factors namely, smartwatch/wristband, smart glass, smart ring, smart clip, smart necklace were considered and only these were demonstrated. Considering that there are variations in terms of style, material, and look even within these broader categories, participants were demonstrated at least two variations of each of these form factors. In the next section, participants were asked about their prior experience with wearable devices. They were mainly asked what type of wearable device they owned and for how long. Further, they were asked open-ended questions about how they would imagine using wearable for learning in their daily lives. In the third section, nine different fictional scenarios of daily life were presented, and participants were asked *"Without restricting yourself to current functions and abilities of wearable devices, how can you imagine using the wearable device to support your learning in this scenario?"*; *"What specific kind of wearable device do you think is the most suitable to use for the above scenario?"*. Six options were given for participants to choose from: smartwatch/wristband, smart glasses, smart clip, smart ring, smart necklace, and others; and the participants were asked to imagine themselves using a wearable for learning in those scenarios. "Without restricting yourself to current functions and abilities of wearable devices" was added to enable participants to freely imagine as they have not used wearable in an educational context before. These scenarios were crafted to portray different settings encountered in daily life. These scenarios were designed to vary in terms of formality of nature of scenario setting (i.e. scenario was in a formal setup or informal setup), different social interaction of the user in the setting (i.e. user is alone, with a person or in a group), level of familiarity with other interacting entities in the setting (i.e. user is with friends, family or strangers), and the users' physical mobility in the scenario (i.e. user is moving or is static). Table 3 shows the categories of all nine fictional scenarios in terms of formality of setting, interaction, familiarity, mobility. Some of the scenarios are listed in Table 2

Table 2. This table lists a few sample scenarios from the nine fictional scenarios presented in the survey.

Scenario ID	Scenario description
S3	You are driving home after class or work. Traffic is surprisingly light today. As you drive, you observe that the asphalt of the road ahead appears to shine, as if there is water on the road. But you know that it has not rained recently. You happen to be wearing a wearable device in your vehicle. Without restricting yourself to current functions and abilities of wearable devices, how can you imagine using the wearable device to support your learning in this scenario?
S4	You are at home watching your favorite show on TV. You feel somewhat chilly and decides that hot tea would be nice. You go to the kitchen to make hot tea for yourself while the show is on a commercial break. You want to get back to the living room before the show starts again. As you put the kettle on the stove, you wonder how long you have to stay in the kitchen until water starts to boil. You happen to be wearing a wearable device at home. Without restricting yourself to current functions and abilities of wearable devices, how can you imagine using the wearable device to support your learning in this scenario?
S5	You and your friends are waiting to order food at an authentic Greek restaurant. The restaurant is really busy and loud. This is your first time trying Greek food and you see one item on the menu, Saganaki, that contains shrimp. You love shrimp. But, you are also on a diet currently. You happen to be wearing a wearable device in the restaurant. Without restricting yourself to current functions and abilities of wearable devices, how can you imagine using the wearable device to support your learning in this scenario?

Table 3. Category variations in all nine fictional scenarios.

Scenario ID	Formality	Interaction	Familiarity	Mobility
S1	Not formal	With a person	Friends	On-the-go
S2	Very formal	Self in a group	Stranger	Static
S3	Not formal	Self	None	On-the-go
S4	Not formal	Self	None	Static
S5	Not formal	With person in a group	Friends	Static
S6	Not formal	With person in a group	Family	Static
S7	Somewhat formal	Self in a group	Stranger	Static
S8	Somewhat formal	With a person	Friend	Static
S9	Not formal	Self in a group	Stranger	On-the-go

In the final section, the UTAUT (Unified theory of acceptance and use of technology) scale was used with adapted items from [20] to evaluate attitude towards wearable use for learning in daily life. The questionnaire used a 7 point likert scale. which are explained below in the context of this paper.

– *Performance Expectancy* is defined as the degree to which an individual believes that using the wearable will help him or her to attain gains in learning.
– *Effort Expectancy* is defined as the degree of ease associated with the use of the wearable.
  Attitude Toward Using Technology is defined as an individual's overall affective reaction to using a wearable to support learning.
– *Social Influence* is defined as the degree to which an individual perceives that important others believe he or she should use the wearable.
– *Facilitating Conditions* are defined as the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the wearable.
– *Self-efficacy* is defined as the judgment of one's ability to use a wearable to support one's learning.
– *Anxiety* is defined as the degree to which a wearable evokes anxious or emotional reaction when it comes to using it to support one's learning.
– *Behavioral Intention* is defined as one's intention to use a wearable for learning in the future.

5.2 Study Participants

The study was approved by our university ethics board and it was conducted through the crowd-sourcing platform called Amazon Mechanical Turk. All participants were compensated through Amazon Mechanical Turk upon completion and a bonus was given for good quality survey responses. Criteria for good quality completion (i) if the duration of survey completion was more than 10 min, (ii) if answers were clearly related to the question, (iii) if the answer is not single worded, if answers were not duplicated and (iv) if the survey is not duplicated and submitted more than once. Consent was collected before starting the survey. Participants were free to withdraw from the study without any consequence. The survey was estimated to take less than an hour for completion. Participants took an average of 29 min to complete the survey.

A total of ninety-three completed survey responses were collected. These collected surveys were further reviewed for quality. Finally, 70 responses were selected after filtering (filtering criteria are described in the data filtration section). These 70 participants consisted of 38 female and 32 male. The average age of the participants was 35.93 years, with a minimum age of 19 years and a maximum age of 67 years. Out of the 70 participants, 58 were employed, while 12 were students. The study population consisted of 39 White/Caucasian, 17Asian, 5 Black/African American, 4 Hispanic/Latino, 2 American Indian/Alaskan Native, 2 multiple ethnicities, and 1 did not specify.

6 Data Analysis

6.1 Data Filtering

Before proceeding with the analysis, data were filtered to remove low-quality data. All the duplicate survey submissions were removed. Duplication was identified through submission IP, multiple duplicate responses and duplicate submission. Surveys fulfilling the following criteria were removed to improve the quality of response. (i) Surveys that took less than 5 min for completion. (ii) More than 5 repeated responses for open-ended questions. (iii) Multiple duplicated responses. (iv) Multiple unrelated and random responses.

6.2 Quantitative Data Analysis

All the survey responses were organized into a spreadsheet. All UTAUT questionnaire responses were organized by sub-constructs. For each participant average score of each sub-construct was used for representing a single score for that sub-construct. These average scores were used for running the statistical test. Non-parametric tests were used when data were not normally distributed or in case of uneven sample size. Participants' prior wearable experience was determined by their response to the survey question "Have you ever owned wearable devices before?". The "yes" response i.e. participant with prior experience were coded as 1, and the "no" response i.e. participant without any prior wearable experience was coded as 0.

In order to examine if *choice of wearable type* is significantly associated with *prior experience with wearables*, a chi-square test of independence was performed. To further understand how prior experience with a particular wearable type affects people's acceptance of wearable devices, participants with prior wearable experience were grouped by wearable type they previously owned. There were 3 groups formed, one having prior 'experience with smartwatches', another having prior 'experience with fitness tracker', and the third having 'experience with other' wearable types. The third clubbed group was created due to the fewer number of participants with experience with other wearable types like ring, necklace, etc. All these groups were compared with the no prior experience group. UTAUT scores were calculated again for each participant in each group. A non-parametric test called the Mann-Whitney U test was conducted due to the uneven sample size of the groups. This test was conducted to find if participants with prior experience with a particular wearable type rated UTAUT sub-constructs differently than those without prior experience. The significance threshold for all tests was set at .05.

7 Results

Out of the 70 participants, there were 18 without any wearable experience and 52 with wearable experience. These 52 participants had experience with one or multiple wearable types. Among these 52 participants, 8 have owned one type of wearable device, 23 have owned two wearable devices, 9 have owned three wearable devices, and 2 have owned more than three wearable devices. Figure 1 shows the distribution of different type of wearable devices owned by people with prior wearable experience. It was observed that the majority of participants with prior experience owned either a watch (50 participants) or fitness tracker (48 participants), as can be seen in Fig. 1. This was expected as smartwatches and fitness trackers are the most common form factor of a wearable device.

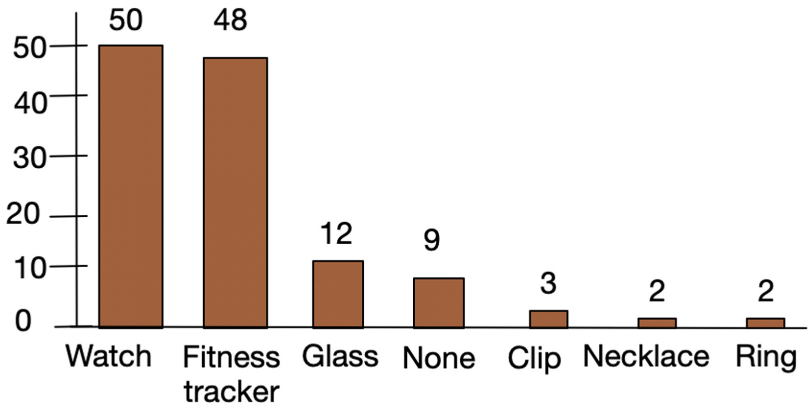

Fig. 1. Tables shows the distribution of different wearable types owned by the participants with wearable experience. There were total of 52 participants with wearable experience

In all the nine fictional scenarios combined, participants chose watch/ wristband, the maximum number of times (56.50% of times) followed by glasses (27.50% of the times). Figure 2 shows the percentage of times a particular wearable type was chosen by the participants. *Other* in the wearable type means wearable type other than the five listed wearable form factors. Participants listed *other* wearable type as smart clothing, smart ear buds etc. Further, we compared the choice of each wearable type by participants' experience. Figure 3 shows the distribution of preferences of different wearable types comparing participants with prior wearable experience with participants without wearable experience for all the nine fictional scenarios. The figure can be read for example as follows: 61.1% of the times, participants with prior wearable experience chose watch/wristband to be used for learning in those nine fictional everyday scenarios.

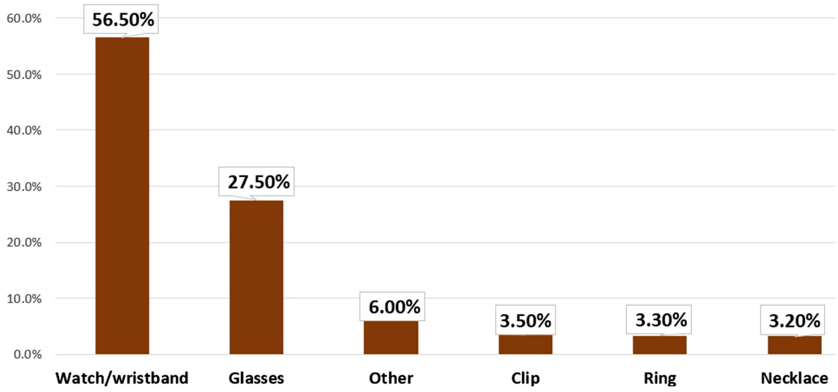

Fig. 2. Tables shows the percentage of each wearable form factor chosen across all the nine scenarios.

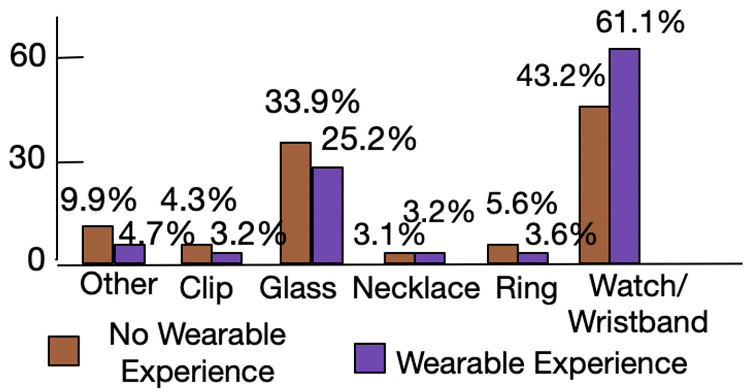

Fig. 3. Cross-tabulation from chi-square test of the presence of prior wearable experience by wearable type

The chi-square test on the combined responses across all the scenarios shows a significant relationship between the choice of wearable type for learning and prior wearable experience, as shown in Fig. 4, (X2(1, N = 630) = 19.18, $p < .005$). Figure 4 shows the number and percentage of each wearable type chosen, combined across all nine scenarios within participants with experience (Exp) and within participant without experience (No Exp). Results from the Mann-Whitney U test showed that people with prior wearable experience of fitness tracker scored significantly lower (Mean Rank = 27.63, Med. = 4.44, N = 42) compared to people with no wearable experience (Mean Rank = 37.19, Med. = 5.44, N = 18) on the social influence sub-construct. Social influence is the degree to which an individual perceives that important others believe he/she should use the new system.

Exp	% within	Glasses	Smartwatch /wristband	Clip	Necklace	Ring	Others
No Exp	Count	55	70	7	5	9	16
	%Within No Exp	34.00%	43.20%	4.30%	3.10%	5.60%	9.90%
Exp	Count	118	286	15	15	12	22
	%Within Exp	25.20%	61.10%	3.20%	3.20%	2.60%	4.70%

Fig. 4. Cross-tabulation from chi-square test of the presence of prior wearable experience by wearable type

8 Discussion

Many of the study participants have either owned or experienced wearable devices. As expected majority of participants have experience with smartwatches or wristbands. Results showed a significant relationship between choice of wearable type and prior experience. Experience is one of the primary ways to build the mental model of the use of any technology. With experience, the mental model of users' becomes richer in terms of what actions wearables can afford and possible ways in which they can see themselves using the wearable. Through experience, people also gain insights into what purpose a wearable can be used. Hence, they build a base on which they can further imagine what learning purposes a wearable can be used for. Further, having experienced one type of wearable makes it easier for people to see themselves using it for yet another purpose. Therefore, experience tends to significantly affect the choice of wearable type. Further, looking closely at the cross-tabulation of Chi-square results in Fig. 4, it can be seen that people with prior wearable experience tend to have a higher preference for a smartwatch/wristband 61.1% of the times) to be used to support learning in everyday scenarios followed by smart glasses (25.2% of the times). Interestingly, for people with no wearable experience, the choice of wearable form factor is more diverse, with the distribution being more spread out across the various wearable types. This shows that prior experience influences the choice for wearables even though wearables forms are constantly evolving, and specific wearable types may be more suitable for any one specific learning scenario. Also, the choice of wearable form factor seems to be guided by experience as the majority of the participants have experience with watch/wristband and they chose the same form factor. People with no prior experience, however, tend to be more open in terms of wearable form factors and may choose to go with the wearable type that seems most suitable for the everyday learning scenario. While the people with no wearable experience tend to be open to other wearable types, watch/wristband and glasses still remained the top choice compared to other forms. Possible reason for this could be the obvious popularity of watch/wristband due to early presence and glasses due to the popularity google glass. Another possible reason could be the presence of display on these two form factors is far higher than other forms.

Our results show that people with prior experience with fitness trackers rated social influence as less important than those without experience. In prior literature, a decrease in the importance of social influence was observed as people use technology over time ([19] as cited in [20]). This implies that social influence contribution to people's attitudes towards wearable devices for learning reduces with gain in experience with the devices.

9 Study Limitations

We acknowledge that assessing prior experience with wearable as binary variable is a limitation. Prior experience with a wearable might not mean an equal level of experience for all participants, as one participant might have used a simple version of a fitness band with just step count and activity tracking, whereas the other might have experienced the latest version of a smartwatch with advanced features like GPS, heart rate monitoring, activity tracking. It might not be a significant problem, as the participants were demonstrated various wearable within the same type to help them think more broadly. Moreover, participants were asked to imagine using wearable without limiting themselves to the current functions and capabilities of a wearable device.

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