Technology Acceptance Evaluation by Deaf Students Considering the Inclusive Education Context

Soraia Silva Prietch(✉) and Lucia Vilela Leite Filgueiras

Escola Politénica, Universidade de São Paulo, Av. Prof. Luciano Gualberto, Trav. 3, N. 158, São Paulo, Sao Paulo 05508-970, Brazil
soraia.roo@gmail.com, lfilguei@usp.br

Abstract. As a consequence of the National Policy on Special Education on the Perspective of Inclusive Education in Brazil, established in 2007, mainstream schools have begun receiving a greater number of Deaf or Hard of Hearing (D/HH) students that previously attended specialized schools. However, data point to the declining number of D/HH students enrolled from primary school to secondary school; i.e., there are reasons to believe that educational barriers are imposed on the means these students have of conquering a complete education. In this context, the goal of this work is to propose a technology acceptance model that takes into account constructs that involve aspects of the inclusive education context, as well as performing a pilot test on the interaction of 16 D/HH users with a mobile application, called SESSAI, to evaluate the model. SESSAI consists of a technology-mediated form of communication, which allows hearing persons and D/HH individuals to interact through an automatic recognition system. Among the constructs of the model, one of them refers to the potential educational barriers experienced by D/HH students in inclusive classrooms. With regard to research methodology, the study was developed in cycles of literature review and conduction of tests. The proposed model has shown positive results in capturing factors that influence technology acceptance given the domain specific context, since they incorporate aspects of pragmatic quality and hedonic quality (emotional user experience), and also considers issues related to perceived usefulness in minimizing potential educational barriers, future expectations, and facilitating conditions. We conclude that the model encompasses both users' personal motivation and context of use aspects, and it can be used for the purpose for which it was proposed. Further investigations need to be conducted in order to adjust the model questionnaire and to recruit a broader number of participants.

Keywords: Assistive technology · Technology-mediated communication · Country specific developments · Human-computer interaction · Media in education

1 Introduction

According to 2010 Brazilian census [13], the country's population reached 190.755.799 inhabitants; among which, approximately, 46 million declared themselves to have some kind of disability. Within this number, among people who are Deaf or

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Hard of Hearing (D/HH), over 300 thousand people informed census takers that do not hear any sound; almost two million people stated that they hear with great difficulty; and, over seven million people declared that they have some difficulty in hearing. Also, it was observed that people who are D/HH with an age between 0 and 50 account for 1.191.682 inhabitants, indicating an expressive number of potential students, from day care center assistance to adult education.

During the past decade, a growth in the number of students with disabilities enrolled in inclusive schools and a decrease in the number enrolled in special schools has been observed through the Brazilian education census [13]. Another observed statistic was the decrease in the number of students who are D/HH concluding primary and reaching secondary schools. In order to not segregate the expressive number of people with disabilities in Brazilian special schools, in 2007, the National Policy for Special Education under the perspective of Inclusive Education was enacted, intending to provide accessibility in inclusive environments in attendance of the different stages and types of education. Thus, every student attends regular classes together in inclusive schools, in which some schools offer specialized educational services in a special education resource room during hours opposite those of regular classes.

In both cases (regular classrooms and special education resource rooms), we believe that technology can help minimize educational barriers that prevent students who are D/HH from completing regular educational stages. However, technology-based products by themselves can not improve complex scenarios such as inclusive schools. For that matter, it is important to study the aspects that influence the acceptance or rejection of technology, considering the specific characteristics of the application.

By specific characteristics we mean the target users, context of use, type of technology and tasks to be accomplished by users. In this sense, it is not enough to simply decide to develop a new technology and, later, verify if users are adopting it, but evaluate its acceptance during the prototyping stage. So, there is a difference between the adoption and acceptance of a technology. Davis [8] informs that technology adoption is a goal for designers/developers/owners, and technology acceptance is related to design and selection processes that constitute stages previous to that of adoption; therefore, acceptance evaluation may prevent expenses with coding and launch in the case of rejection of the early concept.

People who are D/HH may use one or more modes of communication, switching between written language, oral language and lip reading and sign language, among other possibilities. This characteristic of target users shows how diverse this group can be. Language preference or use depends on many factors, well described by [6], including educational background, family support, amongst others.

Given the problematic presented, the goal is to propose a technology acceptance model that takes into account representative constructs of an inclusive education context, and to conduct a pilot test with D/HH students using a technology-based product to evaluate the proposed model. Throughout this work, we were concerned with answering two questions: What constructs are important during acceptance evaluations considering technology use by D/HH students in inclusive classrooms? Is the proposed model able to cover constructs that can identify the acceptance of technology in inclusive educational environments by D/HH students?

To answer these research questions, this paper is organized as follows: in Sect. 2, related literature reviews are presented; Sect. 3 reports the pilot test and findings of research; in Sect. 4, results and research questions are discussed; and, Sect. 5 presents conclusions.

2 Literature Review

The proposition of technology solutions, which may minimize potential barriers in inclusive educational environments for D/HH students, permeates questions regarding acceptance. According to [8], technology acceptance models are a means to explain reasons why people decide to use or not use a particular technology.

The literature review was conducted in two forms: exploratory and systematic reviews. Exploratory reviews were carried out to find which consolidated acceptance models have been used by researchers, what aspects of user experience are present in acceptance models, and to become familiar with existing AT models. Also, one systematic review was conducted; in this case, we intended to find related works that report research conducted regarding technology acceptance evaluations of technology-based interaction with people who are deaf.

2.1 Exploratory Literature Reviews

We carried out three stages of exploratory review, which included: (i) the study of consolidated technology acceptance models; (ii) evidence of user experience aspects in technology acceptance models; and (iii) the analysis of AT evaluation models.

As a starting point, three consolidated models caught our attention for their popularity in academic research. The first two are acceptance models and the third is an adoption model: Technology Acceptance Model (TAM) [8]; Unified Theory of Acceptance and Use of Technology (UTAUT) [32]; and Innovation-Decision Process (IDP) [28]. Davis [8] proposed TAM with the goal of explaining technology acceptance behavior by new users in an organizational context. With this purpose in mind, [8] investigated which, and how, variables and constructs influence the behavior of using technology, and in what manner could user motivation be measured. As a result, [8] postulated that user motivation involves three main constructs: *Perceived usefulness* (PEU) and *Perceived ease of use* (EOU) representing cognitive responses, and *Attitude toward Technology* (ATT) representing affective responses. Design features of technology are considered as external variables that influence PEU and EOU. Also, in TAM [8]: EOU influences PEU; PEU and EOU influence ATT; PEU and ATT influence directly *Behavioral intention* to use (BI); and, BI influences *Actual system use*. *Behavioral intention* is not a construct in the model, but a desired outcome.

It is worth mentioning that, in TAM, PEU has a stronger influence than EOU on BI, because this construct directly influences ATT and BI, reinforcing its importance. In this regard, [8] informs that users are willing to accept a technology that is difficult to use if it provides task accomplishment, rather than accept an easy-to-use system that does not allow users to reach their goals.

The second model, UTAUT [32], is the result of the unification of eight technology acceptance models, including TAM; and, it is interested in explaining user behavior towards technology acceptance and use in organizational contexts. This model is composed of four constructs and four moderating variables. *Performance expectancy* (PE), *Effort expectancy* (EE) and *Social influence* (SI) are constructs that influence *Behavioral intention* (BI), while *Facilitating conditions* (FC) is a construct that directly influences on *Use behavior*. [32] equate PE to *Perceived usefulness* (TAM) and EE to *Perceived ease of use* (TAM), since they have similar definitions. As moderating variables, the authors verified that there are four factors that influence relations between constructs, differently from each other: Gender influences the relation of PE, EE, SI with BI; Age influences the relation of PE, EE, SI with BI, and FC with *Use behavior*; Experience influences the relation of EE, SI with BI, and FC with *Use behavior*; and Voluntariness of use influences only the relation of SI with BI.

The third model, concerned with technology adoption and known as IDP [28], was defined as a model of five stages which an individual or a group must go through in order to decide whether to adopt or reject a technology. These five stages are: (i) Knowledge; (ii) Persuasion; (iii) Decision; (iv) Implementation; and, (v) Confirmation. To measure confirmation of adoption, [28] informs that five variables can determine the rate of adoption of innovations: the perceived attributes of innovations; type of innovation-decision; communication channels; nature of the social system; and, extent of change agents' promotion efforts. The resulting rates indicate adoption classification as innovators, early adopters, early majority, late majority, and laggards.

Over the years, evolutionary technology acceptance models have been proposed, for example: TAM2 [8, 31] and UTAUT2 [33]. These new models are variants of original models, which include new constructs and moderating variables. It is worth noting that in UTAUT2, the authors added *Hedonic motivation* as a construct that directly influences *Behavioral intention*, which "is defined as the fun or pleasure derived from using a technology" [33] (p. 161).

With respect to evidence of user experience aspects in technology acceptance models, [15] demonstrates concern not only with the quality of the technology itself but also with the quality of using the technology as perceived by its users; where quality in use comprises aspects beyond usefulness and usability. The quality in use may be measured by user experience evaluations, in which everything that involves the human-computer interaction must be considered. [12] report that "UX is a consequence of a user's internal state (predispositions, expectations, needs, motivation, mood, etc.), the characteristics of the designed system (e.g. complexity, purpose, usability, functionality, etc.) and the context (or the environment) within which the interaction occurs (e.g. organizational/social setting, meaningfulness of the activity, voluntariness of use, etc.)" (p. 95).

In this sense, [10] presents two dimensions of how users perceive interactive technologies: pragmatic and hedonic quality. According to the author, pragmatic quality is related to manipulation, involving "relevant functionality (i.e., utility) and ways to access this functionality (i.e., usability)" [10] (p. 34), and "supports the achievement of 'do-goals'" [11] (p. 12). On the other hand, hedonic quality refers to stimulation, identification and evocation, involving personal preferences, past experiences and well-being; supporting the achievement of 'be-goals' [11] (p. 12). [10] states that "typical hedonic attributes of software products are 'outstanding', 'impressive', 'exciting' and 'interesting'" (p. 35), so in this paper we use the term 'hedonic quality attributes' as synonyms for emotional outcomes (forms of describing felt emotions during human-computer interactions) in evaluations.

Referring to emotional outcomes, [22] describes that in emotional design three dimensions have to be taken into account: visceral, behavioral and reflective. The visceral dimension is concerned with appearance, aesthetics; the behavioral dimension is related to pleasure and effectiveness of use; and the reflective dimension considers the rationalization and intellectualization of a product. From this, in evaluations, we can assume the visceral and reflective dimensions [22] are responsible for triggering emotions associated to hedonic quality [10]; and, that the behavioral dimension is associated to pragmatic quality. In this context, [24] mention that "UX is surely about how the user feels and how the interaction with the product makes them feel, not only their evaluation of the product or service" (p. 3848) and, fundamentally, this is the reason why we consider important the presence of hedonic qualities in technology acceptance models.

2.2 Systematic Literature Review

Here, we intended to find related works on technology acceptance evaluations involving people who are deaf (target users), in order to know what types of technology were considered and to verify what types of constructs were used.

The systematic review protocol was defined so that works should be found in the English language only and be published from 2003 to 2013, using three repositories ACM DL, IEEEXplore DL and SpringerLink. Eighteen keywords were used in the search: ("Technology Acceptance Model" *XOR* UTAUT) *AND* (deaf *XOR* "hearing impaired"); ("Technology Acceptance Model" *XOR* UTAUT) *AND* ("Assistive technology" *XOR* Chat) *AND* (deaf *XOR* "hearing impaired"); ("Technology Acceptance Model" *XOR* UTAUT) AND ("Automatic speech recognition" *XOR* "Speech-to-text") *AND* (deaf); as well as (Acceptance) *AND* (ASR *XOR* "Speech-to-text") *AND* (deaf). The exclusion criteria for paper selection were: repeated items, table of contents, item with several abstracts, not available for download, medical emphasis, and keywords within papers that were found only in references or were merely mentioned in the text. From this search, 175 items were found and, after applying exclusion criteria, it resulted in 07 included papers. Therefore, from this review, seven papers were selected [3, 5, 16, 18, 23, 26, 27].

On the subject of types of technology considered by researchers, [3] proposed a mobile application that translates a given English written phrase to Signwriting and vice versa, as an alternative to exchanging SMS between people who are D/HH and hearing individuals; [5] conceived a speech rehabilitation system for D/HH children between 1 and 4 years old that use cochlear implants; [16] proposed a prototype of Sign Language Interpreter Module (SLI Module) to improve Web accessibility for deaf users, providing alternative information formats, which was evaluated by thirty one D/HH students with ages between 15 and 21; [18] evaluated mixed reality, using animated avatars, within an assistive learning system with hearing and deaf students;

[23] proposed a Semantic and Syntactic Transcription Analysing Tool (SSTAT) to improve the quality of transcriptions delivered by automatic speech recognition systems, and evaluated it with deaf and hearing students; [26] investigated acceptance of the Dictation function of Nuance's Sample Voice Recognition App among eleven D/HH students with age average of 28; and, [27] chose Digital TV as the technology which was subsequently evaluated by people who are deaf and hearing individuals.

With respect to the constructs used by these researchers, [5] conducted acceptance evaluation with TAM but did not use other constructs; [26] used TAM in their investigation, including other factors that were relevant for technology use in educational environments, such as: hedonic quality attributes (emotional user experience), usability, future expectations of educational improvement, social influence, empowerment of technology, educational barriers; [27] proposed ADOPT-DTV model, adapted from UTAUT, and included three constructs - self-sufficiency, anxiety, attitudes - regarding the use of technologies and intention of adoption (will adopt, undecided, won't adopt).

References [3, 16, 18, 23] proposed a new technology and conducted technology acceptance evaluations; however, these authors did not use or propose structured models [3]. Evaluated preference between SMS and translation, acceptance, system functionalities, ease of use, and consistency between desktop and mobile systems; [16] evaluated usability (including satisfaction, ease of use and comprehension), sign language interpreter (including lip reading and hands-movements), subtitles (including size and readability), and video playback controls (including size of buttons and usefulness); [18] evaluated percentage of acceptance, effectiveness, absent-mindedness, and quality of animated avatars; and, [23] evaluated the following aspects: (i) perception of transcription quality (accuracy); (ii) perceived acceptance of transcripts (between having transcription or not); (iii) usefulness (referring to the quality of transcripts); and, (iv) perceived usability (also referring to the quality of transcripts).

3 Model Proposition: TAM4 IE

The proposed model, which is the aim of this paper in particular, was named as TAM4 IE (Technology Acceptance Model for Inclusive Education), which came as a result of theoretical and empirical research conducted in previous studies [25, 26].

It was noticed that the specific application in hands was not fully covered by consolidated technology acceptance models. When we say specific application, we mean the coverage of context of use, characteristics of target users (people who are deaf), type of technology, tasks to be accomplished and facilitating conditions for users. Many authors, inspired by consolidated models, proposed different research models in order to reach their goals, such as, [9, 27, 34], because they felt that the existing models did not meet their needs. Constructs and hypotheses of the proposed model are illustrated in Fig. 1.

Important aspects were mapped into constructs in this new technology acceptance model for use in inclusive education, which were five: *Subjective perception*; *Perceived usability*; *Perceived usefulness*; *Future expectations*; and *Facilitating conditions*. This new model was called Technology Acceptance Model for Inclusive Education

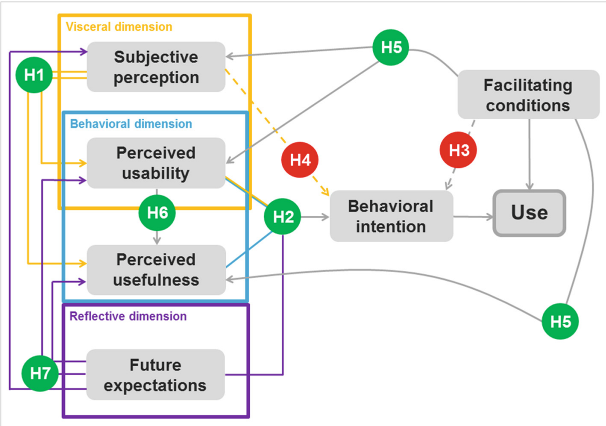

Fig. 1. Constructs and hypotheses of the proposed model (Own source)

(TAM4 IE). Being TAM4 IE a new model, it was necessary to formulate research hypotheses about the relationship between the proposed constructs. Thus, seven hypotheses were elaborated, which are listed below:

- H1: *Subjective perception* has a significant influence on *Perceived usability* and on *Perceived usefulness*;
- H2: *Perceived usability*, *Perceived usefulness* and *Future expectations* have a significant influence on *Behavioral intention*;
- H3: *Facilitating conditions* do NOT have a significant influence on *Behavioral intention*;
- H4: *Subjective perception* do NOT have a significant influence on *Behavioral intention*;
- H5: *Facilitating conditions* have a significant influence on *Perceived usefulness*, *Perceived usability* and *Subjective perception*;
- H6: *Perceived usability* has a significant influence on *Perceived usefulness*;
- H7: *Future expectations* have a significant influence on *Perceived usefulness*, *Perceived usability* and *Subjective perception*.

Subjective Perception (SP) construct was shaped by literature on user experience aspects in technology acceptance models [10, 11, 12, 22], on works that proposed technology acceptance models while taking hedonic quality into account [1, 9, 33, 34], and on those papers that were essential to create Emotion-LIBRAS.[1] Emotion-LIBRAS is an emotional user experience evaluation instrument for use by deaf participants, which was proposed and tested in previous work [25] and is shown in Fig. 2.

Subjective perception is about emotions felt by users during interaction with technology. Such emotions are associated to the visceral dimension [22], being used as

[1] The word LIBRAS stands for Brazilian Sign Language as an acronyms for its Portuguese meaning, and it is the official language of deaf individuals in Brazil.

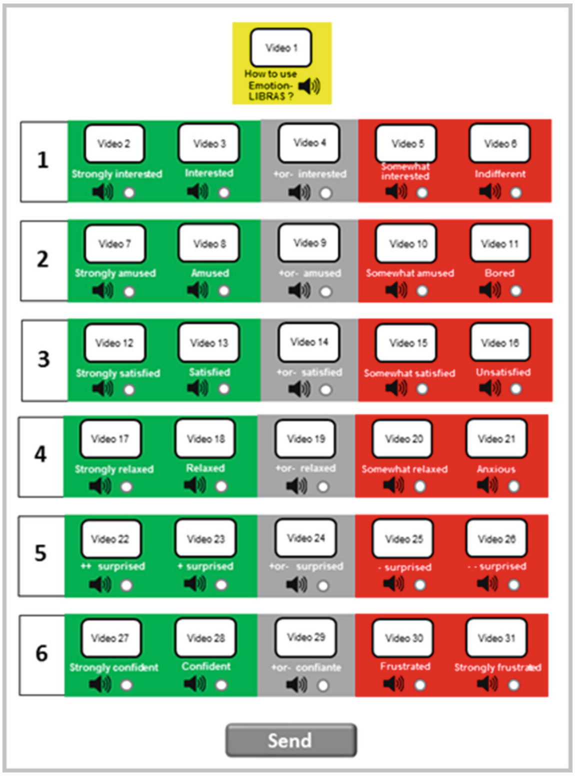

Fig. 2. Emotion-LIBRAS 2.4 (Own source) (The instrument is composed of three parts: (i) An initial video explaining how to use Emotion-LIBRAS, (ii) Six rows of responses (interested/indifferent, amused/bored, satisfied/unsatisfied, relaxed/anxious, positively surprised/not surprised, and confident/frustrated), with 05 mutually exclusive alternatives each. The alternatives are organized as a differential semantic 5-point scale, going from strong and positive intensity of emotion, in green; passing through neutral emotion, in grey; to strong and negative intensity of emotion, in red. All alternative responses have three different ways of displaying the same information: in sign language video, in written language and in audio; and (iii) a send button).

triggers to understand two other constructs: *Perceived usability* and *Perceived usefulness*. In this way, the *Subjective perception* construct is defined as *"the result of measuring hedonic quality attributes triggered during human-computer interaction"*. The instrument of measurement of hedonic quality attributes of TAM4 IE is Emotion-LIBRAS, since target users are represented by D/HH students.

According to [10, 11], both pragmatic and hedonic qualities must be evaluated in order to fully include user experience aspects. Thus, in TAM4 IE we included all of those aspects, represented by usefulness, usability and hedonic attributes. During a previous test with TAM [26], it was verified that *Perceived usefulness* and *Perceived ease of use* were not capable of representing the totality of this complexity. To complement that, Emotion-LIBRAS was also used to understand if hedonic quality attributes could influence these two constructs of TAM and, as result, in the new model (Fig. 1), *Subjective perception* is placed as a construct that may influence *Perceived usefulness* and *Perceived usability*.

In TAM4 IE, the construct called *Perceived ease of use* in TAM is encompassed by *Perceived usability*, considered a broader construct, which is kept close to the *Perceived usefulness* construct to represent pragmatic quality attributes in the model. Together, *Perceived usability* and *Perceived usefulness* compose the behavioral dimension [22]. Also, we believe that these two constructs influence the Behavioral intention to use technology. However, in TAM4 IE, differently from TAM, both constructs have the same weight in the scale.

[8, 10, 11, 21, 22] were the references that inspired the inclusion of ***Perceived usability*** (PUB) as a construct in the new model. Thereby, this construct was defined as *"the result of the perception of usability inherent in the technology"*, which intends to ensure that interaction with technology is not hindered due to diversion of attention of the user's goal caused by difficulties in interaction. This means that usability problems may negatively mask the potential perceived usefulness of technology.

To measure *Perceived usability*, the following attributes were considered while elaborating the questionnaire used in the test: learnability [15, 21], memorability [21], accessibility [15], and aesthetics [15]. Satisfaction also was an investigated attribute but was allocated to the *Subjective perception* construct. As a consequence, in the TAM4 IE structure, *Perceived usability* was positioned in a border zone (Fig. 1), aggregating characteristics from visceral and behavioral dimensions [22].

Perceived Usefulness (PUF) was conceived based on previous works [25], and it was defined as *"the degree to which an individual believes that the use of a technology can minimize educational barriers faced by him/her"*. To measure *Perceived usefulness*, attributes related to educational barriers faced by D/HH students are investigated. The educational barriers included in the questionnaire of the pilot test were the following: (1) Difficulty to follow simultaneous activities during classes; (2) Embarrassment to ask questions in sign language; (3) Difficulty to take notes during classes; (4) Lack of possibility to revise class content; and, (5) Lack of sufficient number of interpreters or unprepared interpreter.

The ***Future Expectations*** (FE) construct was included in TAM4 IE considering three constructs of UTAUT [32]: Effort expectancy, Performance expectancy and Social influence; the value empowerment of technology, and, conceptual aspects of the Decision stage in IDP [28]. This construct has a direct relation to Behavioral intention, in the sense that the intention to use technology is molded by users' expectations. In this sense, if expectations are high, intention of use is highly favorable; otherwise, if expectations are low, intention of use is unfavorable, with expectations being directly proportional to intention of use.

Also, [28] mentions that during decision-making about technology adoption, users reflect upon the consequences that a technology might bring to their lives and weigh the advantages and disadvantages of these situations. Therefore, the *Future expectations* construct allows users to ponder their values and imagine future experiences of technology use.

Because of this perspective, the *Future expectations* construct was placed in the reflective dimension [22] in the TAM4 IE structure (Fig. 1), and it was defined as *"the result of user's reflection with respect to potential future benefits reached by the use of technology"*. Future benefits need to be defined by researchers taking into account their application, since objectives, context of use and the nature of technology may be different from case to case. In TAM4 IE, we are interested in minimizing educational barriers faced by D/HH students in inclusive educational environments; therefore, future benefits are those with the potential to improve some aspects that hinder these students from completing educational stages.

The concept of the *Future expectations* construct is aligned with the *benefits* mentioned by [2], which was defined as "perceived advantages of using computers in the class" (p. 94) [20]. Included *expected consequences of use* in their research model, defined as "the better the task-technology fit the more positive the anticipated consequences of use of a system" (p. 499). Also, [7] proposed *learning expectancy* as a construct in his research model, which was defined as "the expectations for learning performance" (p. 1502).

The ***Facilitating Conditions*** (FC) construct originally was included from the UTAUT model [32], which was defined as *"the degree to which an individual believes that an organizational and technical infrastructure exists to support use of the system"* (p. 453). Also, in UTAUT, this construct directly influences Use behavior. This relation was kept in TAM4 IE.

The definition of *Facilitating conditions* used in UTAUT is organization-oriented, and we are interested in inclusive education; however, a global concept of this construct is desired in TAM4 IE because it includes aspects of assistive technology evaluation models. These aspects are concerned with external factors (neither user nor technology) that may facilitate or hinder technology use in specific contexts, such as: national policies; school infrastructure (e.g., Internet connection); school management (e.g., internal policies of technology use); device cost; technical support (technology and special education professionals); privacy policies; and, training for teachers; among others.

It is worth noting that, besides the inclusion of new constructs, none of constructs from previous models were left out of the new model, they were just adapted with other names or its definition were aggregated to compose a new construct.

After defining constructs, the questionnaire of the pilot test was elaborated in a 5-point Likert scale format (1-Strongly agree; 2-Agree; 3-Neither agree nor disagree; 4-Disagree; 5-Strongly disagree) with one group of questioning for five constructs and for Behavioral intention. For questioning participants regarding *Subjective perception* the Emotion-LIBRAS instrument (Fig. 2) was used. In Table 1, these constructs, their related questions and their references are presented (some questions are equal to those presented in the original reference and others were adapted from references). Also, the type of technology to be evaluated, using the model, was taken into account to elaborate the questions. For this matter, SESSAI, a mobile application for the Android platform was developed, which consists of an instant messaging system for groups with an automatic speech recognition system.

4 Pilot Test with TAM4IE

After the elaboration of the TAM4IE proposal, a pilot test was carried out in a semi-controlled environment of a special school for deaf students. This school offers both fulltime education regular primary education and an integral youth and adult education program in primary education, with 130 D/HH students, in total, amongst the student population. Conducting the test in the school was considered positive due to the fact that students, and their parents, felt comfortable knowing the place and the school staff; on the other hand, a negative point was the lack of control over infrastructure such as Internet connection, cameras and research staff positioning. In order to carry out the test, a mobile application for the Android platform was developed. This application was called SESSAI (acronym in Brazilian Portuguese for Support to Deaf Students in Inclusive Classrooms).

Table 1. Constructs, questions and references

Constructs	Questions	References
PUB1	It is easy to learn how to use	[19, 26]
PUB2	It is easy to remember how to use again later	
PUB3	It promotes accessibility for D/HH students	
PUB4	Aesthetics of user interface is beautiful and attractive	
PUF1	In an inclusive school, while teacher speaks, it is useful to have SESSAI for note taking	[21, 29, 33]
PUF2	SESSAI is useful for review content after class	
PUF3	In an inclusive school, if there is no interpreter or the interpreter is not prepared, SESSAI is useful to follow classes	
PUF4	In an inclusive school, if many individuals (teacher and classmates) are speaking simultaneously, SESSAI is useful by delivering transcription that can be read	
PUF5	In an inclusive school, if someone is embarrassed to make a comment or a question in LIBRAS during classes, SESSAI is useful for sending and receiving comments or questions in written language	
FE1	In the future, SESSAI can help to raise my chances to improve my grades in school evaluations	[2, 6, 21, 25]
FE2	In the future, if only I use SESSAI in class, I will feel important	
FE3	In the future, if only I use SESSAI in class, I will feel impotant	[27]
FE4	In the future, I want SESSAI installed in my cell phone	[33]
FC1	I have the knowledge necessary to use SESSAI	[4]
FC2	I find important to have someone available to help me when I have difficulties in using SESSAI	[32]
BI1	I have intention to use SESSAI in the classroom	[31]
BI2	I would rather have this transcript than not have any transcripts at all	[28]
BI3	I would use even if I would have to pay	[24]

The sample used in the investigation was defined by convenience, because there were a small amount of D/HH participants interested in contributing to the research. The research script consisted of the sequence: profile questionnaire application, followed by interaction of participant with SESSAI and, lastly, acceptance evaluation questionnaire application. In total, 16 D/HH students participated in seven interviews (individual, in pairs or in trio), and each interview took in average 53 min.

During interactions with SESSAI, simple questions were asked the participants, such as: what is your favorite color?; what soccer team do you support?; when is your birthday?; what is your name?. We chose simple questions because in a previous test with TAM [26] we had selected phrases that contained some metaphors, which led to difficulties in participants understanding the question.

With respect to participants' profiles, among the 16 D/HH students, there were 04 women and 12 men; the minimum age was 13 and the maximum 42, with an average age of 21.37 years. Concerning participants' educational level, since the special school offers regular primary education and a program for primary education for youth and adult education, all participants were enrolled at the primary stage of education; however, in Brazil, primary school is divided into two categories: level 1, between 1st and 5th cycles; and level 2, between 6th and 9th years. Among the 16 students, 12 were in level 2, and 04 in level 1, with 03 of level 1 primary education students participating in the youth and adult education program.

With regard to preferences in modes of communication, among those who answered: 14 participants chose sign language as their favorite mode of communication; as their second favorite, 07 chose written language, and 07 oral language/lip reading; 10 participants did not chose Signwriting as a possible mode of communication used by them; and, 01 student marked written language as first mode of communication. Responses for self-reporting on participants' level of written language proficiency showed that 11 classified themselves as regular, 03 as high, and 02 as low. With respect to ownership and experience with technology, 09 participants informed that they did not have their own cell phone; 06 students of the 07 that did report having a cell phone also reported accessing the Internet using their device, and frequently using Whatsapp.

To perform the pilot test, we formed a team with one researcher, two research assistants and one interpreter (sign/oral language), and we were equipped with two smartphones (Samsung GalaxyNote GT-N7000 and Galaxy Ace GT-S5830B), one notebook, one filming camera, printed materials (terms of consent and questionnaires) and pens. The two smartphones were used in order to simulate interaction with multiple persons, using the SESSAI app, where one smartphone was used by the researcher who asked simple questions by speaking, while the other smartphone was used by participants to read transcriptions produced by the app and answer them by typing.

Those simple questions were previously trained using SESSAI, in order to ensure 100 % correctness of automatic recognition, due to the fact that we wanted to produce an interaction free of risk of influence on acceptance results, as a way of simulating a situation that would leave D/HH students comfortable to interact with technology without having the fear of misunderstanding what was asked.

The technology acceptance evaluation questionnaire included 18 questions plus the 06 questions on Emotion-LIBRAS instrument, as can be seen in Table 1 and Fig. 2.

To investigate the hypotheses of this study, the Spearman correlation coefficient was calculated between the variables of interest, since all quantitative variables are ordinal. In this case, a significance level (p-value) for the obtained coefficient was observed. Thus, to reject the null hypothesis means that the correlation is statistically significant. All tests of hypotheses developed assumed a significance level of 5 %, i.e., the null hypothesis was rejected when p-value was less than or equal to 0.05.

It is important to mention that during the interviews two students did not answer 08 questions and one student did not answer 07 questions; these students, all over 30 years old, participated together as a group during interviews and had difficulties in communication, since they had been learning sign language for a short time and were studying in level 1 of primary school. As a result, for some tests of the hypotheses, we consider only 13 answers (Number of participants = N).

- H1: *Subjective perception* has a significant influence on *Perceived usefulness* and on *Perceived usability* (N = 16). Tests results between *Subjective perception* (answers from Emotion-LIBRAS) and *Perceived usefulness* show that: (i) the higher participants rate SESSAI as useful in a situation of embarrassment to make a comment or a question in LIBRAS during classes, the higher the interest (p-value = 0.0048) and more relaxed (p-value = 0.0399) in using SESSAI in class and the lower the feeling of frustration (p-value = 0.0305); and, (ii) the higher participants state SESSAI is useful in a situation of many individuals (teacher and classmates) speaking simultaneously, the less participants are amused (p-value = 0.0411). With respect to the relationship between *Subjective perception* and *Perceived usability*: (i) the better participants declare the interface aesthetics, the stronger participants state their satisfaction (p-value = 0.0411) with SESSAI; and, (ii) the easier participants find it to remember how to use the app again later, the less frustrated they feel (p-value = 0.0011).
- H2: *Perceived usability*, *Perceived usefulness* and *Future expectations* have a significant influence on *Behavioral intention* (N = 13). Between *Perceived usability* and *Behavioral intention* one statistically significant positive correlation was found: the higher participants rated finding SESSAI easy to remember how to use, the higher they state they would rather have this transcript than not have any transcripts at all (p-value = 0.0135). Regarding *Perceived usefulness* and *Behavioral intention* there were more statistically significant positive correlations than negative ones: (i) the higher participants state it is useful to use SESSAI to take notes (transcript) while the teacher speaks during class, the higher they state they would rather have this transcript than not have any transcripts at all (p-value = 0.0002); (ii) the higher participants find SESSAI useful for review content after class, the higher they state the intention to use SESSAI in the classroom (p-value = 0.0004) and that they would even pay to use the app (p-value = 0.0413); and, (iii) the higher participants find SESSAI useful in situation of embarrassment to make comments or pose questions in LIBRAS during classes, the less they state their intention to use SESSAI in the classroom (p-value = 0.0055). With respect to the relationship between *Future expectations* and *Behavioral intention*, no statistically significant correlations were observed.

- H3: *Facilitating conditions* do NOT have a significant influence on *Behavioral intention* (N = 13). Regarding to the relationship between *Facilitating conditions* and *Behavioral intention*, no statistically significant correlations were observed.
- H4: *Subjective perception* do NOT have a significant influence on *Behavioral intention* (N = 13). One statistically significant positive correlation was found between intention of using SESSAI in the classroom and the emotion of being positively surprised (p-value = 0.0365); which consists of a denial of this hypothesis.
- H5: *Facilitating conditions* have a significant influence on *Perceived usefulness*, *Perceived usability* and *Subjective perception* (N = 13). With respect to the relationship between *Perceived usefulness* and *Facilitating conditions*, no statistically significant correlations were observed. As a result from tests conducted between *Perceived usability* and *Facilitating conditions*, it was verified that the higher participants rate as important having someone available to help them when they have difficulties in using SESSAI, the easier they find to remember how to use SESSAI again. Regarding to the relationship between *Subjective perception* and *Facilitating conditions*, the higher participants find it important to have someone available to help them when they have difficulties in using SESSAI, the higher they rate feeling frustrated (p-value = 0.0199).
- H6: *Perceived usability* has a significant influence on *Perceived usefulness*. From this hypothesis test, we observed that the higher participants find SESSAI useful to follow classes when there is no interpreter present or the interpreter is present but not prepared, the higher they believe SESSAI can promote accessibility for D/HH students (p-value = 0.049, N = 16).
- H7: *Future expectations* have a significant influence on *Perceived usefulness*, *Perceived usability* and *Subjective perception*. Only statistically significant correlations were identified between *Future expectations* and *Perceived usefulness*, in which: (i) the higher participants find SESSAI useful to follow classes when there is no interpreter present or the interpreter present is not prepared, and they perceive it is useful when there are many individuals speaking simultaneously, with SESSAI in class, they would feel more important if they were the only one in class using SESSAI (respectively, p-value = 0.0085 and p-value = 0.0278, N = 16); and, (ii) the higher participants rate SESSAI as useful in situation of embarrassment to make a comment or ask a question in LIBRAS during classes, the higher they believe SESSAI can help raise the chances of improving their grades in school evaluations in the future (p-value = 0.0449, N = 13).

4.1 Discussion of the Findings

As a result from the tests of hypotheses, we had a full confirmation of H1, since the attributes of the hedonic quality (*Subjective perception*) influence the perception of usability and usefulness of technology for minimizing the educational barriers of deaf students in inclusive classrooms. Also, we had a partial confirmation of H2 because a significant correlation was found between *Perceived usability* and *Perceived usefulness* with *Behavioral intention*; although, *Future expectations* did not show influence on *Behavioral intention*.

With respect to H3, we observed a full confirmation, that *Facilitating conditions* do not have a significant correlation with *Behavioral intention*. This result confirms the statement is consistent with UTAUT [32], where *Facilitating conditions* influence directly actual usage (adoption of technology). The result from H4 was a denial, since we verified the *Subjective perception* influence on *Behavioral intention*. This evidence shows that subjective perception not only influences *Perceived usability* and *Perceived usefulness*, but *Behavioral intention* directly; as a consequence, this construct represents a significant weight in technology acceptance.

Testing H5, we found that *Subjective perception* and *Perceived usability* can be influenced by *Facilitating conditions*, because if the environment provides support for the use of technology it can be interesting and pleasant, and also might become easier and more intuitive to use. On the other hand, *Facilitating conditions* did not show influence on *Perceived usefulness* on minimizing educational barriers for deaf students in inclusive settings. With respect to H6 results, we identify that accessibility (*Perceived usability*) is an important issue for participants, since the mobile app evaluated was stated as useful when it is not possible to communicate using sign language through a professional interpreter in the classroom (*Perceived usefulness*).

Finally, the testing of hypothesis H7 showed that, although *Future expectations* have no influence on *Subjective perception* or on *Perceived usability*, this construct has influence on *Perceived usefulness*. These constructs make sense together since the usefulness of the mobile app, in this case, is motivated by an interest in minimizing educational barriers and finding answers to questions associated with future expectations that include desired situations for overcoming some of the negative outcomes of those barriers. The final structure of the model is presented in Fig. 3.

Regarding the research questions of this work, which investigated: *"What constructs are important during acceptance evaluations considering technology use by D/HH students in inclusive classrooms?"*; and, *"Is the proposed model able to cover constructs that can identify the acceptance of technology in inclusive educational environments by D/HH students?"*.

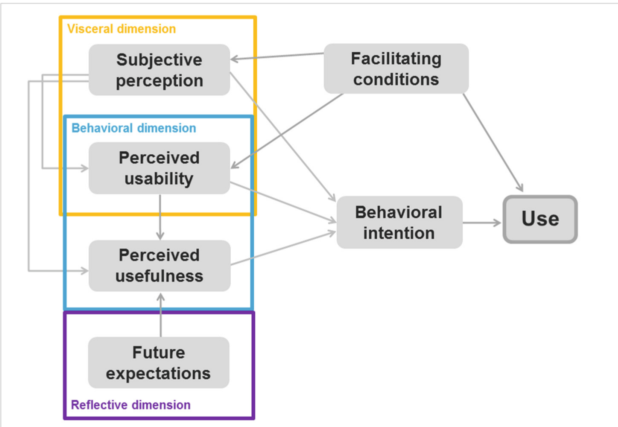

Fig. 3. Final structure of the model TAM4 IE (Own source)

We begin with a review of the relevant literature, where it was possible to verify the existence of consolidated models of technology acceptance and adoption, new models or adapted models from consolidated ones that incorporate hedonic quality attributes as constructs, and research on technology acceptance with D/HH users. This theoretical foundation showed that given differences in the type of application, in the context of use and in target users, it is necessary to reflect upon model characteristics in order to understand if a model's composition can capture the essence of aspects that influence decision-making towards technology acceptance.

Previous work [26] was a great motivator in composing a new model with constructs that could represent more truthfully the context of use and target users of technology, and also that could incorporate aspects of user experience.

It was observed from the results of the test with TAM4 IE showed more significant and positive correlations than negative ones. However, in this study, we included a small number of participants in order to be able to assert a concrete answer. These findings can be seen as a shed of light over a path that can be followed as evidence. The literature review also confirms some of the findings, showing concrete results of the relationship between constructs used in TAM4 IE, such as *Facilitating conditions* with *User behavior* [32], *Perceived usefulness* with *Behavioral intention* [8] and *Subjective perception* with *Perceived usefulness* [1, 34].

Future expectations did not show an influence on *Behavioral intention* in the test. This result is consistent with findings of [7, 20], in which *Learning expectancy* did not present significant influence on *Behavioral intention* to use technology. However, we consider that this construct could be kept in order to compare initial expectations of the students (raised from acceptance evaluation) with results of learning assessments to verify if expectations become reality.

5 Conclusions

We believe the goal of this research was met, since we proposed a technology acceptance model that takes into account representative constructs of inclusive education aspects, and conducted a test with D/HH students using a technology-based product (SESSAI app) to evaluate the proposed model.

As a result, in the pilot test, we found acceptance of SESSAI by participants, who were mostly positively surprised and stated that this technology would be useful to them in an inclusive education context. Also, it was evidenced that the proposed model was able to capture every aspect concerning technology acceptance in an inclusive education setting as can be seen in the final structure of TAM4 IE.

Along the way, we identified other gaps not explored that can be suggested as future work. Regarding Emotion-LIBRAS, we suggest as future work modifying the focus of evaluation; rather than discovering individual emotions, investigate emotions considering the collective, highlighting social relations. Computational systems have enabled the narrowing of human relationships through digital media, social networks, collaborative systems, and virtual learning environments, amongst others. Therefore, evaluation results of emotions with D/HH users may be different than those found for individual identification. Moreover, it is important to highlight that questions of the acceptance evaluation questionnaire (Table 1) can be modified according to technology, users and their specific educational barriers. The model can not be attached to technology or type of user, and because of that its questionnaire must be adapted.

Further investigations using TAM4 IE also deserve attention, especially as regards: (i) to investigate if the emotions ‘Interested’ and ‘Positively surprised’ are only identified when technology is new to participants; (ii) to evaluate technology acceptance in a natural environment, comparing results with research conducted in a controlled environment; and, (iii) to investigate other stakeholders in an inclusive educational environment, such as: hearing students, teachers, interpreters, managers, and parents of D/HH students. Also, other aspects from the educational environment can be included as questions in constructs already proposed in the new model, such as teaching-learning strategies, school projects, and the interface between school and universities.

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