A Novel Tangible Interaction Authoring Tool for Creating Educational Activities: Analysis of Its Acceptance by Educators

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***Abstract*—The creation of applications based on tangible interaction (TI) applications, particularly on tabletops, is a developing area that requires the collaboration of professionals with expert knowledge in specific domains. Having an authoring tool that facilitates interdisciplinary intervention in the design and implementation of such applications is a current challenge to bring TI to different contexts. This article presents an authoring tool (named EDIT) and analyzes its acceptance by educators for creating educational activities. The novelty of the tool lies in the possibility of creating projects with a schedule of educational activities, sequenced as required for a group of students. In addition, it has specific characteristics for the educational scenario, such as the personalization of feedback and the meta-annotation of projects. Sessions were held with educators ($n = 38$) to analyze variables related to the Technology Acceptance Model (TAM) (such as perceived usefulness and perceived ease of use) when creating TI educational activities on tabletops using the EDIT tool. The sessions were observed and recorded on video, and a Focus Group was held afterward. During the sessions, educators gave a positive assessment in relation to using this type of tool. It was observed that, in general, they find TI valuable mostly for working with children. Finally, the results showed a high acceptance obtained from the TAM and the novel features of EDIT were found to be useful.**

***Index Terms*—Authoring tool (AT), human–computer interface, tangible interaction (TI), teaching/learning strategies.**

I. Introduction

TANGIBLE Interaction (TI) applications are those that allow users to interact with digital information using everyday physical objects, which can result in more intuitive and effortless use of Information and Communication Technologies (ICT) [1], [2]. The benefits of TI applications for learning processes are mainly related to physical manipulation [3], [4]. The intrinsic educational value of physical manipulation in learning dates back to the designs of Froebel [5], [6] and Montessori [7], [8] that promote learning through discovery and play [9]. In [10], it is mentioned that Bruner et al. [11] and Piaget [12] emphasized the importance of the use of the body and the interaction with physical materials for cognitive development and learning in children. Other works such as those mentioned in [10], [13], and [14] focus on the opportunities provided by TI applications to approach abstract concepts using physical manipulation in combination with digital information. In this context, the benefit of physical materials is related to the use of mental images formed while working with them, which as a whole can guide problem solving and the approach to abstract concepts in areas such as music, programming, biochemistry, or mathematics [4]. In [15], [16], [17], [18], and [19], contributions in solving abstract scientific problems are represented. McNeil and Jarvin [20] state that working with tangible interfaces provides an additional channel to transmit information and TI applications activate the knowledge of the real world and improve memory through the physical actions carried out with the objects. Some studies focus on the use of TI specifically on tabletops (horizontal table-type surfaces that are computationally augmented), where the arrangement of users around a table encourages communication and favors visual contact between students and educators while adding the benefits of the digital world together with multimodal interactions, immediate feedback and a high degree of interactivity [21]. Working with TI applications around a tabletop helps to perform the tasks better and increases group collaboration quality and playfulness [22]. These benefits of TI applications are also especially valued for students with physical, cognitive, or social disabilities [23], [24], [25], [26].

In summary, the use of TI in educational activities is of interest in many disciplines. However, since its inception, the generation of TI applications has been closely linked to Information Technology specialists. The creation of this type of application requires the collaboration of professionals with expert knowledge in specific domains, in addition to the engineering and computer skills involved in system development [26]. In many cases, communication problems between domain and technical experts lead to frequent design errors [28], [29]. In addition, for each change in the application, the domain expert must go back to the technical expert [28]. It is clear, therefore, that the potential of TI technologies can be leveraged even more when

Manuscript received 24 January 2022; revised 25 May 2022 and 10 September 2022; accepted 16 October 2022. This work was supported in part by Project "RTI2018-096986-B-C31" of the Spanish Government, in part by Project "AffectiveLab-T60-20R" of the Aragon regional Government, in part by the Project REFORTICCA of the Scientific Research Agency of the Province of Buenos Aires (CICPBA), in part by the Project 11/F023 of III LIDI, Faculty of Computer Science, National University of La Plata, and in part by CONICET. *(Corresponding author: Sandra Baldassarri.)*

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Digital Object Identifier 10.1109/TLT.2022.3216117

experts in the domain, such as educators and therapists, participate in the process of developing TI applications [30]. In [23], a set of cases related to the use of these applications in special education is analyzed. In most of these cases, an attempt was made to involve the participants (educators, therapists, tutors, and students) in the process of creating the activity. This context presents new challenges for TI application developers, aimed at giving new opportunities for participation to domain experts and offering the possibility of adapting the applications developed on a case-by-case basis. Tetteroo et al. [30] describe some of these challenges and provides guidelines related to the interactive quality of these applications. It is in this context that authoring tools (ATs) make sense, as mediators for the creation of TI applications. One example of this is presented in [31], where it is shown that to be able to offer truly personalized visits to museums, it is necessary to have a system that helps museum professionals create tailor-made visits that can be adapted to the desires of groups of visitors and individuals. Domain experts need to be involved in several of these design and development tasks. Therefore, a TI AT, aimed at the educational field, helps to create activities that fit the specific context of the educator's work, with personalized feedback and with the possibility of establishing the order in which the activities will be presented [32].

On the basis of these ideas, in this study, two research questions were initially formulated (Q1 and Q2), which guide a review of previous works and the search for any gaps in relation to the development of ATs for the creation of TI applications, specifically aimed at educators. Two other research questions then emerged (Q3 and Q4), which were analyzed in light of the results of the sessions carried out with educators. These are focused on determining the degree of acceptance of educators of this kind of tool, considering the variables of the Technology Acceptance Model (TAM). Moreover, the perception of educators regarding TI is also analyzed. The four research questions that guide this work are the following.

1) Q1: What are the characteristics of ATs that allow non-computer-expert users to participate in the development of TI applications?
2) Q2: What are the needs that are not yet met by this type of tool for the development of TI applications for educational activities?
3) Q3: What level of acceptance do educators show in relation to using an AT such as EDIT to create TI applications?
4) Q4: What value do educators assign to TI in the educational setting?

In this context, this work presents an AT called EDIT, which allows educators to participate in the design of a TI application for educational activities, its sequencing (ordering the activities according to the context needs), and its exportation with standardized metadata, following the IEEE LOM standard [33]. Educators can adjust their projects to the context requirements and share them. Also, an evaluation of EDIT using the TAM is presented. This model is widely applied in educational scenarios for analyzing the ease of use of a tool, the usefulness perceived by educators, and other variables that influence the intention of use [34], [35], [36], [37], [38], [39]. This evaluation produces some interesting results for working with this kind of tool, as well as about TI in the educational field.

The rest of the article is organized as follows: Section II presents the conceptual framework where the concept of ATs and their characteristics are defined. In Section III, an analysis of the state of the art is conducted in relation to ATs for creating TI applications, aimed at answering questions Q1 and Q2. In Section IV, the EDIT AT is described, and in Section V, the TAM used during the sessions with educators is presented. The results obtained in these sessions are detailed in Section VI and discussed in Section VII. Section VIII presents some limitations of the research. Finally, the conclusions and future lines of work are presented in Section IX.

II. Conceptual Framework Related to ATs

This section presents the conceptual bases considered by the authors for the development of the work and for the design of EDIT, in relation to ATs and their characteristics.

First, the analysis presented in [28] describing different types of users that may be involved in the creation of software applications is taken into account. While the more technical users need to attend to advanced programming aspects and those relating to hardware, with tools to help them solve their tasks (tools closer to the hardware, for example, programming libraries), domain experts should focus on incorporating the contents and defining the behavior of the application, for which they need tools to help them (tools closer to the users). These tools should offer abstraction layers to ensure that domain experts do not have to deal with complex technical issues.

This article focuses on the latter type of tool, considered as ATs. ATs are programs that allow users to create their own computer applications without advanced programming knowledge [26], [32]. ATs have gained a special interest in the field of education because they allow educators to create their own educational materials and thus to enrich their teaching proposals. Usually, these ATs, such as Ardora [40], ExeLearning [41], or Malted [42], work through preset templates and, after a compilation process, they generate an application that can be run independently from the software that generated it [43], [44].

The AT approach brings with it a transformation of the user role, assuming responsibilities and tasks traditionally assigned to developers. ATs, aimed at the domain expert, solve multiple aspects of the application creation process, from specifying parameter values to deciding whether to include certain contents and behaviors [26], [30], [31], [32]. In the educational field, ATs are useful because they help to serve a variety of students with different profiles by designing different types of educational activities, with strong intervention by educators [45]; in this sense, ATs are particularly helpful in the context of special education [23], [46], [47], [48], where the requirements are heterogeneous and constantly changing due to the characteristics of each student and the nature of their educational needs. Thus, the technology used to mediate and create activities must be highly flexible, evolutionary, and easy to modify in order to adapt activities to the developmental level of each student [49].

In this article, the focus is on those ATs aimed at creating TI applications. According to [26] and [30], these tools should guide the design of the interactions so as to create relationships between the physical and the digital worlds. This may involve using data input and output technologies. Data input technologies are used, for example, to track objects and user gestures in the physical world. These technologies include the following: Radio frequency identification (RFID), computer vision techniques, microcontrollers, and sensors, among others. As regards output, in addition to using screens and speakers, there is a variety of technologies to create the physical output (LEDs, vibrators, etc.). As each of these technologies requires a different set of physical devices and instructions, integration and customization are difficult and expensive [49], [50]. The AT must offer guides that help in this respect as well as ordering the tasks of creating each interaction and of the activity as a whole. AT should anticipate the problems of users without technical training and consider their needs [26], [28], [30]. Thus, the tool should propose abstraction layers for the complex and technical aspects to facilitate the task of the noncomputer-expert user [31]. Several of the tasks mentioned above will be transparent to the user of the AT, thanks to these abstraction layers.

If the TI AT is geared to enable educators to create educational content and activities, the ease of use will be an important factor [23], as well as the aspects of configuration and customization, as described in [26], [28], [29], [30], and [31]. According to these works, some of the aspects that educators should be able to configure are as follows: the association between the application and the physical objects that will be used, components of the interface such as the background images that will be part of each activity related to the topic to be worked on, and different kinds of feedback that will contribute to student learning. Regarding the association between physical objects and the application, the AT should allow configuring how the physical objects can modify the behavior of the application. For example, the educator can select an animation or image that will be displayed when a certain object is placed on the tabletop. This configuration feature is important because it indicates the representations and associations, which the educators want students to work with, promoting the use of multiple sensory channels [9], [20], [21].

The tool should also allow the educator to configure feedback. According to Brookhart [51], feedback is more effective when it is adapted to the students. In [52], a possible classification of types of educational feedback is presented, which is also aligned with that mentioned in [51]. The authors mention four types of feedback: 1) about the task, 2) the processing of the task, 3) self-regulation, and 4) the self as a person. Feedback about the task is the most common (also called corrective feedback or knowledge of results): It tells a student whether the answer he or she provided is correct or incorrect and gives clues for the student to learn and improve performance. The processing of the task feedback should be considered as the one that specifies the necessary steps to achieve a task. The instructions for carrying out a task should be able to be presented in different formats (audio, images, and text) depending on the specific needs of educators and students [20], [23]. Self-regulation feedback can prompt the student to look for more information on a certain topic, without specific directions. The teacher can configure some aspects in the AT to help the student's self-regulation, for example, leaving a timer available in the interface so that he/she can control the completion times of the task, if this is important. Finally, the self-as-person feedback typically expresses positive evaluations, such as "Well done" or "Great effort." This can be considered effective feedback, and it is important in order to motivate and encourage students [51].

The AT should enable and guide the educator to configure these types of feedback. For example, it should allow the educator to add the instructions or steps necessary to perform an activity, to indicate whether the activity was solved correctly or not, to incorporate affective messages, and/or to add elements that help self-regulation.

Other configuration aspects that an AT used for the creation of TI applications should allow are related to the sequencing of the activities provided to the student and the possibilities to finish an activity by a particular time or according to the student's performance (how the activity ends). As in every educational process, it is important that the educator can sequence and generate the itinerary of activities, for example, to go from the general to the particular or the simple to the complex, or to start with an example or a theoretical concept to facilitate the learning process [53]. Correctly sequencing activities is a key factor in improving the performance of students [54]. In summary, it is desirable that an AT for the creation of TI applications should allow the educator to configure easily and without advanced programming requirements (Q1): to establish relationships between physical objects and the application, to arrange interface configuration aspects (resources such as images, sounds, etc.), to establish different types of feedback, to sequence activities, and to indicate how each activity ends. Finally, the exportation of the sequence of activities created with standardized metadata and packaging will be useful for sharing it with other educators.

III. ATs for Creating TI Applications for Tabletops—Related Work

This section analyzes related work focusing on tools that can be used to build TI applications for tabletops in order to answer question Q2: What are the needs that are not yet met by this type of tool for the development of TI applications for educational activities?

For the search and selection of bibliography about ATs for creating TI applications for tabletops, the protocol proposed by Kitchenham [80] was followed. We considered conference and journal papers, Ph.D. dissertations, and research reports written in Spanish or written in English, and published from 2008 until 2019 in the Journal of Computers and Education, SpringerLink, IEEE Xplore, ACM digital Library, Conference

TABLE I
TOOLS FOR THE CREATION OF TI APPLICATIONS ORDERED CHRONOLOGICALLY

Tools	Authors (years)
TUIMS	Shaer and Jacob (2009)[29]
ESPranto	Van Herk et al. (2009) [28]
TUIO	Kaltenbrunner (2009) [55]
TLF	Garzotto and Gonella (2011) [46]
TUI-VR	Israel et al (2011) [56]
TEC	Hochstenbach-Waelen et al. (2012) [57]
Toy Vision	Marco, Cerezo and Baldassarri (2012) [58]
CLAY	Gerken et al (2013) [27]
TULIP	Tobias, Maqui and Latour (2015) [59]
DIY-AT	Moraiti et al (2015) [60]
ContrAct	Poutouris et al (2017) [61]
TouchTokens	Appert et al (2018) [62]
Arcadia	Kelly et al (2018) [63]
E-dub-a	Preuss et al (2019) [64]
KitVision	Bonillo et al (2019) [47]

IDC, Journal of Universal Computer Science (JUCS), and Google Academics.

The keywords used for the search were as follows: interacción tangible + herramienta / tangible interaction + toolkit, interacción tangible + diseño / tangible interaction + design, interacción tangible + entorno / tangible interaction + framework, interacción tangible + editor / tangible interaction + editor. Other works included in the references of the publications found first were also considered. A total of 492 articles were reviewed in the first stage (from reading the titles and abstracts). A total of 418 were discarded (following the exclusion criteria: works not focusing on tools for creating TI applications, not written in English or Spanish, or where complete works were not available). The remaining 74 were considered for a more in-depth analysis, being read in their entirety. In this process, all the authors worked on the definition of the inclusion and exclusion criteria, on the selection of articles, and finally on the complete reading of the selected works. Of the 74 articles, after the complete reading, 53 were discarded for not presenting or describing tools for the creation of the TI applications mentioned. Finally, the selection of articles comprised the 21 that met the search criteria initially set and that focused on aspects related to the research questions. Several of these 21 papers present an analysis of the same tool, so that the amount of evaluated ATs was 13. At the same time, in 2019 and 2020, a new group of works (related to editors and/or ATs, suggested by researchers in the area) was considered, adding 2 ATs to the previous ones.

Table I lists the 15 tools finally considered and analyzed in this section. The reviewed works present, on the one hand, tools with an abstraction layer of the underlying TI technology (closer to the hardware) intended to help programming experts to create TI applications (see Fig. 1, left side). These tools are TUIO, TUIMS, TUI-VR, CLAY, and TULIP. They are outside the interest of this analysis, since our focus is on ATs oriented to domain experts without programming skills. In the case of ToyVision, the tool presents an abstraction layer for the inclusion of active objects in a TI application through templates, but it does not include the design of the

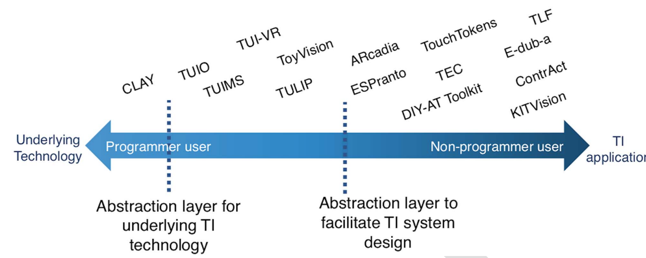

Fig. 1. Tools organized based on abstraction level.

activity as a whole, so it is also outside the scope of this work. On the other hand, tools with an abstraction layer to facilitate TI application design oriented to domain experts were found. Programming is not required in this type of tool (closer to the user; see Fig. 1, right side). Nevertheless, although TouchTokens and DIY-AT are oriented to domain experts, they are not ATs because they cannot be used to create applications; instead, they only allow configuring aspects of the physical objects with which the application interacts. Furthermore, Arcadia is a tool that, even though it offers a quick process for creating applications, does not have a TI application as an end result, but rather an initial prototype based on AR for a future TI application. The remaining tools in this category are ESPranto, TLF, TEC, KitVision, E-dub-a, and ConstrAct. These tools are considered for analysis in this section.

To provide an in-depth answer to question Q1 and address question Q2, these tools are analyzed taking into account the following features (based on the analysis of Section II).

1) *Strategy*: possibilities offered by the tool for creating applications.
   a) Includes templates.
   b) Basic programming skills are required to create activities.
2) *Underlying technology*: analyzes the technology associated with the detection of tangible objects in the tool.
   a) Computer vision techniques.
   b) RFID.
   c) Adaptable: enables users to select the type of technology to be used for detection.
3) *Configurable aspects*: possibilities for modifying functional and graphic aspects, in order to more efficiently adapt to the needs of each educator. The criteria described in Section II are considered.
   a) Association between the application and physical objects.
   b) Background images for the interface.
   c) Types of feedback: about the task, processing of the task, self-regulation, and affective feedback.
   d) Possibility of configuring the end of each activity (end of activity): by time and according to the students' performance.
   e) Possibility of sequencing activities (activity sequence).
4) *General aspects*: other important aspects regarding the interest in sharing and reusing the projects in the

TABLE II
TOOLS COMPARISON BY FEATURES OF INTEREST

Features		ESPranto	TLF	TEC	KitVision	E-dub-a	contrAct	**EDIT**
Strategy	Template		x	x	x	x	x	**x**
	Basic programming	x						
Underlying technology	Computer visión				x	x	x	**x**
	RFID	x	x	x				
	Adaptable	x						
Configurable aspects	Association between app and physical objects	x	x	x	x	x	x	**x**
	Background images	x	x		x	x	x	**x**
	Types of Feedback*				x			**x**
	End of activity	x			x			**x**
	Activity sequence	x						**x**
General	Standards for meta-annotation and packaging							**x**
	Tool availability	x			x			**x**

*More than one type of feedback mentioned

educational community and in having the possibility of use by educators.

a) Standards: possibility of meta-annotation and exporting content, complying with packaging standards. This provides a common language so that contents can communicate with various technological environments (for example, different types of applications and repositories on the web).

b) Tool availability: this refers to having licenses available for using the tool.

Based on the criteria defined, the tools selected are described as follows (see the summary presented in Table II).

1) ESPranto [28] has various design levels aimed at different types of users. At the level closest to a noncomputer-expert user (in the case of this AT, parents, and educators), it uses a graphical editor with blocks as described in Scratch [65], so basic programming knowledge is required. It allows working with RFID technology, but users with expert programming knowledge can incorporate other technologies. It is available for free download for Linux and Windows. Activity sequencing is not specified, but when working with block programming, an expert user could program it. In relation to feedback, this could be achieved by programming it, but it is not indicated whether the graphic editor makes it possible to do so. There is no mention of the use of standards for meta-annotation or for content packaging.

2) TLF: Tangible Learning Framework [46] is a web tool that allows developing TI applications with RFID technology. This tool is presented at a nonfunctional prototype level, so the tool is not available. However, it is of interest for this analysis as it proposes to address different types of activities that arise from working together with therapists. It enables design through templates corresponding to the different types of activities, such as playlists, selection activity, multiple choice tests, and so forth. It permits configuring in each activity the background images. In relation to feedback, it only mentions the possibility of adding feedback about the task in some of the proposed activity patterns, so it does not consider different types of feedback. There is no specific reference to how to configure the end of an activity or how activity sequences are created. There is also no mention of the use of standards for meta-annotation or for content packaging.

3) TEC: Tag-Exercise Creator [57] is based on ESPranto; it proposes a further abstraction layer to facilitate the task for therapists. In this sense, it sacrifices flexibility to favor ease of use. It allows creating a type of activity aimed at carrying out specific rehabilitation exercises. It limits its application to a specific technology, an RFID-based board called TagTiles. Activity editing is done through templates that specify interaction areas, and auditory feedback is linked to them. However, it is not indicated whether that feedback is related to feedback on the task. Other types of feedback are not mentioned. There is no information about availability. Even though it does not use standards, it does mention the importance of promoting practices related to the creation and exchange of software that are known in the open-source software community, but still relatively unknown in the health and education community. There is no specific reference to how activity sequences are created.

4) KitVision [47] is a tool designed for therapists to develop TI applications for educational activities. It uses templates, and the activities are aimed for use with a computer vision-based tabletop. It allows configuring different activity aspects: different tasks, feedback about the task, instructions through audio (feedback on the processing of the task), but it does not indicate anything about the other types of feedback. Also, it allows configuring a background image, an area associated with a set of objects that would give a feedback of correct, and also allows defining a set of physical objects that when placed in the defined area of the tabletop trigger a feedback of incorrect. While it is allowed to have several tasks, the educator cannot sequence the tasks in an itinerary. This is the only tool in the group that is available for download under a GNU, General Public License version 3.0 (GPLv3). There is no mention of the use of standards.

5) E-dub-a [64] is a tool mainly oriented to working in the field of special education, although it could also be used in other areas. It allows creating scenes that can have customizable backgrounds, interaction areas to be related to the correct objects expected to be placed in each area, and feedback about the task that is displayed when an object is placed on the tabletop. No other types of feedback are mentioned. This tool is also based on the use of templates, and the applications created with it use computer vision. The applications that can be created consist of one scene. There is no mention of the

possibility of creating sequences with several scenes. There is also no mention of working with standards or information about their availability.

6) ConstrAct [61] is a game editor that has five different minigame templates; namely, “Multiple choice quizzes,” “Find the correct sequence” games, “Classification” games, “Wrong item detection” games, and “Execute a process” games. The resulting minigames are capable of supporting multimodal interaction as the players can interchangeably use either the digital facilities offered by a typical GUI or various physical input sources that facilitate interaction. In this case, the technology is based on computer vision. The educator can 1) designate the physical boundaries of the touch-enabled surface, 2) set the brightness level to match the lighting setting of the educational space, 3) generate and print QR-codes to identify players, 4) insert appropriate illustrations for items that could be used physically as printed cards, which maximize the recognition rate and minimize false-positives by the computer vision algorithms, etc. Even though this editor is interesting due to the variety of activities it offers, there is no mention of any standards packaged with the games or of how games can be organized into sequences. Feedback is given only about the task. There is also no information about availability.

Moreover, a systematic review of ATs related to the creation of TI applications has recently been found [66]. However, in this review, the tools are specifically aimed at creating storytelling applications.

As can be seen, the analyzed tools present interesting features but they do not use packaging standards or descriptions with standardized metadata for subsequent storage and retrieval from repositories. Most of them are based on templates [46], [47], [57], [61], [64] that guide the design of each activity, but there is no explicit mention regarding the possibility of organizing these activities into sequences. Regarding their availability, only one indicates that it is free for Windows and Linux [28], and another that it is available for download under GNU General Public License version 3.0 (GPLv3) [47]. The rest of them do not offer information about this in the analyzed articles. Only a few of the tools indicate that they enable different types of feedback (they only consider feedback about the task and the processing of the task), but this aspect in general is only briefly described [47], [57], [64]. None of them describe self-regulation feedback or self as a person feedback. Finally, it must be highlighted that some of the tools found are oriented to a specific target group, such as the case of TEC, TLF, Kitvision, and E-dub-ab that are oriented to working with therapists [46] [47], [57], [64].

From the analysis carried out, it can be observed that there are several projects focused on the creation and use of ATs linked to the development of TI applications by noncomputer-expert users. However, there are some features of interest for education scenarios mentioned in Section II that are not fully addressed by the analyzed AT. Therefore, this article presents a novel AT for creating educational TI applications, which considers these features.

As a summary, Table II presents the criteria analyzed for each tool reviewed using the features of interest established above, detailing the configurable aspects of each one and adding in the last column the features to consider in the AT proposed in this article.

IV. EDIT. Development of an Editor for TI Educational Applications

EDIT (Spanish acronym for Tangible Interaction EDitor) was created with the aim of allowing educators to create TI applications. Like any AT, it allows editing and customizing different options for creating applications, in this case, those based on TI for tabletops, based on computer vision techniques (the technology feature). To do this, it integrates an abstraction layer with the underlying technology (capture and detection with a camera, identification of object position, and rotation in relation to the coordinates, etc.) and also with different design aspects of the TI application (relationship between physical objects and the application, areas of interaction, different types of feedback, etc.). The tool, therefore, lies in the category of “closer to the user,” as stated in Section II.

To detach the user from both underlying technology and design aspects, EDIT relies on the use of templates (like the majority of the ATs analyzed in Section III), which offer the user different types of predesigned activities. Users select the type of activity and then adjust various settings according to their needs. This addresses the challenges mentioned by [30] in relation to designing integration bridges between the physical and virtual worlds, as well as in relation to guiding the creation of interactions. As regards the link with physical objects, the user assigns an identifying name to each physical object with which the application will interact. In the templates, users indicate the areas on the tabletop where they want the interactions to take place, as well as the identifiers corresponding to the linked objects in each interaction. As can be seen, users do not have to worry about how these associations are implemented. In this way, using EDIT the educator can build a TI application without having any programming knowledge.

A. *EDIT as a TI AT for Tabletops, Specifically Aimed at the Educational Field*

EDIT has been designed to be used in education and it is, therefore, focused on its ease of use and its usefulness for educators. It provides the possibility of creating a customized sequence of educational activities integrated into a project so that the educator can adjust it to their own context. The project can be saved to be edited again and customized (.la file). In addition, it can be exported as a SCORM package (.zip file), in such a way that it can be shared in different repositories, and meta-annotated following the IEEE LOM standard. Here, the educational level to which it is oriented, the range of ages to which it is intended or the theme and educational objectives can be specified, to mention some of the descriptors that contribute to the location of the project and its reuse. These meta-annotation and packaging features are not addressed by the ATs analyzed in Section III. Another aspect of interest

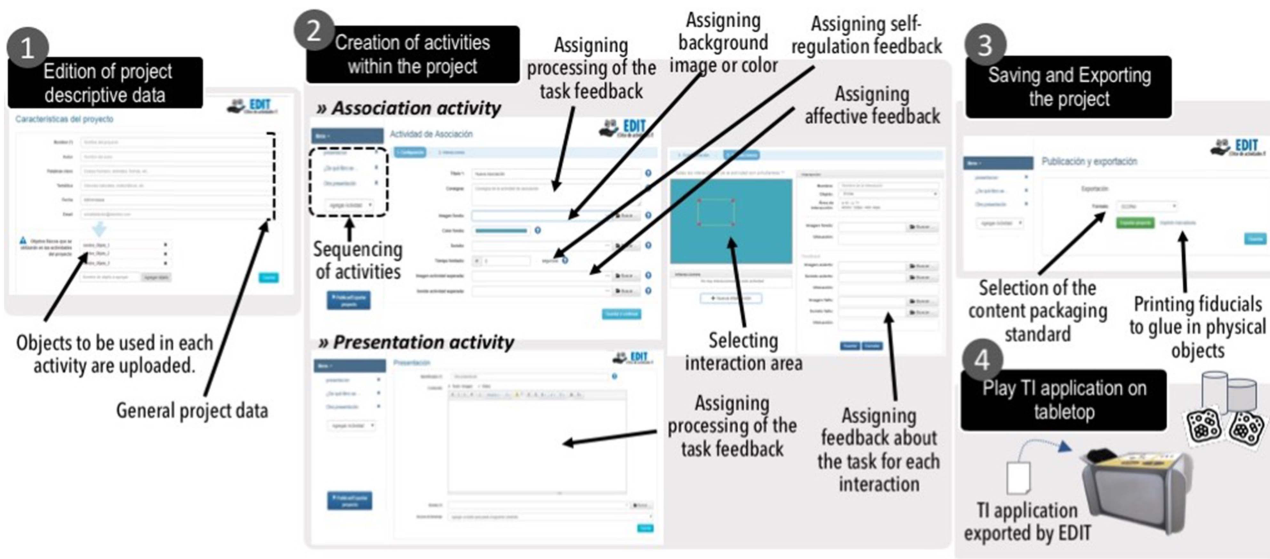

Fig. 2. Working stages with EDIT.

considered in EDIT is that it allows the educator to give different types of feedback, as discussed in Sections II and III. It allows the educator to give instructions on the task to be carried out in different formats (text, audio and/or images, or even a video), to give feedback on how the task was carried out until the finish of an activity, and to give feedback on the different interactions that the student performs on the tabletop. It thus supports the process of solving an activity through affective messages. Finally, it also includes the possibility of including a timer, or a button to finish the activity and continue with the next one in the itinerary [52].

B. Project Design Process With EDIT

When the educator works with EDIT, he/she creates a project that will include a sequence of navigable educational activities, determined by the educator [53]. This is a very important aspect, as indicated in Sections II and III. The working stages with EDIT are summarized in Fig. 2: 1—Editing project descriptive data; 2—Creation of activities within the project and the itinerary (sequence in which activities will be navigated); 3—Saving and exporting the project, considering standards; 4—Playing TI application on tabletop. Some examples of activities created with EDIT are shown in Fig. 3.

In summary, EDIT provides for the following.

1) Abstraction layers that allow educators without previous programming knowledge to create TI projects, avoiding having to deal with low-level aspects and underlying technologies (see Fig. 4). In this way, it is similar to the ATs analyzed in Section III.
2) Design by using templates (strategy feature) that guide educators through the steps and data to be completed. Templates also offer help through two icons that appear during the process of creating a project, having two purposes: a) serving as guidelines for the design of TI educational projects and b) assisting EDIT users. Currently, these templates allow creating two types of activities: a) simple association activities, in which students are asked to link specific objects to different areas on the tabletop, and b) content presentation creation activities using various multimedia resources, which can serve to present task processing feedback and affective feedback [51], [52] (see examples of feedback in Fig. 3).
3) Creation of projects that allow integrating a browsable sequence of activities, be these content presentations and/or associations (configurable aspects). This sequence can be modified based on the needs of the project and the educational objectives. This feature is original in comparison with the ATs analyzed in Section III.
4) Incorporation of specific spaces to include instructions personalized by the educator in text, audio, or video formats (configurable aspects, in this case for processing the task feedback and for affective feedback). For example, the student may be told to place the objects that correspond to a given category on a certain area on the tabletop.
5) Configuration of backgrounds, to give context to the activity, and interactive areas, which can also have their own background image or color (configurable aspects).
6) Setting the way in which each activity will be finished (for example, by time—it is possible to guide the student with a timer; by the decision of the student—it is possible to configure a button to skip the activity). This is a novel feature proposed by EDIT.
7) Saving and editing projects, loading metadata with the IEEE LOM standard, and exporting projects as SCORM packages so that they can be published and found

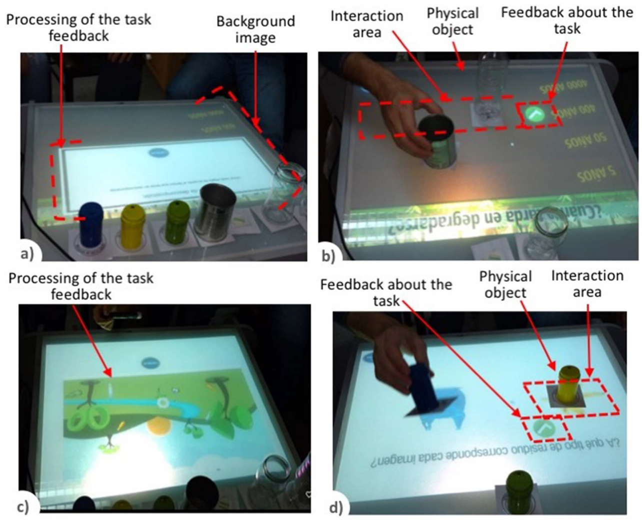

Fig. 3. Examples of applications created with EDIT.

through their metadata in virtual environments (standards feature). This is aligned with the possibility of being able to create, in the future, a community in which TI applications are shared. This feature is original in comparison with the ATs analyzed in Section III.

Fig. 3 shows examples of activities created with EDIT by educators. The activities differ from each other thanks to the customization possibilities offered by our AT. In this figure, it can be observed how the activity is presented. Image a) shows the processing of the task feedback with the instructions for the activity to guide what the student should do. Image b) shows an association activity with a background created by an educator with different periods of time (in years), so that the student takes objects prepared by the educators and must place them in the area corresponding to the approximate time it takes to degrade (the activity is related to the care of the environment). This image also shows the feedback about the task that indicates if it was correctly answered or not, in this case using an image. Image c) presents the processing of the task feedback, but in this case, the educator decided to present the instructions through a video. Finally, in image d), another activity is presented with two areas of interaction and a background image with two categories (plastic waste and organic waste), so that the student has to classify each physical object in one of these categories. The objects were provided by educators.

From a technological point of view, EDIT was implemented on PHP 5 using the Laravel 4.2 [67], JQuery [68], and Bootstrap [69]. The application that will be available for download by educators (Tool availability feature) was developed using Java 1.8 with Reactivision [70].

V. Educator Acceptance Analysis of Edit for Creating TI Activities for Tabletop

In order to know if the EDIT AT enjoys a suitable level of acceptance by educators, since this is indispensable for its use

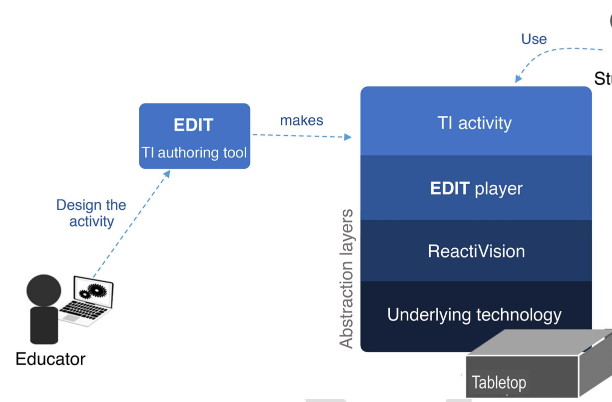

Fig. 4. EDIT abstraction layers.

and inclusion, assessment sessions were carried out with a group of 38 educators at the School of Computer Science at the National University of La Plata, Argentina. During the sessions, the educators were also asked about their appreciation of TI in education in order to identify possible barriers and the potentialities perceived by teachers for this technology. These aims are directly related to questions Q3 and Q4.

To answer research questions Q3: What level of acceptance do educators show in relation to using an AT such as EDIT to create TI applications? and Q4: What value do educators assign to TI in the educational setting?, the TAM model proposed in [71] was used, but we worked with a variant proposed in [34], where the model was adapted to predict the acceptance level of technologies by educators. Additionally, we surveyed educators' reflections and assessments in relation to the possibilities offered by TI at their own educational levels.

A. Participants

The study involved 38 educators (24–58 years old). The participants were invited from among students enrolled in a master's degree in applied information technology in education and teachers of this degree course. The students belong to different educational institutions in the country and were invited via email. In addition, the invitation was extended to potential teaching colleagues who were interested in participating. The 38 educators who participated did so voluntarily and because of their interest in the subject. The gender distribution was 66% women ($n = 25$) and 34% men ($n = 13$). As regards the educational level at which they teach, 18.4% of these educators worked at the primary level, 18.4% at the secondary level, 60.6% at the tertiary level, and 2.6% in special education. Considering their prior knowledge of TI, 24% indicated that they had no prior knowledge about this technology, and only 3% indicated that they had thorough knowledge. The highest percentage (73%) corresponds to those who indicated they had some knowledge (little, moderate, or thorough) of TI. As regards use, 53% indicated that they had never used TI-based technology. From the remaining 47%, only 3% indicated they had used it a lot. It should be noted that, among the educators who were invited to participate, some with expertise in TI were included to make sure there was a diversity of profiles. Those educators are teachers of the aforementioned master's degree that had previously participated in educational activities with TI as part of their teaching work and, in one case, the teacher had also participated in the creation of an application with TI.

B. Instruments

Three types of instruments were used: 1) a TAM questionnaire to find out the degree of acceptance by educators of EDIT, 2) an observation form aimed at registering doubts, comments, and the time spent by educators while they worked with EDIT, and 3) finally a Focus Group questionnaire to find out educators' assessments and thoughts in relation to TI and its application at the educational level in which they work.

To analyze the technological acceptance by educators in relation to EDIT, the TAM presented in [34] was modified and used. This model is widely used in research in the educational field due to its potential to predict the intention of use of the technological tools to be included in these scenarios, by analyzing the ease of use of a tool, the usefulness perceived by educators, and other variables [34], [35], [36], [37], [38], [39], [72]. In this article, the TAM model is used to analyze the possible barriers and benefits that the educators participating in the sessions perceive in EDIT and, thus, know their acceptance. It should be clarified that this model explains the causal relationships between perceived usefulness (PU), perceived ease of use (PEU), attitude toward the use of technology (ATU), and intention to use technology (BI). The results presented in [34] showed that PU, attitude toward computer use (ATU), and computer self-efficacy (SE) have a direct effect on behavioral intention (BI) to use technology while PEU, technological complexity (TC), and facilitating conditions (FC) affect BI indirectly.

In this article, Teo's TAM model [34] has been modified by adding other items to gather information about participants' profiles. The instrument was split into two parts; the first one was to collect data identifying the educators (gender, age, educational level, and previous experience with TI applications), and the second one was to collect data related to the study variables in the TAM model. This second part is composed of 16 items that are rated using a 5-interval Likert scale (0 = Strongly disagree; 1 = Disagree; 2 = Neutral; 3 = Agree; 4 = Strongly agree). It should be noted that, unlike Teo's instrument, this one does not include the items related to the "facilitating conditions" variable. This decision was made because in this first version of EDIT, there are as yet no user manuals and tutorials that would serve as an aid for educators. The instrument can be found at rebrand.ly/6ye9p96.

To obtain the instrument's reliability index, the internal consistency measure called Cronbach's alpha coefficient was used. This coefficient is appropriate for instruments that use Likert-type scales, as in this case. The coefficient varies between 0 and 1, 1 being the highest value. There are different reports on acceptable alpha values, which range from 0.70 to 0.95. If the alpha is too high, it may suggest that some items are redundant, as they are assessing the same question but are worded differently. A maximum alpha value of 0.90 has been recommended [73]. After applying the Cronbach alpha statistic using the PSPP application [74], a value of $\alpha = 0.86$ was obtained, which indicates a high-reliability index.

C. Methodology

The methodology followed was organized in two stages. In the first stage, educators were presented with the concept of TI and applications were provided, by way of example, so that they could experiment with this technology. These applications had been developed with EDIT, so the educators were able to visualize the kind of activities that can be carried out with the tool, the resources that can be incorporated, the way in which feedback is provided, etc. In the second stage, each participant was asked to use EDIT to create his/her own application, for which the necessary multimedia content (images, videos, and sounds) was offered. During this stage, each session was observed by at least two researchers who completed an observation form with notes about doubts and questions made by the educators. The time of completion of each project was also registered. Finally, a Focus Group was held to collect the opinions and conclusions of the participants regarding the experiences. Sessions were recorded for later analysis, and they were used to contrast with the forms completed by the researchers.

A total of 10 sessions corresponding to two types (A and B) were held. Of these sessions, 9 were of Type A and 1 of Type B. The Type A sessions lasted approximately 1 h, with groups of 3–4 educators each. In these sessions, the educators developed a project using EDIT with different sequenced activities. Two observers completed the observation forms in these sessions. The Type B session lasted 2 h and was carried out with 10 educators and with 4 observers. For the second stage in this session, participants also had to create a project with different activities. In addition, participants were given time to run their projects on a tabletop, so that the rest of the participants could use them as if they were students.

In order to evaluate the acceptance of EDIT by the educators who participated in the sessions, an analysis of the results, obtained through the different data collection instruments, was made. The items related to the variables SE and TC were recorded as they were negative items. The mean and standard deviation (SD) were calculated for each model variable (for a better reading, the values obtained were rounded). In order to allow comparisons of the values obtained, each variable was labeled with the level of its mean score (MS) and SD, following the scoring table ranging from Extremely Low (1.0–1.5) to Extremely High (4.5–5.0), and with the following intermediate levels: Very Low (1.5–2.1), Low (2.1–2.7), Moderate (2.7–3.3), High (3.3–3.9), and Very High (3.9–4.5). These levels and their intervals were taken from the work in [75].

VI. Results

In this section, the results are presented in relation to the research questions Q3 and Q4.

TABLE III
VALUES OBTAINED IN EACH ITEM OF THE QUESTIONNAIRE AND VALUES FOR EACH ANALYZED CONSTRUCT OF THE MODEL

Item	MEAN	SD	Construct MEAN	Construct SD
PU1	4.289	0.654	Very High (4.4)	Extremely Low (0.52)
PU2	4.395	0.638		
PU3	4.526	0.557		
PEU1	4.342	0.582	Very High (4.3)	Extremely Low (0.60)
PEU2	4.158	0.679		
PEU3	4.500	0.647		
ATU1	4.526	0.603	Very High (4.3)	Extremely Low (0.61)
ATU2	4.263	0.795		
ATU3	4.237	0.852		
TC1	4.132	0.844	Very High (4.1)	Extremely Low (0.74)
TC2	3.921	0.912		
TC3	4.289	0.654		
SE1	3.763	1.025	Moderate (3.2)	Moderate (1.04)
SE2	2.605	1.386		
BI1	4.474	0.647	Very High (4.3)	Extremely Low (0.65)
BI2	4.316	0.739		

TABLE IV
PEARSON CORRELATIONS—SIGN (2 QUEUES)

	PU	PEU	ATU	TC	SE	BI
PU	1.00					
PEU	.15	1.00				
ATU	.42 **	.34*	1.00			
TC	.14	.46**	.33*	1.00		
SE	.21	.51**	.21	.68**	1.00	
BI	.31	.27	.54**	.04	.07	1.00

Significant correlations are indicated by * $p < .05$ and ** $p < .01$

A. Results Related to Q3: What Level of Acceptance Do Educators Show in Relation to Using an AT Such as EDIT to Create TI Applications?

A descriptive analysis of the results (see Table III) shows that the values obtained from the participants in variables PU, PEU, ATU, TC, and BI are Very High, with a MEAN over 4 out of a maximum of 5, and with an SD Extremely Low, below 1, similar to the data presented in [75]. However, in the items related to the variable that refers to SE, the MEAN values are lower, with a higher SD (Moderate). It should be remembered that the SE variable refers to the extent to which a person believes that by executing and organizing actions, they can achieve specific objectives with the level of skills they possess. It refers to the person's judgment of their own abilities [76]. This fact evidences that educators felt the need for external help to create a TI application with EDIT. This would be a possible area for improvement.

In addition, the existing correlations between the constructs were analyzed, following [34] and [75]. It is important to highlight that these correlations are comparable to the results obtained in [34], with scores that vary slightly (see Table IV).

From the analysis of the data obtained from the TAM questionnaire used in the sessions, the following can be seen.

1) the perceived utility (PU) has a direct effect on the attitude toward the use of technology (ATU). The latter has a direct effect on the intention of use (BI) of the educators who participated (these results coincide with those found in the research reported in [34] and [75]) while PEU, TC, and SE affect BI indirectly.
2) It was also found that there is a correlation between TC and PEU, and between SE and PEU, which indirectly affects the intention to use (BI).
3) Although direct relationships of PU, ATU, and SE with BI were found in the model of [34], in the tests carried out in the present study, it was only possible to verify the direct link between ATU and BI, and also of PU, PEU, and TC with ATU.

From these correlations, it can be inferred that educators find a tool like EDIT useful and this seems to influence their attitude toward the tool and their intention to use it.

The correlation of the model variables with the profile information of the participants has been studied applying the Pearson correlation [77], showing that there is no evidence of a correlation between the variables PU, PEU, ATU, TC, SE, and BI with the educational level in which the educator works, or his/her previous knowledge, previous use of TI or gender.

To analyze what educators thought about the process of building a project with educational activities using EDIT and about the tool itself, a Focus Group and observation sheets were used. The results showed that all the educators found no major problems to complete the creation of the TI application with EDIT. However, in several cases, they had to be reminded that the areas used for the interaction are the spaces on the table where the student is expected to place a physical object and, therefore, that they need to indicate their size and location on the table. Similarly, in terms of feedback about the tasks, there were some doubts about the place where the feedback configured by educators will appear on the tabletop. It is important to mention that after these initial clarifications, the educators were able to continue with the task and complete the project with no further issues.

This situation is consistent with the educators' responses to the TAM model question SE2: "I feel like I can complete a project using EDIT if someone shows me how to do it first." This can explain the moderate score obtained in the SE variable commented previously; 45% of the educators requested some kind of help when creating association activities. Some of the aspects that were asked about are listed as follows.

1) Relocating and resizing interaction areas (10 participants out of 38) and images for feedback in each interaction area (5 out of 38).
2) Loading the physical objects that would be used during the activity (7 out of 38). Educators had doubts about whether they should only use the name, about adding objects that are not used in the activity, about adding objects in later stages of the project, and about editing already loaded objects.

3) Adding activities to the project (2 out of 38). Some educators did not understand that activities can only be added after project data have been configured.
4) Editing a previously created interaction (2 out of 38).

There were no doubts during the process of exporting the project in any of the sessions.

During the Focus Group, questions revolved around which aspects of the tool could be improved. In all sessions, the educators valued the step-by-step guide to creating projects. Positive responses were also recorded as regards ease of use, an aspect that was well rated in the TAM model instrument, which reinforces this result.

The most relevant improvement suggestions for the creation of TI applications with a tool like EDIT were as follows.

1) Assigning a different color to each interaction area and feedback. This would help know to which area each feedback (about the task) corresponds at a glance.
2) Assembling an animation that allows visualizing what the effect would be when each feedback appears and disappears, simulating execution.
3) Including more advice about the data to be completed, and aids/suggestions when creating interaction areas and adding feedback about the task.

These aspects may also influence the SE variable addressed in the analysis of the TAM questionnaire and is related to that of TC.

B. Q4: What Value Do Educators Assign to TI in the Educational Setting?

To better organize the presentation of the results in relation to Q4, three main categories are addressed: 1) opinions related to TI and the combination between physical and virtual objects; 2) opinions about possibilities of TI in educational practice; and 3) barriers considered in the use of TI in educational practice.

1) Opinions Related to TI and the Combination Between Physical and Virtual Objects: During the Focus Group, the educators were also asked about their assessment of TI and how valuable they considered combining interaction with physical and virtual objects in their class would be. In all sessions, the educators valued this type of activity in contexts in which students are children or in the field of special education. These statements coincide with other works' results, previously described in this article, in which TI applications were used with these groups [24], [46], [25]. This could be attributed to the fact that the educators, in the Focus Group, highlighted the importance of physical manipulation for working with these groups, combined with the multimedia possibilities of these technologies [10], [13], [14], [20], and that they remarked on the possibilities of personalization of the projects (similar to what was referred to in [31]) through the EDIT tool, which would make it possible to adjust the activities to the specific profile of the students. There were also responses emphasizing the overall benefits of TI in the educational field, such as multimodality, motivation, involvement, and collaboration, in agreement with the benefits mentioned by authors previously cited in [20] and [21].

2) Opinions About Possibilities of TI in Educational Practice: As regards the possibilities for educators to use TI applications in their educational practice, some of them responded positively and gave some examples while others mentioned that they had difficulty imagining TI activities working with adults or with the topics they taught. Examples of applications mentioned as possible ways of incorporating TI include the following:

1) *"Maybe Mathematics, topics related to volume that are probably difficult to visualize, for example an intersection.";*
2) *"Creating a timeline where physical objects related to it are placed.";*
3) *"An activity that allows composing, and that has no right or wrong answers.";*
4) *"An activity to increase information.";*
5) *"Activities where specific feedback can be configured for each incorrect answer.";*
6) *"It can be useful to carry out activities outside the classroom, for example in psycho-pedagogical departments or at home."*

These examples can be related to the previously discussed benefits of TI in education, such as its potential for addressing abstract topics [10], addressing socio-cognitive aspects [25], and also issues related to the personalization of feedback. The latter could be linked to the experience of working with EDIT and configuring the different types of feedback.

It can be noted that several of the activities previously mentioned by the educators can be created using EDIT (12,46) while others would require new templates to be added (35).

3) Barriers Considered in the Use of TI in Educational Practice: As regards the aspects that make it difficult for educators to include TI in their institutions, they indicated that the obstacles to incorporating this type of technology include the following: financial difficulties for acquiring the tabletop, even if it is not really expensive; the predisposition of educators to dedicate time to class design using a dynamic that is different from the one they are already familiar with; the number of students in courses, which would require educators to plan how to implement the activity; the challenge of finding the relevant metaphors for using physical objects in order to work with content to design activities that are attractive to adult students: "*I think that using physical objects in activities for 4th year courses at university is more difficult to plan*."; "*For the concepts I work with, I find it difficult to find tangible objects to represent them.*"

In this sense, the idea that they perceive that it is easier to find examples to work with children is reinforced. They also express that they require more examples of TI applications for adults, to help them to imagine what can be done with their students. However, it should be noted that the literature contains a large number of experiences of the use of TI with higher education students, as in [15], [78], and [79].

It is interesting to note that in no case was the use of the ATs indicated as a barrier, in agreement with the results on EDIT acceptance for creating TI applications.

VII. Discussion

In this section, the research findings are discussed and reflections are made. Also, the educators' assessment of TI in their work spaces and the distinctive characteristics of EDIT in light of the results obtained in the sessions and the previous work reviewed are analyzed.

Throughout the sessions, the educators considered TI as a technology that is attractive and has potential, as mentioned in [9], [2], and [4], and which requires changes in the way classes are planned. In this sense, they value having examples that help them awaken their own creativity, specifically in working with adults. The importance of creating a repository where TI educational activities can be shared with the teaching community is reinforced, so that educators would be able to use or adapt the activities created by others. Thus, the EDIT feature related to packaging and meta-annotating the projects in a standardized way supports this need found by educators, since they could be integrated into repositories, making it easy to search and locate projects of interest. As mentioned in Section III, none of the ATs reviewed included this functionality.

Regarding the use of EDIT during the sessions, participants of the different educational levels were able to create their TI applications for tabletops without having previous programming knowledge. EDIT was used as an AT close to the non-programming user. In light of the answers of the TAM questionnaire, it was considered useful PU and easy to use PEU, with Very High scores. As explained in the previous section, it was found that the PU has a direct effect on the ATU. The latter has a direct effect on the intention of use (BI). However, a moderate SE with the tool is observed, which opens the door to searching for strategies to further facilitate this perception. From the Focus Group and the participant observation, it is inferred that this can be related to the need for help required by the educators in some aspects of the configuration of the activities, such as the location of the interaction areas, and the feedback in the miniature image that EDIT shows of the tabletop interface. It was also observed that the educators sequenced their activities within the project according to their own criteria, which may have contributed to the usefulness perceived by them and expressed in the TAM questionnaire. This feature makes it possible to customize the project, an aspect positively valued by educators, and which was not found in the ATs analyzed in Section III. This was also considered positively by the Focus Group, as they related this customization to the needs of working with different groups of students [23], [30], [31], [32]. The configuration of different aspects such as the background and the different kinds of feedback was used in the creation of the projects and mentioned as a positive aspect during the sessions. The template for content presentation provided by EDIT was used to give feedback on task processing [52]; in all cases, the educators completed the steps that students should attend to in order to carry out an activity. This was done using text, image, and/or video, which may indicate that they found this possibility useful. This feature of EDIT is considered a contribution in relation to other ATs. Although some ATs like [47], [57], and [64] indicate that the AT they present gives the possibility of editing the feedback, they mainly provide feedback about the task. Kitvision explicitly mentions the processing of the task feedback. None of them indicate self-regulation feedback or affective feedback. EDIT guides educators to complete the instructions for the processing of the task and it also includes the possibility of being aware of the time expended on each activity as self-regulation feedback. The interface of EDIT also enables incorporating affective feedback through audios, images, or text. Educators used and valued these possibilities during the sessions carried out. This positive valuation of feedback coincides with the results of a recent work using a tangible robot system, which has a component designed to give automatic feedback in relation to the programming task being performed by students [81]. While in the case of EDIT the feedback is given through templates completed by educators (which makes it flexible), it can also be considered as future work to develop an automatic feedback component that complements the one configured by educators in each activity of a project. For example, the automatic feedback could alert users that the time to complete the activity is about to finish or it could describe the type of error made by a student.

The results analyzed here represent an opportunity to reflect on this type of AT for the educational scenario.

VIII. Limitations

Although the results of this work show a high degree of acceptance of EDIT for the creation of TI educational activities, some limitations need to be pointed out.

The sessions were held with a small group of educators. In future research, this group will be increased with a more diverse population. Also, the sessions were carried out in controlled environments with multimedia resources, most of them provided by the researchers who conducted the study. It is important to perform these tests in a real context, making applications for the areas of interest of each educator, with the resources chosen by them and then using the applications created with their students. The TAM instrument was used without the FCs items, because there are as yet no user manuals and tutorials that would serve as an aid for educators in the version of EDIT used in the sessions. This aspect will be taken into account in future evaluations.

IX. Conclusion and Future Work

This work presented EDIT, an AT for creating TI applications oriented to the educational scenario. The tool was designed considering the necessity, detected in previous works, to develop an AT that allows experts in specific domains to use it, without programming knowledge. The research carried out has been taken into account in developing EDIT, which offers distinctive features compared to other state-of-the-art tools. EDIT considers some of the aspects not found in other tools, such as the sequencing of activities, the different kinds of feedback offered, and the standardized packaging and meta-annotation of projects.

The results of the sessions showed a very high acceptance of EDIT for creating TI educational activities. The educators considered EDIT as a bridge for bringing TI to the classroom. The acceptance by the participating educators yielded a very good result, although one of the model variables was rated with a lower score (Moderate). In addition, the results obtained showed that the educators involved were interested and motivated by the possibilities of TI in their educational contexts of work. One of the highlights revealed during the sessions is that participants needed examples to be able to conceive their own educational activities with TI. In general, they considered that this technology favors learning situations with children, and/or in the field of special education. They expressed the need to further analyze the use of TI in activities with adults or to see examples aimed at a teenage/adult audience. Therefore, a space where educators can share their TI applications should be created, promoting application reuse by adapting projects to different contexts, and offering inspiration for the creation of their own TI applications. The EDIT feature for standardized packaging and meta-annotating projects is a contribution in this sense.

As future work, we plan to add to EDIT new templates that enable the creation of other types of TI activities, based on the activities that educators said they would like to create, and we will consider the feedback received from educators in relation to usability aspects. Additionally, the study will be extended to a larger and more diverse population. Finally, the creation of an environment or community where educators can share TI applications will be addressed as a central aspect, to promote the dissemination of this technology. Making an AT such as EDIT and its source code available is considered important for bringing this project to society and furthering our goal of extending the use of TI in educational contexts.

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