

ADOPTION OF DIGITAL STORYTELLING TOOL IN NATURAL SCIENCES AND TECHNOLOGY EDUCATION BY PRE-SERVICE TEACHERS USING THE TECHNOLOGY ACCEPTANCE MODEL

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Introduction

The use of educational resources based on practical cases has a key role in course design (Hudspeth et al., 2006). These are useful, especially to teach natural sciences (e.g., physics, earth sciences, life sciences) and applied technologies subjects in pre-primary and primary education. The Natural Sciences and Technology Education are essential subjects in the training of pre-service teachers. Fulfilment of high-quality teaching is a continuous challenge for universities, and, as current literature confirmed, an improvement of the quality of instruction, especially in the case of Science and Technology Education subjects, is necessary (Fitzgerald, 2019; List, 2019; Pimthong & Williams, in press; Todorova et al., 2017). For example, the use of video-based learning can be a useful resource to guide and enhance especially those parts of the training that pre-service teachers considered to be challenging in the absence of accurate examples (Beilstein et al., 2017). The practical activities are usually performed as project-based learning with small groups of children during the didactics of natural sciences classes (Avsec & Sajdera, 2019). In this context, the video educational resources based on practical cases are always appreciated. A video resource (Nassim, 2018) that forms the basis of the development of Digital Storytelling (DS) can accurately synthesize what the users must understand and retain. One incontestable advantage of video resources is the possibility to return to a required sequence for further explanations. Another advantage is the possibility of making simulations of imaginary cases based on real cases (Dunleavy et al., 2009; Päivi et al., 2007).

Experiential education has the potential to improve the pre-service teachers' understanding and to develop a critical approach. Nevertheless, real-life examples assumed that "learning by doing, active learning, simulations, or incorporating real-world information in instruction, as an alternative, it requires pre-service teachers' to Do, Reflect, Think, and Apply" (Butler et al., 2019, p. 12). The real-life examples used in experiential education represented a specific or hypothetical problem, modelled or simulated, which exists or may exist in



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Abstract. *This research aimed to contribute to the overall understanding of pre-service teachers' acceptance of the Digital Storytelling (DS) tool. The primary associations of the Technology Acceptance Model (TAM) were tested in the academic years 2017/2018 and 2018/2019 for statistical significance when the effects of the pre-service training teachers' digital age and status were controlled. Data from 296 pre-service teachers, from second and third study year, majority women considered vulnerable group were collected. The factor analysis and invariance tests on basic TAM were performed. The results revealed that DS tool usage intention was a function of perceived usefulness and ease of use. This research established the TAM applicability with the control variables addition to model the DS tool acceptance by pre-service teachers, as didactic material for natural sciences and technology education. Configural, metric, and scalar invariance were confirmed across both cross-temporal and cross-sectorial groups. Perceived ease of use of DS has strongly influenced both usefulness ($\beta=.571, t=11.958, p<.0001$) and intention to use of DS ($\beta=.763, t=19.914, p<.0001$), under the influences of the control variables. The outcomes contributed to the general understanding of DS pre-service teachers' adoption relevant for natural sciences and technology education and for recognition of vulnerable category behavior.*

Keywords: *digital storytelling tool, natural sciences didactics, technology education didactics, pre-service teachers' digital age, pre-service teachers' status, TAM model.*

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a particular context. Overall, learning from examples and real cases was appreciated to be a reasonable basis for acquiring knowledge and skills in varied fields (Cucos, 2016), but it usually varied in its efficiency (Gentner et al., 2003). From an educational point of view, the active teaching methods using practical examples lead to differentiated education, which depends significantly on the quality of the educational material (Heemsoth & Kleickmann, 2018), and also by the acceptance level of the users. The additional training necessary for the development of such educational materials can discourage teachers in higher education to use them. Therefore, this kind of achievement of higher education practical application remained a challenge for teachers in higher education.

Therefore, researchers are continuously looking to understand the acceptance by users of new modern educational tools (Ceobanu & Boncu, 2014) that stimulate creativity and innovation. One current example was the DS tool that was developed optimally in a constructivist context of learning, where internal and external interactions were perceived as active knowledge developments. From an educational perspective, the practical teaching methods for both formal and non-formal contexts have multiple educational benefits (promoting collaboration between participants, enhancing and streamlining information transfer, developing creativity) (Lazar et al., 2019). Highlighting the oscillations (Grigore et al., 2016), teaching motion in a uniform gravitational field (Marciuc et al., 2016), mapping of the polluted soil or water (Cozzolino, 2016; Faciu et al., 2014) or various quantitative biological applications (Liu et al., 2016; Mielke et al. 2012; Voundi et al., 2015) were some practical examples which can be used as experimental cases during the development of DS tool.

The research behavior of pre-service teachers had gathered extensive interest (Aalto et al., 2019) when they started adopting digital tools for educational aims. Various models of digital behavior of pre-service teachers (List, 2019; List et al., 2020; Prilop et al., 2020) have examined into a variety of contexts as set up points for modelling each behavioral intention to adopt the educational resources. One of the most disseminated theoretical contexts used in modelling digital human behavior was the Technology Acceptance Model (TAM) (Kamal et al., 2020), which provided a better knowledge of individuals' behavior when intended to use digital tools (Kim et al., 2019) or Web 2.0 (Muhaimin et al., 2019) in learning.

TAM has been tested and validated in different contexts (Shih et al., 2013) and was extended with different external variables to increase its predictive power (Sepasgozar et al., 2019) resulting into generalized TAM that were reliable and valid as structure (Deliu et al., 2019). However, during this research the results were not found of other in-depth exploration on the adoption of DS tools across pre-service teachers in different national contexts. Consequently, the external validation of the relations of the TAM in the context of the acceptance of DS by pre-service teachers relevant for natural sciences and technology education was the primary purpose of this research.

Literature Review

Technology Acceptance Model

The Technology Acceptance Model developed for the first time in 1989 by Davis was based on "*perceived usefulness of the information system, defined as users' belief that the use of the system is beneficial to them and perceived ease of use of the information system, defined as the extent to which an information system is perceived to require a low degree of effort for use*" (Davis, 1989, p. 320). The correlation between the underlying factors of the TAM model was already recognized: "*the perceived ease of use explored the ability of users to experiment with a new innovation and evaluate its benefits easily*" (Jahangir & Begum, 2008, p. 034), taking account that "*behavioral intention was based on deliberative processing*" (Kidwell & Jewell, 2010, p. 407).

Therefore, it was unanimously recognized that the basic TAM is a generally accepted robust model (Scherer et al., 2019). The TAM has been regularly improved and modified accordingly to different requirements as an illustration of the user behavior related to intention to use an educational tool. Numerous extended TAM models who proposed to explore the behavioral intention to use the digital educational resources in different contexts can be found in the literature (Balog, 2013; Balog et al., 2013). Despite some certitudes, however, the research reports found included relatively few studies presenting the measurement of the significant variation of TAM associations under moderating variable influences (Yoon, 2018) such as gender, age, experience, or volunteering. This research intended to extend existing statements by testing the behavior of pre-service teachers to use a new educational resource in a context where the effects of control variables such as digital age and pre-service teachers' status were considered.



Control Variables

The relations between the dimensions of the basic TAM can be quite complicated, generating several possible interpretations. A good theoretical research model needed to consider many possible external causes that influenced the behavioral responses. Some of these were independent variables having, at the same time, a control role and a significant influence on the association between the latent variables of the model. The selection of control variables was based on the didactic experience of the authors and literature findings. Therefore, the selected control variables are directly related to the particularities of pre-service teachers in science education (Kennedy-Clark, 2011). The age was undoubtedly a common control variable. Consequently, the present research responds to the need to understand how the digital age and status of pre-service teachers, which are described in the following paragraphs, influenced the DS tool adoption, as educational material for natural sciences and technology education.

Pre-service teachers' digital age: digital native vs. digital immigrant pre-service teachers

The digital age, as a category variable, has been less appreciated in the literature, even though it may have a decisive role in the exhaustive understanding of users' behavior regarding the intention to use digital resources. Prensky has made a significant distinction between adults' age since 2001. He discussed about digital natives (those born with the computer in their hand and who are native "speakers" of computer, video games, and Internet language) and digital immigrants (Prensky, 2001, 2008). Prensky (2008) renamed the digital native as "i-kids". They were constantly connected to mobile phones, mp3 players, and game consoles. Adults who were born before 1980 were part of the second category, respectively, the digital immigrants. Even if they finally succeeded in adapting to this new world, they were like geographic immigrants. Despite the fact that the digital immigrants acquired the language of the new country, they will always have an accent, they will never be as fluent as the children born in that country (Prensky, 2001).

Over time, with the development of digital technology, the theoretical concepts related to the native digital and immigrant digitals were changed progressively. Also, the differences between natives and immigrants, as initially described by Prensky (2001), were modified over time. Tapscott (2008) noticed that although it was talking about the "net Generation" since 1997, the concepts were perceived differently from the present. At the time of Tapscott's research, there was no Google, no Facebook, no Twitter, and not even YouTube, and therefore what he did, as an author, was to intuit and speculate the immense impact that technology would have in people's lives (Tapscott, 2008). Besides, it is already known that middle-aged people (over 40 years), namely digital immigrants, were less skilled at using digital resources. As a result, it can be supposed the existence of a diversity of digital competences of pre-service teachers, but also of their interests. In such educational contexts, the personalized and differentiated education must be intensively promoted.

Previous studies suggested that digital immigrants (Kesharwani, 2020) have difficulties in the use of digital tools, especially those less intuitive. Moreover, researchers have seen a decline in digital skills with age (Mannheim et al., 2019). One of the key objectives of science education at the university level was to prepare future teachers with a level of awareness of Science and Technology subjects much larger than the present teachers' generations. However, this objective was not allowed to be easily reached by the inhomogeneous character of the current generation of pre-service teachers in terms of age, coupled with digital abilities.

From their native digital perspective, pre-service teachers have certain clear features. Thus, the digital natives were exceptionally curious, open to contradictions, smart, focused, able to adapt, with high self-esteem and global orientation (Autry & Berge, 2011). Margaryan et al. (2011) consider sociability and openness to new experiences as essential psychological features of this generation. On the other hand, digital natives used technology, first, for fun and socializing (Giurgiulescu et al., 2015). As a result, they were less interested in using technology as a scientific resource for cognitive motivations, being prevalent the positive, affective, hedonic motivations of technology use. The way in which digital natives used technology was about certain interaction features with games and social networks. In games, the feedback was received very quickly, so immediate reward (through points/bonuses/new levels) and satisfaction was necessary. Also, the level of attention should be kept on a subject for a short time.

On the contrary, DS involves "serious" interaction coupled with voluntary effort towards focus, more deep learning, in contradiction with the usual way of work of the generation of digital natives, whether they are called



millennials, generation Z, or generation snowflakes (Panisoara & Panisoara, 2005). For these reasons, teachers in higher education need to be ready to adapt their message to this new generation and to promote the usage of digital tools considering the inhomogeneous features of the digital age of pre-service teachers. However, at present, these aspirations were difficult to be obtained. Researches have shown that the integration of technology into education must cross five essential steps: "*recognizing, accepting, adapting, exploring, and advancing*" (Niess & Gillow-Wiles, 2015, p. 523). Only in the exploration phase, the integration of technology into teaching can be seen. Consequently, there were more steps to complete the integration of technology into educational activities. Therefore, the present research model assumed the digital age (*digital immigrant pre-service teachers* who were born before 1980 and *digital native pre-service teachers* who were born after 1980 (Kesharwani, 2020) as control variables of TAM.

Pre-service teachers' status: traditional vs. non-traditional pre-service teachers' status in higher education

Another control variable category, also related to age (Sandu et al., 2015) was the status of the pre-service teachers, respectively if they belong to the category of traditional pre-service teachers or non-traditional pre-service teachers. The age of pre-service teachers partly shapes their professional careers. The non-traditional students who are at the point of changing the profession have a greater desire to learn new things, to know more data that can help them to perform in a new career. In addition, pre-service teachers who are already teaching and who are in the middle of their professional careers can have a variety of reasons for professional development because they left school a long time ago, so they try to maintain themselves at a high professional level. Moreover, career development motivation increases adults' preference for life-long learning (Kulcsár et al., 2019). Traditional students are often more rigid, less flexible, and they want to adopt the paths already followed. Unlike traditional students, the non-traditional ones are more open, more creative, more open to trial and error, to assume non-convents and specific risks. In this context, it is necessary to research the effects of the status of pre-service teachers, as a control variable, on the latent factors of the model.

The literature proposes the following features of non-traditional pre-service teachers, as well-presented by Wladis et al. (2015, p.288): "*delayed enrolment; no high school diploma; part-time enrolment; financially independent; have dependents; single-parent status; and working full-time while enrolled*". Furthermore, Cho (2019, p.55) reported that the term "non-traditional" could describe undergraduates "*who meet any of the five criteria as defined in his study: join part-time for at least part of the academic year, work full time while enrolled, considered financially independent, have dependents other than a spouse (usually children, but sometimes others), and a single parent*".

Pre-service teachers who have chosen careers in education are diverse in terms of enrolment age, current occupations, and previous experience in the workplace. Nontraditional pre-service teachers, as they are defined by (Donahue & Glodstein, 2013, p. 2), are those who meet one or more criteria most often used being the higher school admission at the age of more than 25 and "*holds a general equivalency diploma*". At this time, the characteristics of pre-service teachers enrolled on the pedagogy of primary and preschool education program at Bucharest University are different from other pre-service teachers because the proportion of non-traditional pre-service teachers who already work is higher than from other university programs. Another peculiarity of this study program is the unusual imbalance between the proportion of men and women, women considered vulnerable group being overwhelmingly majority. Moreover, results found from the literature review revealed that nontraditional pre-service teachers have difficulties in using different teaching styles, which implies the use of various didactic material (Bartholomew et al., 2018; Kikas et al., 2016). Thus, particular attention should be given to the science education field to which nontraditional pre-service teachers join in large numbers (Wladis et al., 2015). In such a context, educational strategies coupled with didactic materials need to be revised and redesigned to be really adapted to particularities of target group.

In this research, *traditional* was a term used to describe pre-service teachers who were starting university studies before the age of 25 (on-time enrollment) (Metzner & Bean, 1987) and considered financially dependent by their family. The non-traditional was a term used to describe pre-service teachers who were starting university studies after the age of 25 (delayed enrollment), and also they were considered financially autonomous (Cho, 2019).



Research Problem

Storytelling combined with multimedia resources assisted pre-service teachers in learning the Natural Sciences Didactics and Technology Education Didactics in an effective way. However, research data related to the acceptance level of DS tools by undergraduate pre-service teachers enrolled in the pedagogy of primary and preschool education study program seemed to be non-existent. The main purpose of this research was to explore the psychological constructs underlying Romanian preservice teachers' behavioral intentions to use DS tools based on the basic Technology Acceptance Model.

Research Aims, Objectives, Key Results and Hypotheses

The present research focused on understanding the acceptance of the DS tool by Romanian pre-service teachers to learn educational science subjects. In particular, the research explored the effects on Intention to Use DS tool, when controlling for pre-service teachers' digital age by Perceived Usefulness and Perceived Ease of Use when controlling for pre-service teachers' status. Also, the similarities of links between research model factors through preservice teachers enrolled in Natural Sciences Didactics and Technology Education Didactics courses, in the second and third years of study, were tested.

A model based on the basic Technology Acceptance Model which correlates the following factors perceived usefulness, perceived ease of use, and behavioral intention to use (Ramírez-Correa et al., 2015) was used for this research. The variables of the basic model TAM were adapted from previous studies. This basic TAM was enhanced with two controls, namely pre-service teachers' digital age and pre-service teachers' status. These control factors are identified from past literature on technology adoption by teachers. The role of each independent variable (PEU and PU) in the basic TAM with two control variables was also investigated. The specific aims of the research linked to objectives played an important role in shaping the strength of the research (Farrugia et al., 2010). General research objective was to determine the adoption of digital storytelling tool in natural sciences and technology education by pre-service teachers. In order to achieve specific research objectives, the theoretical issues summarized above were applied to formulate the following research objectives (ROs) and key results (OKRs).

These objectives, associated measurable key results and hypotheses (Niven & Lamorte, 2016) are settled (Table 1) as follows:

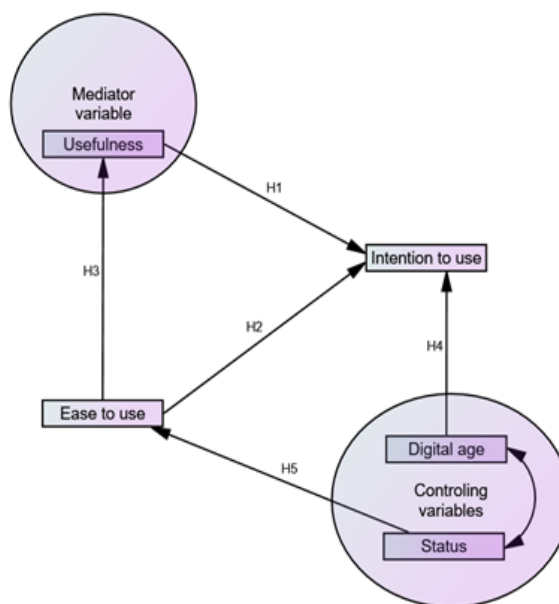
- RO1: to measure the scale validity of the proposed research model;
 - OKR1: *construct validity indexes met the thresholds requirements*
- RO2: to evaluate the invariance of the measurement model through cross-temporal category variable;
 - OKR2₁: *the configuration invariance was confirmed in case of cross-temporal multigroup analyses;*
 - OKR2₂: *the metric invariance was confirmed in case of cross-temporal multigroup analyses;*
 - OKR2₃: *the scalar invariance was confirmed in case of cross-temporal multigroup analyses;*
- RO3: to evaluate the invariance of the measurement model through cross-sectorial category variable;
 - OKR3₁: *the configuration invariance was confirmed in case of cross-sectorial multigroup analyses*
 - OKR3₂: *the metric invariance was confirmed in case of cross-sectorial multigroup analyses;*
 - OKR3₃: *the scalar invariance was confirmed in case of cross-sectorial multigroup analyses;*
- RO4: to evaluate if the hypothetical structural model well fit the experimental data based on the value of indexes quality;
 - OKR4: *indexes quality of the hypothetical structural model met the thresholds requirements*
- RO5: *to analyze the correlations through TAMc dimensions in the context of DS adoption.* Accordingly, with this research objective twelve research hypotheses were proposed (Table 1). H1-H5 are represented in Figure 1. H1-H10 were statements (Stalvey et al., 2019) about links between dimensions. In the present research all hypotheses were assessed, after previous objectives and key results (OKR1-OKR4) were reached.



Table 1

Summary of hypotheses testing for direct, mediated, multi-group effects and cross-temporal variable effects, the requirements and descriptions of hypotheses

Effects category	Requirements	Code	Description
Direct effects	OKR1	H1	Perceived usefulness (PU) has a positive direct effect on Intention to use (BU) DS tool when controlling for pre-service teachers digital age (DA)
		H2	Perceived ease of use (PEU) when controlling for pre-service teachers' status (ST) have a positive direct effect on Intention to use (BU) DS tool when controlling for pre-service teachers digital age (DA)
		H3	Perceived ease of use (PEU) when controlling for pre-service teacher's status (ST) have a positive direct effect on Perceived usefulness (PU) of DS tool
		H4	Pre-service teachers' digital age (DA) has a positive direct effect on Intention to use (BU) DS tool
		H5	Pre-service teachers' status (ST) has a positive direct effect on Perceived ease of use (PEU) DS tool
Mediated effect	OKR1	H6	Perceived usefulness (PU) mediated the relationship between Perceived ease of use (PEU) when controlling for pre-service teachers' status (ST) and Intention to use (BU) DS tool when controlling for pre-service teachers digital age (DA) and pre-service teachers' status (ST).
		H7	The positive relationship between Perceived usefulness (PU) and Intention to use (BU) DS tool when controlling for pre-service teachers digital age (DA) was similar for pre-service teachers enrolled in Technology Education Didactics course (TE) and for pre-service teachers enrolled in Natural Sciences Didactics courses (NS);
		H8	The positive relationship between Perceived use of use (PEU) when controlling for pre-service teachers status (ST) and Intention to use (BU) DS tool when controlling for pre-service teachers digital age (DA) was similar for pre-service teachers' enrolled in Technology Education Didactics course (TE) and for pre-service teachers' enrolled in Natural Sciences Didactics courses (NS);
Multi-group effects	OKR1 OKR31 OKR4	H9	The positive relationship between Perceived usefulness (PU) and Perceived ease of use (PEU) DS tool when controlling for pre-service teachers' status (ST) was similar for pre-service teachers enrolled in Technology Education Didactics course (TE) and for pre-service teachers enrolled in Natural Sciences Didactics courses (NS);
		H10	The positive relationship between pre-service teachers' digital age (DA) and Intention to use (BU) DS tool was similar for pre-service teachers enrolled in Technology Education Didactics course (TE) and for pre-service teachers enrolled in Natural Sciences Didactics courses (NS);
		H11	The positive relationship between pre-service teachers' status (ST) and Perceived ease of use (PEU) DS tool was similar for pre-service teachers enrolled in the Technology Education Didactics course (TE) and for pre-service teachers enrolled in the Natural Sciences Didactics courses (NS).
Cross-temporal variable effects	OKR1 OKR21	H12	The study year (SY) as a cross-temporal variable does not affect the mean rank scores of Perceived usefulness (PU), Perceived ease of use (PEU) and Intention to use (BU) DS tool;

Figure 1*The research model*

Research Methodology

General Background

This research used a correlational study design, in order to explore the settings of this educational situation and allowed the explanation of correlations between the independent variables and dependent variable when external variables were controlled (Bardakçı & Alkan, 2019). Considering the purpose of the research, four structural equation models were suggested in order to describe the structures causing the intention to use DS by pre-service teachers. The first structural equation model examined the positive significant correlations between basic TAM variables (perceived ease of use, perceived usefulness and intention to use DS). The choice of the first structural equation model was motivated by the fact that the basic TAM showed a good model fit to interpret the experimental data (Wu et al., 2011). The second alternative structural equation model scrutinized the positive relationships between original three TAM variables when controlling for pre-service teachers' digital age. The third structural equation model examined the positive relationships between essential TAM variables when controlling for pre-service teachers' status of traditional or non-traditional student. The last alternative structural equation model scrutinized the positive relationships between original TAM variables when controlling for pre-service teachers' status and pre-service teachers' digital age.

The theoretical structural equation models were designed with the purpose of comparing a phenomenon or an event in various contexts (Lazar, 2019a). The mandatory condition to achieve this is to use measuring instruments that are invariant to the tested conditions. Briefly, the measuring instrument must be equivalent to different conditions explored. Consequently, after the establishment of the best fit of theoretical model, the invariant tests regarding the selected variable categories must be performed.

Participants

In this research, a questionnaire was distributed to 313 pre-service teachers at the Psychology and Science Education Faculty from Bucharest University in Romania. Pre-service teachers (Manuel & Dutton, 2019) refer to undergraduates who receive training to become full-time teachers on initial education level (pre-school and primary



school). They were recruited from two different study years of the same study program, pedagogy of primary and preschool education: the second year of the program, when pre-service teachers learned about natural science didactics for pre-primary education and the third year of the program when pre-service teachers learned about natural science didactics and technology education didactics for primary education level. The period covered by the collection of experimental data was the 2017/2018 and 2018/2019 academic years. Overall, 296 pre-service teachers correctly answered the survey, resulting in a response rate of 94.5%, so only these answers were acceptable for the current research. The main criteria for asking pre-service teachers to join the research were to be involved actively and completed each course, thus the collected answers were made at the end of every course. All respondents agreed to participate voluntarily in the research and, in advance, were informed about the purpose and methodology of the research, thus ensuring compliance with the rules of ethics in research.

The respondents had a mean age of 27.26 years with a standard deviation (*SD*) of 8.608. The mean age of traditional pre-service teachers was 21.20 (*SD* = 1.564), and of nontraditional pre-service teachers was 35.22 (*SD* = 7.511). The mean age of digital native pre-service teachers was 25.01 (*SD* = 6.225), and of digital immigrants was 44.06 (*SD* = 4.144). Gender was disproportionately distributed. Most of them were females which are vulnerable groups, about 99%. A similar pattern was found for current pre-service teachers enrolled in the 2019/2020 academic year, of which 3.93% male were registered in the first year of study, 0% male was registered in the second year of study, and 0.95% male were enrolled in the third year of study. The participants' profile was presented in Table 2.

Table 2.

Participants demographic data (N = 296) during two academic years 2017/2018 and 2018/2019

Variable	Number (%)
Gender	
Female	294 (99.3)
Male	2 (0.7)
Study year	
Second year	96 (32.4)
Third Year	200 (67.6)
Course	
Natural sciences didactics for pre-primary and primary education	190 (64.2)
Natural sciences didactics for pre-primary education	96 (32.4)
Natural sciences didactics for primary education	94 (31.8)
Technology education didactics	106 (35.8)
Course level	
Pre-primary education	96 (32.4)
Primary education	200 (67.6)
Pre-service teachers' status*	
Traditional	168 (56.8)
Nontraditional	128 (43.2)
Pre-service teachers' digital age	
Digital native	261 (88.2)
Digital immigrant	35 (11.8)

Note: all research participants are from Bucharest University, Faculty of Psychology and Science Education from Bucharest, Romania and also from the Focsani and Buzau Branches of this Faculty; all nontraditional pre-service teachers declared they have financial independence and have no problem paying their tuition fees, if any, unlike traditional ones, who declared they have dependent by the financial support of the family.



Questionnaire

This research was part of an extensive educational research evaluating undergraduates' and graduates' behavior towards the use of digital educational resources and was approved by the Research Commission Ethics of the University of Bucharest, Romania. The construction of an adapted version of TAM Questionnaire (TAMc) to assess the intention to use DS tool by pre-service teachers was built based on the literature reviewed and discussions with several teachers in higher education, before this research (Lazar, 2019b). A panel of academic teachers from Bucharest University, Romania, confirmed the content validity questionnaire.

The initial questionnaire had three subscales following the structure suggested by Davis (1989) and was composed of two main sections. The first one included the items about pre-service teachers' biographical details, involving age, gender, year of study, and the course at which they were enrolled at the time of asking. Section 2 of the questionnaire was linked to the usefulness, ease of use, and intention to use the DS tool and covered 12 initial statements of the basic TAM. They are perceived usefulness (PU) (five items), perceived ease of use (PEU) (four items), and behavioral intention of use (BU) (three items). The items selected to develop the current basic dimensions of the TAM were mainly adapted from previous findings (Leong et al., 2013; Teo, 2009) to enhance the validity of the content (George, 2018). Accordingly, the measures for the three main dimensions were adapted from literature as follows: Perceived Usefulness of DS tool from Davis (1989), Perceived Ease of Use of DS tool from Teo (2009), and Intention to Use DS tool from Leong et al. (2013).

A pilot study involving a non-biased sampling was performed on 30 voluntary pre-service teachers. They were asked to indicate the level of applicability, objectivity, relevance and understanding of each item of the initial questionnaire (Lazar, 2019a). Accordingly, with the results of this preliminary research, several misunderstandings were identified, and the initial questionnaire has been amended as suggested by this pilot group of participants. These participants were also part of the demonstration experiment on DS, after the large study was started. The 12-items questionnaire was designed using a five-point Likert scale, and the possible answers are "I strongly disagree", "I disagree", "I am undecided", "I agree" and "I strongly agree". All items from the questionnaire are listed in *Appendix A*.

Data Analysis

The initial 12-item questionnaire was administered on 313 pre-service teachers using the online and traditional paper/pencil data collection methods, as described in the Participants section. The Kaiser-Meyer-Olkin (KMO) values completed by Bartlett's test were calculated, and it was agreed that three factors covered the best explanation, as suggested by Gavora and Wiegerová (2019, p.561). Exploratory Factor Analysis (EFA) with Promax oblique rotation was used to establish several common factors for the set of variables contained in the survey. This represented the first step in the theoretical validation of the proposed research model. Univariate analysis was performed with IBM SPSS software version 20.0, and multivariate analysis was performed with IBM SPSS AMOS 26.0 free version.

Confirmatory factor analysis (CFA) was used to discuss the structural validity and internal consistency of each construct; the average variance extracted values (AVE) were used to measure the correlation between different structures. The rate between Chi-square (χ^2) and degrees of freedom (df), comparative fit index (CFI), Tucker-Lewis fit index (TLI), Root mean square error of approximation (RMSEA), standardized root mean square residual (SRMR), and the test of close fit (PCLOSE) were the indexes taken into account for estimated the CFA model quality.

The non-parametric Mann-Whitney U test (Pinto et al., 2019) was used for running univariate analysis to compare samples in the cross-sectional groups for which the measurement model was invariant. A p (calculated probability) value higher than .05 means was thought to be not statistically significant, and no effect was detected (Freund et al., 2010). The evaluation of replicability and generalizability of the TAM validated scale was performed through the measurement of invariance tests. Tests of measurement invariance of the TAM validated scale using two pairs of samples (e.g., second and third year of study, natural science, and educational technology courses) were performed. Measurement invariance was determined by performing Multi-Group Confirmatory Factor Analysis (MGCFA) in a sequence of steps or test levels (Balog, 2013), in order to explore the stability of the measurement model across every two groups (Sullman et al., 2019).

The structural equation modeling (SEM) was used to analyze the fitness of the whole model, and the factor loadings of different paths (Rafique et al., 2020). Explicitly, path diagrams as a structural equation modeling tool and bootstrap estimation were applied (Talbot et al., 2014). The mediating effect was also used to analyze the relationship between latent variables. Thus, one mediation analysis was performed to establish the possible mediating



effect of perceived usefulness on the correlation between perceived ease to use and intention to use in the context of DS adoption, when controlled for pre-service teachers' digital age and their status.

Finally, tests of measurement and structural invariance of the basic TAM with two control variables (TAMc) using two groups (e.g., Natural Science Didactics course and Technology Education Didactics course) were performed. The measurement invariance tested, if the measurement model does not differ significantly across groups (Rusticus & Hubley, 2006). The measurement invariance included the scanning of a sequence of gradually limiting hypotheses, each reaching more statements about the equal opportunity of the two groups. The configural invariance was tested in the first stage. This stage assumed that the model factors consisted of the same items for both sample groups. The next stage was metric invariance, where the correlation between items and a factor were also equal across groups, and the next stage was scalar invariance, where the item intercepts were also equal across groups (Dovgan et al., 2019). The metric invariance tested if different groups reacted to the scale items in a similar manner (Milfont & Ronald, 2010), and the scalar invariance tested whether the scale items had the same point of origin for separate groups (Pfeiffer, 2008).

Research Results

Exploratory Factor and Reliability Analysis Results

KMO Measure of Sampling Adequacy and Bartlett's Test of Sphericity (BTS) were analyzed to explore the factor dimensions. The KMO value was found to be .863, which is good value, and BTS showed an approximately Chi-Square value of 2060.246 ($p < 0.0001$), which meant that the correlation matrix of data for factor analysis is appropriate. According to the outcomes of the EFA, the cumulative explanation percentage of the variance was perceived as 71.178%. The first factor (PU) had an eigenvalue of 10.688 and explained 41.107% of the total variance, while the second factor (PEU) had an eigenvalue of 1.312 and explained 5.045% of the total variance. The eigenvalue and the variance for the third factor (BU) were found to be as 1.044 and 4.015%, respectively.

Cronbach's alpha coefficient was used to verify the reliability of each subscale. The final outcomes of the reliability test showed an excellent Cronbach's Alpha coefficient (.894) for the three-factor 12-item survey. The three-factor model met acceptable reliability for each subscale (i.e., Cronbach's alpha coefficient $\geq .7$) (Taber, 2018). Cronbach's Alpha values for Factor 1 (PU), Factor 2 (PEU), and Factor 3 (BU) were calculated as .884, .840, and .814, respectively. All values of Cronbach's alpha coefficients confirmed the overall reliability of our data.

Construct Validity of Measurement Model

Confirmatory factor analysis (CFA) was applied to identify the consistency and construct validity of the research model. The measurement model identified any item with low factor loadings. It pointed out that two of the factor loadings were irrelevant at .468 (PEU1) and .450 (BU2), indicating that the responses to these items might be contradictory with other answers using the same construct. Thus, both items were removed.

The results of the next round of CFA (*Appendix B*) are presented in Table 3 for convergent and discriminant validity tests. So, the composite reliability (CR), average variance extracted (AVE), Maximum Shared Variance (MSV) are provided for each factor loading. The thresholds values are Reliability: CR > 0.7 , Convergent Validity: AVE > 0.5 , Discriminant Validity: Maximum Shared Variance (MSV), MSV $< AVE$, Average Shared Variance ASV $< AVE$, and Square root of AVE MaxR (H) higher than inter-construct correlations (Alumran et al., 2014). Examinations of dimensions' reliability and validity were performed before the hypotheses were started to be tested (Kline, 1998).

Table 3

Model validity measures of the measurement model

	CR	AVE	MSV	MaxR (H)	Usefulness	Ease to use	Intention to use
Usefulness	0.873	0.587	0.272	0.934	0.766		0.512*
Ease to use	0.811	0.591	0.578	0.826	0.521*	0.769	0.760*
Intention to use	0.816	0.694	0.578	0.901			0.833

*Significance of Correlations: * $p < .0001$*



The results of the measurement model showed an excellent construct validity, which supported OKR1 for the three-factor 10-item survey. While all basic TAM relationships are construct validated in the measurement model, in the next step of the analysis (e.g., structural model), the control variables were included in the model to test in which conditions TAM links were validated when controlled for pre-service teachers' digital age and status.

Results of Measurement Invariance Tests

A prerequisite for testing the invariance is to demonstrate the validity of the measuring instrument, respectively 10-items TAM scale, for each group taken separately. In the first stage, the quality of each structural model was tested (Balog, 2013). The model fit comprised of 5 items as listed in Table 4 that purpose to evaluate each model quality, being therefore distributed for: pre-service teachers enrolled in year II ($n = 96$); pre-service teachers enrolled in year III ($n = 200$); pre-service teachers enrolled in Natural Sciences Didactics for pre-primary and primary education ($n = 190$), and pre-service teachers enrolled in Technology Education Didactics for primary education ($n = 106$).

Table 4

Model fit indices descriptions and thresholds used in assessing model quality results

Model fit indices	Results of structural models				Thresholds	References
	Cross-temporal variable category		Cross-sectorial variable category			
	Year II ($n = 96$)	Year III ($n = 200$)	Natural Sciences Didactics for pre-primary and primary education ($n = 190$)	Technology Education Didactics ($n = 106$)		
Ratio of chi square and degrees of freedom (χ^2/df)	1.473	2.151	2.559	1.209	If the ratio = 1 or just over 1 the fit is perfect; if the ratio ≤ 2 the fit is good; if the ratio ≤ 5 the fit is acceptable and if the ratio ≥ 5 the fit is unacceptable	(Guiné et al., 2016)
Probability level p	.046	.000	.000	.199	The probability is suggested to be greater than 0.05	(Stalvey et al., 2019)
Comparative Fit Index (CFI)	.976	.968	.956	.989	If the CFI ≥ 0.90 the fit is acceptable	(Arpaci, 2019)
Root Mean Square Error of Approximation (RMSEA)	.071	.076	.091	.045	RMSEA ≤ 0.06 may indicate a good fit; $0.05 < RMSEA < 0.10$ indicate a weak fit; the values over 0.10 will be rejected	(Boateng, et al., 2018; Brown, 2015)
Standardized Root Mean Square Residual (SRMR)	.0701	.0534	.0675	.0422	If the SRMR ≤ 0.08 the fit is acceptable; the SRMR ≤ 0.05 may indicate a good fit;	(Guiné et al., 2016; Livheim et al., 2016)

The model fit indices descriptions that included Ratio of Chi-square and degrees of freedom (χ^2/df), probability level p , Comparative Fit Index (CFI), Root Mean Square Error of Approximation (RMSEA), Standardized root mean square residual (SRMR), provides a good fit for the data in all samples, as it can be observed in Table 4. Nevertheless, the values indicating the best fit are those for the Technology Education Didactics study case, followed by pre-service teachers enrolled in year II.

Accordingly, with previous results, the model must be tested in both groups for measurement invariance tests. In the second stage, the invariance of the measuring instrument has been measured in each separate group,



these tasks corresponding to the assessment of OKR2 and OKR3. Firstly, the configuration invariance was tested, which corresponded to OKR_{2,1} and OKR_{3,1} (Bhat et al., 2019), and secondly, the metric invariance was tested, which corresponded to OKR_{2,2} and OKR_{3,2} (Rodríguez-Jiménez et al., 2016). In the last step, the scaling invariance was tested, which corresponded to OKR_{2,3} and OKR_{3,3} (Huang et al., 2017). The invariance is confirmed if the result of the $\Delta\chi^2$ difference test is statistically insignificant (Kwon et al., 2017; Lazar, 2019a), and if the difference in CFI (Δ CFI) between nested models was less than the threshold value – 0.01 (Milfont & Ronald, 2010; Teo, 2013). The results of the quality indices of the nested models (M1-M3) and the difference tests between these are shown in Table 5.

Table 5

The results of the quality of the CFA indices and the differences between the nested models (M1-M3) of the structural models

Tested Models	χ^2	df	$\Delta\chi^2(\Delta df)$	Threshold for $\Delta\chi^2(\Delta df)$	χ^2/df	RMSEA	CFI	SRMR	Δ CFI	Threshold for Δ CFI	Results
Configural invariance M1!	108.791 ^a	60 ^a	-		1.813 ^a	.053 ^a	.970 ^a	.0701 ^a	-		
	113.012 ^b	60 ^b	-		1.884 ^b	.055 ^b	.968 ^b	.0675 ^b	-		
Metric invariance M2!	123.175 ^a	70 ^a	14.384 (10) ^a ns	$\Delta\chi^2(\Delta df)$ is nonsignificant	1.760 ^a	.051 ^a	.968 ^a	.0849 ^a	.002	Δ CFI between nested models was less than 0.01	Reached RO1 and RO2
	127.526 ^b	70 ^b	14.514 (10) ^b ns		1.822 ^b	.053 ^b	.965 ^b	.0743 ^b	.003		
Scalar invariance M3!!	135.507 ^a	80 ^a	12.332 (10) ^a ns		1.749 ^a	.063 ^a	.965 ^a	.0854 ^a	.003		
	137.058 ^b	80 ^b	9.532 (10) ^b ns		1.713 ^b	.049 ^b	.965 ^b	.0748 ^b	.000		

Note: *** $p < .001$; ** $p < .05$; ns = non-significant; $\chi^2/df < 3$; comparative fit index CFI (criterion $> .90$); root mean square error of approximation RMSEA (criterion $< .08$); Standardized Root Mean Squared Residual SRMR (criterion $< .08$) (Ref); a. cross-temporal category; b. cross-sectorial category; !Signifies best fitting model for cross- cross-temporal category; !!Signifies best fitting model for cross-sectorial category.

The factor loadings (*metric invariance*) and the item intercepts (*scalar invariance*) are comparable through both category variables (Table 4). The metric and scalar invariance models were supported due to the chi-square difference test $\Delta\chi^2(\Delta df)$ yielded insignificant results, and Δ CFI between nested models was less than 0.01 (Table 4). In the case of the year of study category (cross-temporal variable), the outcomes of the measurement models demonstrated the metric invariance M2 as best fitting model, because the fit indices are closest to indicate a good fit, as it can be observed in Table 3 (RMSEA for M2 (.051) is smaller than RMSEA for M3 (.063)). In the case of the course study type category (cross-temporal variable), the outcomes of the measurement models demonstrated the scale invariance M3 as best fitting model, because the fit indices are closest to indicate a good fit, as it can be observed in Table 3 (RMSEA for M2 (.053) is higher than RMSEA for M3 (.049)). These findings demonstrated a strong measurement invariance of the basic TAM scale for acceptance of the DS tool regarding the cross-temporal category (year of study), which supported OKR_{2,1-3} and the cross-sectorial category (study course type), which supported OKR_{3,1-3}.

Results of Path Analysis

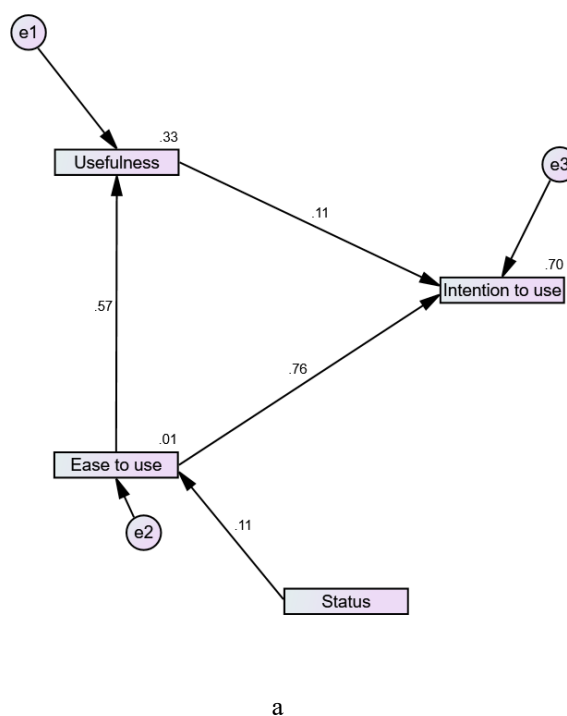
The path analysis results related to one structural equation model (SEM) without the control variables (SEM_a), one structural equation model with digital age as control variable (SEM_{DA}), one structural equation model with status as control variable (SEM_{ST}) and one structural model with both control variables (SEM_{DA_ST}) were presented individually (Bardakçı & Alkan, 2019). The resulting model fit with interpretation (Lowry & Gaskin, 2014) for all five structural equation models with the direct path status $ST \rightarrow$ Ease to use PEU, the direct path digital age $DA \rightarrow$ intention to use BU and both direct path status $ST \rightarrow$ PEU and $DA \rightarrow$ BU have the data fit presented in Table 6. Although χ^2 test for the structural equation model without the control variables is significant, the other quality indices of the structural model have been framed in the threshold values. SEM_{DA_ST} shows the best quality fit, and a significant χ^2 test, so it can be declared the best model of experimental data.

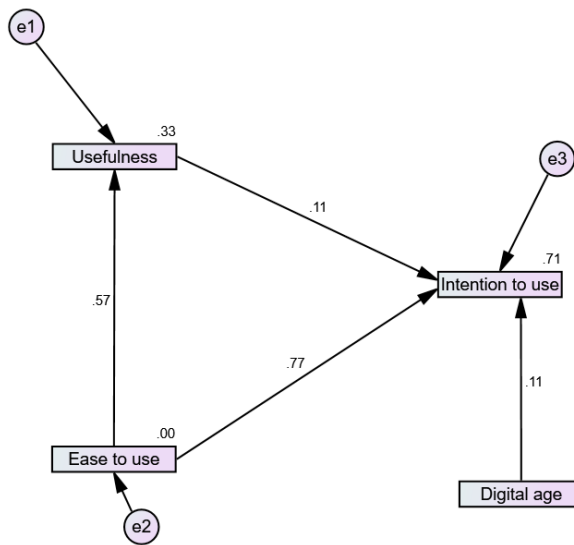
Table 6
 The resulting model fit for all four structural equation models

SEM tested	Model fit Indexes					Thresholds	References	Model fit quality
	χ^2/df	p	CFI	RMSEA	SRMR			
SEM a	1.911	.0001	.975	.056	.0601	1 < χ^2/df < 3 p > .05 CFI > .90 RMSEA < .10 SRMR < .08	(Teo, 2013)	Good
SEM_DA	0.832	.435	1.000	.001	.0324			Fair
SEM_ST	2.828	.059	.992	.079	.0324			Good
SEM_DA_ST	2.326	.054	.990	.067	.0334			Excellent

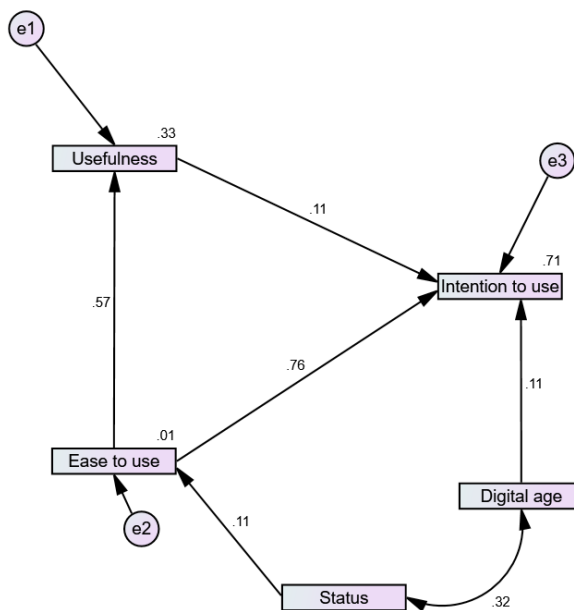
The evaluation of all models suggested the preference, in terms of the model fit, of the structural model with both control variables, which supported OKR4. The path analysis also calculated the standardized regression weights describing relationships between dimensions of the structural equation model with both control variables. Resulting figures from SEM analysis are shown in Figure 2 a-c.

Figure 2
 Three alternative structural models





b



Note: a-SEM with the direct path digital status ST -intention to use BU; b-SEM with the direct path digital age DA - intention to use BU; b-SEM with the direct path digital age DA and the direct path digital status ST.



The path analysis validated the basic TAM, described and predicted DS adoption among the pre-service teachers when controlled for pre-service teachers' digital age and status (TAMc). In the context of learning Didactics of Natural Sciences and Technology Education, the H1-H5 hypotheses were confirmed as follows (details in Table 4):

- Intention to use DS was *weakly* influenced by perceived usefulness of DS, if the effect of digital age was considered, which supported for H1;
- Intention to use DS was *strongly* influenced by perceived ease of use of DS, if the effect of digital age and of status were considered, which supported for H2;
- Perceived usefulness of DS was *strongly* influenced by perceived ease of use of DS, if the effect of status were considered, which supported for H3;
- Intention to use DS was *weakly* influenced by the effect of digital age, which supported for H4;
- Perceived ease of use of DS was *weakly* influenced by the effect of status, which supported for H5.

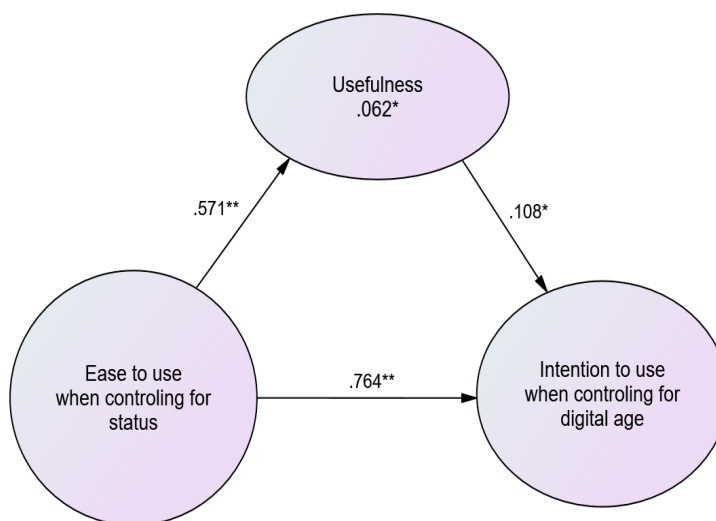
Mediation Effect

Perceived ease to use was incorporated into the mediation TAMc model as an independent variable with pre-service teachers' status as a covariate variable, and with perceived usefulness as a possible mediator. Intention to use DS tool was incorporated as the dependent variable, with pre-service teachers' digital age as covariate variable.

There was a significant strong direct effect of perceived ease to use DS tool on the intention to use it ($\beta = .764, p = .000$) (Figure 3). Also, there was a significant weak indirect effect from perceived ease to use DS tool to intention to use it through perceived usefulness ($\beta = .062, p = .038$) (Figure 3). A significant strong total effect of perceived ease to use DS tool on the intention to use it ($\beta = .830, p = .001$) was found when the effects of the digital age and status were controlled.

Figure 3

Ease to use and Intention to use DS when controlled for pre-service teachers' digital age and status



In the context of learning didactics of science, the TAMc mediation model was validated as follows:

- Pre-service teachers' perceived usefulness to use DS tool mediated the relationship between perceived ease of use and intention to use this tool when controlling for pre-service teachers' digital age and pre-service teachers' status, with a path coefficient $\beta = .062, p = .034$, which supported H6.



Results of Multigroup Effects Analyses and Non-Parametric Tests

The testing of the multigroup effects represented a moderation test. The validated structural model has been tested separately for each group of the type of course study. Thus, the purpose of this test was to determine whether the links of the path model fluctuated depending on the value of the moderator, who, in this case, was the type of course study.

Therefore, to answer the hypotheses, a multigroup analysis was performed. A Chi-square difference test was run to test each hypothesis H7-H11, and no significant differences were found. Regarding the hypotheses analysis (see Table 6), the positive relationship between Perceived usefulness and Intention to use DS tool when controlling for pre-service teachers digital age was found similar for pre-service teachers enrolled in Technology Education Didactics course and for pre-service teachers enrolled in Natural Sciences Didactics courses, which supported H7.

The positive relationship between Perceived ease of use when controlling for pre-service teachers status and Intention to use DS tool when controlling for pre-service teachers digital age was found similar for pre-service teachers enrolled in Technology Education Didactics course and for pre-service teachers enrolled in Natural Sciences Didactics courses, which supported H8. The positive relationship between Perceived usefulness and Perceived use of use DS tool when controlling for pre-service teachers' status was similar for pre-service teachers enrolled in Technology Education Didactics course and for pre-service teachers enrolled in Natural Sciences Didactics courses, which supported H9. The positive relationship between pre-service teachers' digital age and Intention to use DS tool was similar for pre-service teachers enrolled in Technology Education Didactics course and for pre-service teachers enrolled in Natural Sciences Didactics courses, which supported H10. The positive relationship between pre-service teachers' status and Perceived ease of use DS tool was similar for pre-service teachers enrolled in Technology Education Didactics course and for pre-service teachers enrolled in Natural Sciences Didactics courses, which supported H11. A strong invariance measurement of the TAMc scale across the cross-temporal category (year of study) was demonstrated (support for OKR2_{1,3} and for OKR3_{1,3}). So, the differences of each TAMc dimension, corresponding to hypothesis H12 were tested between the cross-temporal category variables using the non-parametric tests.

The results showed that there were no significant differences between the pre-service teachers enrolled in the second year of study ($n = 96$) and pre-service teachers enrolled in the third year of study ($n = 200$) in the mean rank scores of Perceived ease of use (Mann-Whitney $U = 9506.000$, $p > .050$, $z = -0.136$), Perceived usefulness (Mann-Whitney $U = 8838.000$, $p > .050$, $z = -1.106$), and Intention to use (Mann-Whitney $U = 9383.000$, $p > .050$, $z = -0.315$). The findings proved that there were no differences between groups in terms of the study year of pre-service teachers), which supported H12 (Table 7).

Table 7
Hypothesis testing summary

Code	Hypothesis short description	Control variable	Standardized coefficient (β)	Standard error (SE)	Critical ratio for regression weight CR	p-value	Result
H1	PU \rightarrow BU	DA	.108	.038	2.822	.005	Supported
H2	PEU \rightarrow BU	ST, DA	.763	.038	19.914	<.001	Supported
H3	PEU \rightarrow PU	ST	.571	.048	11.958	<.001	Supported
H4	DA \rightarrow BU	-	.105	.031	3.344	<.001	Supported
H5	ST \rightarrow PEU	-	.113	.058	1.983	.050	Supported
H6	PEU \rightarrow PU \rightarrow BU	ST, DA	.062	.038	-	.034	Supported
H7	<PU and BU> _a	DA	.100	.045	2.205	.027	-
	<PU and BU> _b	DA	.158	.083	2.165	.030	-
Nested Model Comparisons between: <PU and BU> _a and <PU and BU> _b						.505	Supported



Code	Hypothesis short description	Control variable	Standardized coefficient (β)	Standard error (SE)	Critical ratio for regression weight CR	p-value	Result
H8	<PEU and BU> _a	ST, DA	.742	.049	15.059	<.001	-
	<PEU and BU> _b	ST, DA	.777	.062	12.608	<.001	-
	Nested Model Comparisons between: <PEU and BU> _a and <PEU and BU> _b					.656	Supported
H9	<PEU and PU> _a	ST	.632	.064	9.877	<.001	-
	<PEU and PU> _b	ST	.484	.067	7.203	<.001	-
	Nested Model Comparisons between: <PEU and PU> _a and <PEU and PU> _b					.112	Supported
H10	<DA and BU> _a	-	.148	.048	3.035	.002	-
	<DA and BU> _b	-	.087	.043	2.017	.044	-
	Nested Model Comparisons between: <DA and BU> _a and <DA and BU> _b					.345	Supported
H11	<ST and PEU> _a	-	.291	.115	2.528	.011	-
	<ST and PEU> _b	-	.263	.098	2.647	.007	-
	Nested Model Comparisons between: <ST and PEU> _a and <ST and PEU> _b					.852	Supported
H12	SY → PU _c	DA	-	-	-	.269	Supported
	SY → PEU _c		-	-	-	.892	
	SY → BU _c		-	-	-	.753	

Note: a = Natural Sciences Didactics NS; b = Technology Education Didactics TE; c = mean rank scores

The results of non-parametric test and multi-group analysis demonstrated that there no significant differences in terms of categories independent variables. These outputs can be supported by the fact that, there is a common behavior pattern in all category variables, similar like other research (Padilla-Meléndez et al., 2013) and the TAMc can be generalized to the whole pre-service teachers. These findings assured the opportunity to combine all the pre-service teachers as a total sample (Lee, 2019, p. 139) due to the homogeneity of the topics' Perceived usefulness, Perceived ease of use, and Intention to use.

Discussion

The main instrument to research the acceptance of different advanced tools in various domains was the basic or extended TAM (Chintalapati & Daruri, 2017). Digital Storytelling, as an educational tool (Gyabak & Godina, 2011; Psomadaki et al., 2019; Smeda et al., 2014), has been universally recognized by different researchers for collaborative engagement (Rambe & Mlambo, 2014), facilitation of deep learning (Wu & Chen, 2020), stimulating co-creativity (Schmoelz, 2018), enhancement of self-esteem and critical thinking mood of users (Chan, 2019). The main purpose of this research was to fill the gap in the current literature by exploring the adoption of the Digital Storytelling tool as educational resource for natural sciences and technology education among pre-service teachers.

This research evaluated the appropriateness of an extended TAM construct for the examination of associations between behavioral intention to use Digital Storytelling tool, two independent factors, perceived usefulness and perceived ease of use, and two control variables, digital age and status of pre-service teachers. Accordingly, eight objective key results and twelve hypotheses were established considering the theory. In this part, the findings achieved by taking into consideration the proposed measurable key results and hypotheses were discussed and compared with previous researchers' conclusions (Yeşilyurt et al., 2016).

According to the Exploratory Factor Analyzed (EFA) with Promax oblique rotation, it can be observed that around 71% of the variance in usage intention of the DS tool was justified by the basic TAM. The research showed that perceived usefulness and perceived ease of use were important drivers for acceptance of DS tool in the framework of teaching and learning of natural sciences and technology education in pre-primary and primary schools. Previous research suggested that the same both factors were significant in the context of various educational tools



adoption, in order to teach and learn different topics in higher education (Abdullah et al., 2016). Therefore, these factors were usually evaluated to measure the acceptance level of digital tools in the higher education context.

Confirmatory Factor Analyses were used to examine the reliability and validity of TAM dimensions. The research outcomes indicate that the basic TAM has an excellent construct validity, so the validity indexes met the thresholds requirements for the three-factor 10-item survey. Moreover, the results of the measurement invariance tests confirmed the solidity of the scale in both cases of cross-temporal and cross-sectorial multigroup analyses. The research results for validity test recommend the extension of the proposed measurement of DS tool acceptance among other pre-service teachers, using the same three-factor 10-item survey. In this research the outputs revealed that the proposed measurable objective key results were achieved, and the estimated hypotheses were all valid. In the context of learning Didactics of Natural Sciences and Technology Education, the results from the path analysis validated the basic TAM when controlled for pre-service teachers' digital age and status (TAMc). Nevertheless, the constructs of TAMc were only the starting point for the research of DS adoption by pre-service teachers.

The presented results revealed that perceived ease of use of DS tools by pre-service teachers was the most substantial contributing factor to their intentions. This result was different from that communicated by Sadaf et al. (2015) who suggested that "*perceived usefulness was the strongest contributing factor of preservice teachers' intentions to use Web 2.0 tools*". Comparing with other TAM research on user adoption of different digital tools, the obtained outcome was similar to that of Chen & Chen (2011) who observed that in the case of GPS devices, "*perceived usefulness had little to no effect on behavioral intention*". This can be understood as a suggestion that users of DS tools are interested to acquire skills related to DS before using such tools.

Based on the TAMc responses, three equations were written:

- $Intention\ to\ use = .76 \times Ease\ of\ use + .11 \times Usefulness + .11 \times Digital\ age + 0.290$
- $Usefulness = .57 \times Ease\ of\ use + 0.671$
- $Ease\ of\ use = .11 \times Status + 0.984$

Therefore, pre-service teachers' perceived usefulness to use a DS tool has mediated the relationship between perceived ease of use and intention to use this tool when controlling for pre-service teachers' digital age and pre-service teachers' status. Under the effect of both control variables, intention to use DS tool was strongly influenced by the ease of use of DS and weakly by the usefulness of DS and digital age. The usefulness of DS was strongly influenced by the ease of use of DS, which was weakly influenced by the status. These results reinforced the evidence that TAM is a consistent research experience when aims to describe and predict pre-service teachers' intention to use a DS tool.

The confirmation of the validity of the TAMc made a comparison between the relative importance of each factor. The TAMc explained 71% of the variance in the intention of use, 33% in the perception of the utility, and 0.1% in the perception of ease of use. This result was contrary to that of Ramírez-Correa et al. (2015) who found that their TAM model for measuring users acceptance of e-learning among college students explained 25% of the variance in the intent of use, 28% in the perception of the utility, and 39% in the perception of ease of use. Consequently, the adoption level of each digital tool varies on "*the experiment, research framework, and IT tools under consideration*" (Diop et al., 2019).

The overall intent of use and associated dimensions have had similar significance in the following groups: pre-service teachers enrolled in Technology Education Didactics course and pre-service teachers enrolled in Natural Sciences Didactics courses, respectively pre-service teachers enrolled in the second year of study and pre-service teachers enrolled in the third year of study. No significant differences have been recorded between the groups of the two years of study because the pre-service teachers from both groups belong to the same generations and have roughly the same personality structure as a standard feature. Also, the timeframe at which pre-service teachers were subjected to educational experiences can lead us to the conclusion that they were possibly subjected to the same types of general educational experiences.

The results highlighted the influence of ease of use on the intention to use DS by pre-service teachers, majority of female, as a vulnerable group, with less ICT digital skills compared to a man group (van Deursen et al., 2011; Yu et al., 2017). This effect was realistic if taken into account the particularities of the target group, the respective digital age and status. The solution to increase the degree of adoption of DS is to explain in detail how to use it, bearing in mind that women have recognized low-level digital skills (Chetty et al., 2017). In this context, the development of the digital base competences remains a key factor for ease of use and implicit intention of use of digital tools. The results of this research completed the current framework of data about the adoption of a DS tool across different kinds of users. This research detailed the first empirical study of DS acceptance from pre-service teachers' perspective in Romania, based on the extension of TAM with two new control variables, namely digital age and status.



Conclusions and Implications

New generations of pre-service teachers with distinct learning profiles compared to other generations require the use of varied and creative educational resources to support their capabilities and motivation for learning. A modern tool designed to maintain the attractiveness of the learning contents and enhancing the digital skills by direct involvement of pre-service teachers was presented in this research. Storytelling mixed with digital tools like video resources supported pre-service teachers to learn the Natural Sciences Didactics and Technology Education Didactics in an interactive way. With the increasing use of digital educational resources, especially in higher education contexts, the cross-sectional research on the topic of digital tool acceptance were amplified. Previous research evaluated the relationship between basic TAM factors among various digital tools, in which endogenous variables have been associated with adult's age as an exogenous variable.

The requirements for higher education for innovation, evolution, identification of modern educational practices to proper and personalized usage of DS tool were outputs of this research. In this research, the level of acceptance of the DS was measured across pre-service teachers to learn natural sciences and technology education, for the first time. The main aim of this research was to contribute to the overall understanding of pre-service teachers' acceptance of the DS tool to learn the Didactics of Natural Sciences and Technology Education into a particular educational context. The research surveyed the influences on Intention to Use DS tool when controlling for pre-service teachers' digital age by Perceived Ease of Use when controlling for pre-service teachers' status and Perceived Usefulness. Furthermore, the comparisons of correlations between research model variables through pre-service teachers enrolled in Natural Sciences Didactics course and those enrolled in Technology Education Didactics course, respectively, through pre-service teachers enrolled in the second year of study and those enrolled in the third year of study were tested.

Dimensions supporting pre-service teachers' acceptance of a DS tool were studied with a basic version of the technology acceptance model using a structured survey. Thus, the basic version of the TAM using data collected from 296 undergraduates enrolled in the pedagogy of primary and preschool education program of Bucharest University from Romania was tested in the academic years 2017/2018 and 2018/2019. Differences between cross-temporal and cross-sectorial groups regarding DS tool acceptance were tested through multi-group confirmatory factorial analysis and Mann-Whitney *U* Test methods. Briefly, it was explored whether the construction of the extended TAM was perceived in the same way by pre-service teachers from the different cross-sectorial and cross-temporal groups and secondly and if the differences between different groups regarding the perceptions of usefulness and ease of use, and also the intention to use the educational tool were significant.

Ten-item, three-factor validated survey resulted from the exploratory factor analysis as it was described in the results chapter. The latent factors were categorized by exploratory factor analysis as the perceived usefulness of DS tool, perceived ease of use of DS tool, and the intention to use the DS tool. In this sample of 296 pre-service teachers, Perceived Usefulness of DS statistically mediated the association between Perceived Ease of use of DS when controlling for pre-service teachers' status and Intention to Use of DS when controlling for pre-service teachers' digital age. The Perceived Ease of use of DS when controlling for pre-service teachers' status has an overall strong positive effect on Intention to Use of DS when controlling for pre-service teachers' digital age and on Perceived Usefulness of DS. Perceived Usefulness of DS has overall a weak positive effects on Intention to Use of DS when controlling for pre-service teachers' digital age.

The results of the invariant measurement analysis showed that the 10-items version of the TAM was invariant between cross-sectorial and cross-temporal groups. Moreover, the invariant measurement analysis, coupled with the results of the nonparametric tests, showed that there were no differences regarding all scores of each latent factor of TAM in terms of the study year of pre-service teachers.

This research explored the factors shaping DS tool adoption in Romania, proving comparisons between pre-service teachers during the time and over cross-sectorial category variable. The outcomes represented a helpful evaluation of the DS acceptance by pre-service teachers across comparison groups and presented a precise and valid measurement. The findings that the digital age predicted the Intention to Use of DS and status predicted the Intention to Use of DS across pre-service teachers increased the possibility that behavioral factors could contribute to understanding the acceptance of the DS. The insertion of nontraditional pre-service teachers, which represented a significant part of those enrolled in the Science Education study program, was an important challenge of many universities. Thus, it is essential for departments who coordinate curricula for teacher's preparation to consider new learning contexts with the participation of more and more nontraditional pre-service teachers in university education.



Diagnosis of the digital storytelling tool in different situations has been done to identify contexts in which it was not recognized by users. The results obtained do not show that there was any learning course (Didactics of Natural Sciences and Technology Education) that should not use the method. The results of the research were most likely explained by the fact that pre-service are women (99.3%) considered vulnerable group, with a large proportion of non-traditional students (43.2%) and less digital immigrants (11.8%). Thus, the target group was a mixed group with many individuals to take into account in promoting new teaching strategies that also required new didactic materials, such as DS tool.

Effectively, under the influence of the digital age and student status, ease of use has strongly influenced both usefulness and intention to use of Digital Storytelling tool. So, if more pre-service teachers appreciate as easy to use DS tool, then their interest in using it will implicitly increase, as well as their perception of usefulness. In order to improve the level of adoption of the DS, it is necessary to promote the personalized and differentiated curriculum for teaching science education courses.

The adoption of blended learning is recommended for pre-service teachers, according to the new pedagogical paradigms and appropriate to situations where there are socio-demographic imbalances and vulnerable groups (e.g. women), as in this research. The outputs regarding TAM dimensions can contribute to the good practices exchange on the learning effectiveness in universities across the European Union countries. The outcomes presented a helpful evaluation of the acceptance of DS by pre-service teachers and may offer as a reference for future studies involving the use of DS tools in education by digital immigrants' pre-service teachers and nontraditional pre-service teachers, both representative groups for a Science Education program.

Statements

All authors have equal contributions.

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Appendix A. The questionnaire to measure the acceptance of Digital Storytelling tool

PU1: The main argument for using Digital Storytelling tool is to capture pre-service teachers' interest when presenting new concepts.

PU2: The main argument for using Digital Storytelling tool is to improve self-education.

PU3: The main argument for using Digital Storytelling tool is to support complex problem solving.

PU4: The main argument for using Digital Storytelling tool is to improve learning performance.

PU5: The main argument for using Digital Storytelling tool is to improve the efficiency of learning.

PEU1: The development of Digital Storytelling tool is easy.

PEU2: The use of Digital Storytelling tool is clear and logical.

PEU3: Digital Storytelling tool provides flexibility in user interaction.

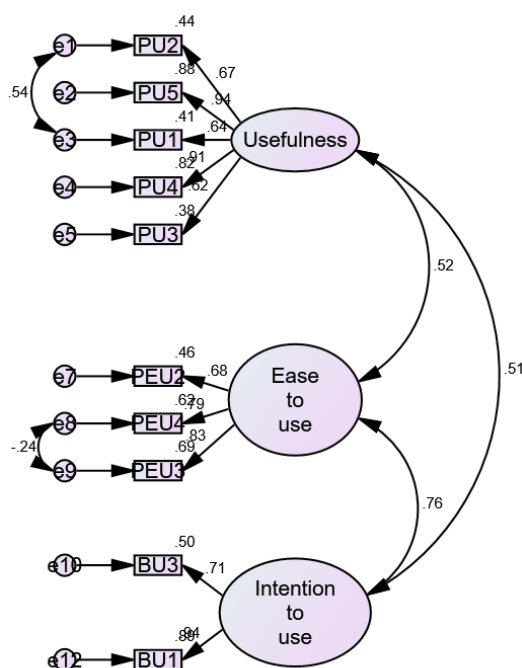
PEU4: Obtaining skills for using Digital Storytelling tool is effortless.

BU1: Assuming I have opportunity to use the Digital Storytelling tool, I will use it immediately.

BU2: I will use the Digital Storytelling tool, only if it will be necessary.

BU3: I will use Digital Storytelling tool, only after I am documenting about it.





Appendix B. CFA results of measurement model with three factors.

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