A conceptual framework concerning education as factor of elders’ acceptance for smart assistive technologies

Dorin POPESCU
Technical University of Cluj-Napoca, Romania
dorinelax@gmail.com

Sorin POPESCU
Technical University of Cluj-Napoca, Romania
Sorin.Popescu@muri.utcluj.ro

Stefan BODI
Technical University of Cluj-Napoca, Romania
stefan.bodi@muri.utcluj.ro

ABSTRACT

The aging of the world's population, raises issues of assisting elderly in conditions of sustainable spending. In this respect, smart technologies bring both an opportunity, providing solutions to assist elders’ life and a barrier coming from the lower acceptance of older adults for digital technologies.

The paper proposes a research focused on education and its influence on older adults’ readiness to adopt new, digital technologies. As reference the two versions of the Unified Theory of Acceptance and Use of Technology (UTAUT and UTAUT2) were used. The research is based on a systematic literature review aimed to draft a conceptual framework placed on two dimensions: the first one tries to establish "if and how the initial education is influencing the elders’ acceptance of assistive technologies" and, the second targeting "how this initial education is correlated and/or imbedded in the elements of the UTAUT models".

Keywords: Elders’ acceptance for assistive technology, education as variable of UTAUT models

INTRODUCTION

Amongst the challenges 21st century society faces, two are of special interest to us, apparently independent but strongly connected, impressive by their dynamic, coincidental as change direction, but only partially convergent as effects: the numerical increase of the elderly population (EC, 2014) and the fast growth of knowledge and technology. The second is the source of the first one while at the same time delivering a solution to its effects. The tremendous evolutions in medical knowledge have led to an extended life expectancy that, combined with a drastic decrease in birth rate, have determined the increase of the elderly segment of population. The gerontotechnologies, assistive technologies creating “ambient assisted living” environments, or “smart spaces” that allow elders to live independently in their homes in conditions of sustainable spending bring, not only solutions to assist elders’ life but also barriers, coming from their lower acceptance of these technologies.

The acceptance of new digital technologies constituted an extended research subject in the last two decades, generating many consecrated approaches. However, none of these list “education level” explicitly between the factors that influence the acceptance of new technologies although logically, its impact on the elders’ readiness for using these technologies should be expected. Even if, in the elders’ case, initial education happened a long time before and has not included knowledge and skills referring to digital technologies, it would have an indirect effect on their adoption, impacting attitudes and behaviours via the cognitive triangle (thinking-feeling-doing).
The present paper brings to attention education as a factor of influence for elders’ acceptance of modern digital assistive technologies. A systematic literature review is undertaken aiming to identify the extent and ways that the initial level of education influences the attitude of older adults toward usage of different digital technologies, general purpose (computers, smartphones, Internet, eBanking etc.) and specialized for health or assisted living. Complementarily, the study targets the correlation of this initial education with the components (constructs and moderating variables) of the UTAUT models. Both parts try to contribute at drafting a conceptual framework aimed at describing a structured landscape of the role of education on the efficient use of elders’ assistive technologies.

BACKGROUND

Smart assistive technologies

From the perspective of the U.S. Department of Health, Administration on Aging, Assistive Technology AT is “any service or tool that helps the elderly or disabled do the activities they have always done but must now do differently” (U.S. Dep. of Health, 2008). From their characteristics, (Cook & Polgar, 2012) distinguishes 6 different perspectives for AT: Complexity (Low vs. High), Tangibility (Hard vs. Soft), Necessary skill level (Appliances vs. Tools), Functional role (Minimal vs. Maximal), Purpose (General vs. Specific) and Source (Comercial vs. Custom). Adding the “smart” sintagm, limits these options to complex intelligent technologies generically integrated into the “smart home” or “intelligent living space” concepts. As equipment type, a large range of applications are mentioned by (U.S. Dep. of Health, 2008) as: Adaptive switches, Communication equipment, Computers, Mobility aids, Orthotic or prosthetic equipment, Assistive robots etc.

The functional structure of an intelligent living space (integrating smart assistive technologies) is described by (Amiribesheli, 2015) as being stratified into four distinct layers, each with its specific functions and technical solutions. The information is collected from the physical layer through the sensors, then are transmitted through the communication layer to the device responsible for the processing and storage from where are transmitted to the interface layer to which the involved persons have access. The control signals start from the interface layer following user’s or programmed commands leading them to the physical layer where actuators generate specific actions.

Beyond the technical aspects related to the realization of its functionality, the conception and configuration of an assistive system is targeting stakeholders’ perceptions (beneficiaries and caretakers) regarding the system in question. This perception is related to those layers with which the mentioned stakeholders are in direct or indirect contact: first, the interface layer having as functions the system control, data introduction and visualization. At the level of perceptions, this interface layer is similar to the most of digital devices largely used in daily jobs and living (computers, tablets, smartphones etc.), finally its acceptance, rejection or adoption depending on similar or same factors.

Technology acceptance models

Human technology interaction has already become one of this century’s critical issues. The tremendous development of technology, together with the complexity of factors (social, cultural, economic and psychological) influencing human perceptions, attitudes and behaviours have contributed to the generation of an impressive number of theoretical models explaining patterns of behaviour in adopting and use of new technologies. The most spread models for predicting and evaluating technology acceptance are TAM (Technology Acceptance Model) developed by (Davis 1989) and UTAUT (Unified Theory of Acceptance and Use of Technology) both having more variants. Between many other existing models, we mention here: Theory of Reasoned Action TRA (Fishbein & Ajzen, 1975), Social Cognitive Theory SCT (Bandura, 1986), Theory of Planned Behaviour TPB (Ajzen, 1991), Innovation Diffusion Theory IDT (Rogers, 1995).
UTAUT (Vekantesh & al., 2003) integrates under a common framework 8 different precedent models, each with its specific factors (some of these equating from one model to another). Its improved 2012 UTAUT2 version (Venkatesh & et al., 2012) assumes that is capable to explain about 74% of the variance in behavioural intention to use a technology and about 56% of the variance in technology use, unlike TAM that justifies only 40% of the intention to use (Legris et al. 2003). For this reason, these became the most widely adopted technology acceptance assessment models.

The UTAUT model defines four key constructs as the determinants of the intention to use a new technology: Performance expectancy, Effort expectancy, Social influence and Facilitating conditions to which UTAUT2 (Figure 1) added three more: Hedonic motivation, Price and Habit. They are moderated by 3 variables: gender, age and experience. Performance Expectancy (PE): refers to the extent to which the individual believes the technology will be helpful in meeting its purpose and has the strongest correlations with the intent to use. The factor is influenced by gender and the age of the individual. Effort Expectations (EE): is the degree of easiness with which the individual can use the technology and in addition to gender and age, it is also moderated by the experience (user becoming accustomed to technology, the expectations of effort are decreasing). Social Influence (SI): The extent to which the user perceives the pressure from his relatives, caretakers, friends to use the new technology. It is moderated by gender, age and experience. Facilitating conditions (FC): The extent to which the user considers that the use of technology is supported organizationally and by technical infrastructure. It moderates the influence on behavioural intention by age, and experience.

Hedonic motivation completes the utilitarian value of performance expectancy (extrinsic motivation) with its intrinsic part (based on feelings as pleasure, fear, joy, love or hate), treated usually in marketing as a key predictor in consumers’ behaviour. The Price construct extends the area of effort expectancy, assessing the financial part of the overall effort associated with the acceptance and use of technologies, determinant in the decision to purchase any product or service especially at the third age. Experience and habit - declared by (Venkatesh & et al., 2012) as a single construct is introduced in the model on two different dimensions: Habit as a construct and Experience as a moderator (independent) variable. The association of these two concepts in the same construct is explainable if we assess them from a knowledge acquiring perspective, both supposing an action/intervention played a several number of times, during a certain period or acquired by education.

All the mentioned constructs are direct determinants of “Behavioural intention” to use technology through which they influence the “Use behaviour” itself. “Facilitating conditions” and “Habit” also have direct influence on “Use behaviour”.

Figure 1 UTAUT2 model - after (Venkatesh & et al., 2012)
RESEARCH METHODOLOGY AND RESULTS

As a research aim and at a methodology level, the paper assumes a systematic literature review, intending to draft a conceptual framework concerning the influence of initial education on elders’ acceptance and use of smart assistive technologies. For that, the investigation attempts to identify an answer for two main topics and for their subsequent questions, as follows:

1. Determine “if and how initial education influences the adoption of assistive technologies by older people” – having as subsequent questions: “Does education have a significant influence on elders’ adoption of digital technologies?”; “How does education act in this matter?”; “With which other factors is education associated in this sense?”, “Can a certain dynamic be predicted for this influence?”.

2. Identify “the extent and way education is connected to the UTAUT and UTAUT2 models” supposing as questions: “Is education a part, directly involved/embedded and/or an influence factor for the constructs of the mentioned models?”; “Is education a significant moderating factor of these models, for which of their constructs and how does it influence them?”

As methodology for the literature review, two different groups of scientific papers were identified using afferent keywords: the first search was focused on papers proposing a general approach to older adults’ acceptance of assistive technologies, non-connected with existing models and the second one, was targeting papers with same topic but using as reference the UTAUT models.

The identified papers were filtered in several stages: after the first check of relevance for the general subject, the next filtration was done by searching the consistent presence (more as one or two times) of the word "education" used with the meaning of elders’ initial level of education as factor for influence of their acceptance of digital technologies. In the next stage, assuming a detailed study of the papers content, the ones were selected that have presented in their deployment significant, valuable ideas connected to the above-mentioned questions, able to contribute to the drafting of the intended conceptual framework. The final selected papers were listed in the table below together with their aims and research methodology. The ideas considered as being relevant concerning education influence on technology acceptance are briefly recorded in the last columns of these tables and are resumed in a structured way within the research conclusions.

Table 1 Education level influence on elders’ acceptance of digital assistive technology

| Citation                  | Research aim and methods                                                                 | Ideas referring to the influence of the education                                                                 |
|---------------------------|------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|
| (Czaja & al. 2006)        | **Aim:** Factors Predicting the Use of Technology (general), Computers and Internet.     | - Education as factor influencing technology adoption is associated with: socioeconomic status (income), attitudes toward the technology (computer anxiety), access to and perceived benefits of technology. |
|                           | **Methods:** Empiric res. (1204 individuals aged 18–91 years) and regression models.      | - Education level determines crystallized intelligence level which is connected to computer anxiety level.       |
|                           |                                                                                          | - The relationships among these variables are complex, people’s choices about using technology cannot be explained solely by their age or education. |
| (Nayak, Priest, & White, 2010) | **Aim:** Identifies variables related to the older adults’ Internet usage. **Methods:** based on TAM principles and a linear regression analysis. |                                                                                                               |
| (Berry, 2011)             | **Scope:** Develop a map of factors that influence the adoption of ICT/Internet by elderly in UK. **Methods:** data from 2010’ reports: ONS’ | - Internet use tends to be lower among people with lower educational attainment.                               |
|                           |                                                                                          | - Education level has to be incorporated as a map of reasons for digital exclusion.                           |
| Source | Aim | Method | Findings |
|--------|-----|--------|----------|
| Plattfaut, 2014 | Older adults’ readiness to adopt health-related ICT. | Literature review | Educational background is considered as factor associated with older adults’ access to ICT; Persons with HE were 3.1 times more likely to use a PC as those with a lower educational level; Higher financial status favours ICT acceptance and it is directly connected to the education level. |
| (Flandorfer, 2012) | Assisting robots’ acceptance by older people - evaluation of importance of sociodemographic factors as: age, gender, education and technological experience, family status, and cultural background. | Systematic literature review | The defined model (based on UTAUT) introduces Technology acceptance of older adults. Survey in Lower Saxony: Contemporaneous digital technologies get older too, the today one which usage is learned in schools will be different when learners will reach their 80s. |
| (Heart & Kalderon, 2013) | Senior’ attitudes toward computer technology in the context of a 20-hour course in basic skills. | A questionnaire applied pre- and post-course - sample of 191 adults over the age of 60. | Although other studies suggest that education impacts on elders’ interest for ICT, the study found no significant correlations between these variables. It concludes that even older people with a low level of education and computer use modify their attitudes positively toward new technologies as a learning tool, as a way of relating to others and as entertainment. |
| (Künemund & Tanschus, 2014) | Propose and test a conceptual framework based on UTAUT with moderating variables concerning use of mobile phones in China. | Survey of 221 Chinese nationals | Education levels significantly moderate Performance expectancy. Effort expectancy and Social influence constructs, a stronger effect being found on attitude in the low education group. Influence on effort expectancy is stronger in earlier stages of adoption, people with lower education are more sensitive, perceiving technology as a barrier. In the high education group, the influence of effort expectation is weaker, the persons mainly shaping their attitude on technology with social influence. |
| (Park, Yang, & Lehto, 2007) | UTAUT in Adoption of Mobile Banking, proposes a modified UTAUT. | Empirical research (162 resp.) testing 21 hypotheses | Add education as a moderator factor together with experience in UTAUT model. “Performance Expectancy” is the most moderated factor by education then „Facilitating conditions“, „Social influence” and „Design issues“ being neutral to education. |
| (Al Mashagba & Nassar, 2012) | Internet adoption by the elderly (65+) based on modified UTAUT model. | Literature review survey +interviews (150 resp.) | 113 relevant empirical studies concerning elders’ adoption of digital technologies based on UTAUT model, use as socio-demographic variable: Gender (95%), Age (84%); Income (9%); Education (8%). The defined model (based on UTAUT) introduces education as a moderating factor. |
CONCLUSIONS

General remarks

No paper was identified having the influence of initial education on the elders’ acceptance of general purpose or assistive technologies, as the main subject of research. The fact that this is a less popular subject of research is also underlined by other authors (Pheeraphuttharangkoon, 2015). It is also reiterated here that none of the well-established forms of widely used models (TAM or UTAUT) are referring to education as an explicit element of the model. However, a relevant number of papers have been found that independently or based on the mentioned models introduce education as a factor of influence or as moderating variable of this acceptance, some of them proposing new models where it appears explicitly e.g. (Park, Yang, & Lehto, 2007), (Al Mashagba & Nassar, 2012).

A particularity of education as a factor of influence in the elders’ attitudes towards the use of contemporary technologies is the temporal gap between the education provision and the reference moment (when educated people become elderly). This temporal gap also generates a significant technological gap, accentuated by the high rate of technological change. In other words, the elders were acquainted long ago with technologies, which are no longer in use. Even if young people are well versed in today’s digital technologies (Flandorfer, 2012), these will be old-fashioned by the time today’s youth becomes tomorrow’s elderly population (Künemund & Tanschus, 2014). In this matter, the solution is continuous learning (Fischer, David, & et al., 2014) including for people apparently not being active professionally anymore. It means society needs to invest in elders’ education (Berry, 2011) otherwise; it will be unsustainable to assure them an independent living in conditions of wellbeing.

Sustainable education for the elderly will be an important challenge in the future. Numerically this category is already comparable to the young population that is institutionally a beneficiary of this service. Again, virtual environment and learning assistive technologies could be a solution. But for that, training is critical in elders’ access to IT. Seniors could receive the necessary skills but can become also trainers for other older adults. (Fischer, David, & et al., 2014).

Influence of education level on elderly acceptance of digital technologies

Most of the analysed papers conclude that the level of education has a significant influence on the acceptance of digital technology by the elderly: persons with higher education HE are 3.1 times more likely to use a PC as those with a lower educational level (Heart & Kalderon, 2013). HE senior using...
Internet have rates exceeding the general population (Fischer, David, & et al., 2014), (Nayak, Priest, & White, 2010) and (Niehaves & Plattfaut, 2014). (Berry, 2011) even declares that the education level should be incorporated as a map of reasons for digital exclusion. Papers were also identified (González, Ramírez, & Viadel, 2015), (Cimperman & et al., 2016) that concluded a insignificant or neutral influence of education level upon the elders’ acceptance for digital technologies, declaring that even older people with a low level of education modify their attitudes positively toward new technologies when they are motivated by application (learning, connecting to others, entertainment). The reason for this influence would lie not in the specific skills of using the technology (that were not delivered in school long before) but in the development of so called “crystallized intelligence” (Czaja & et al, 2006), which level is determined by the initial education level and has the ability to strongly diminish the negative attitude towards technology (computer anxiety).

In the context of influencing technology adoption, education is included in the category of sociodemographic factors such as: age, gender, education, economic status, family status, health status, cultural background etc. These variables are strongly interlinked (Flandorfer, 2012) and the relationships among them are complex, people’s choices about using technology cannot be explained solely by education or by another similar variable (Czaja & et al, 2006). In this sense, education is associated (as coupled variables) with financial status (Heart & Kalderon, 2013), income (Nayak, Priest, & White, 2010), access to resources (Pheeraphuttharangkoon, 2015), experience with technology (Flandorfer, 2012) and is difficult to totally detach it as an independent study variable.

Education level as variable in UTAUT models

Regarding the relationship that the “education level” variable has with UTAUT models, the studies that include it in association with these models are also few. (Niehaves & Plattfaut, 2014) mentions that from the 113 identified relevant empirical studies concerning elders’ adoption of digital technologies based on UTAUT model, only 8% use education as variable.

The analysed papers place education both as independent and as moderating variable, but with a strong preference for the second position. Findings are sometime contradictory concerning the moderating influence of education on some of the UTAUT constructs.

(Pheeraphuttharangkoon, 2015) analyses education of the UTAUT model. “Social Influence” (those of friends and family) in adopting specific technology was less significant when older people had higher education. It is also stated here that education is moderating the impact of “Facilitating conditions” on “Behavioural intention”, the effect being stronger for those who have higher education. (Park, Yang, & Lehto, 2007) found that education levels significantly moderate “Performance expectancy”, “Effort expectancy” and “Social influence” constructs, a stronger effect being found on attitude in the low education group. The influence on “effort expectancy” is stronger in earlier stages of technology adoption, people with lower levels of education being more sensitive in this matter, perceiving technology as a barrier. In the highly educated sample, the influence of “effort expectation” is weaker, the persons mainly shaping their attitude on technology with “social influence”, statement in a way contradictory with the above cited from (Pheeraphuttharangkoon, 2015). (Al Mashagba & Nassar, 2012) add education as a moderating factor in UTAUT model and remarks that it mostly influences “Performance Expectancy”, then “Facilitating conditions”, while “Social influence” proved to be neutral to education, confirming the findings of (Pheeraphuttharangkoon, 2015).

REFERENCES

Al Mashagba, F. F., & Nassar, M. O. (2012). Modified UTAUT Model to Study the Factors. International Journal of Sciences: Basic and Applied Research (IJSBAR) Volume 6, No 1, 83-94.

Amiribesheli, M. e. (2015). A review of smart homes in healthcare. Journal of Ambient Intelligence and Humanized Computing, 6(4), 495–517.
Berry, R. (2011). *Older people and the internet, Towards a „system map” of digital exclusion*. London: The International Longevity Centre - UK (ILC-UK).

Cimperman, M., et al. (2016). Analyzing older users’ home telehealth services acceptance behavior applying an Extended UTAUT model. *International Journal of Medical Informatics* 90, 22–31.

Cook, A. M., Polgar, J. M. (2012). *Essentials of Assistive Technologies*. Elsevier.

Czaja, S. J., et al. (2006). Factors Predicting the Use of Technology: Findings From the Center for Research and Education on Aging and Technology Enhancement (CREATE). *Psychol Aging*, 333–352.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, 13 (3): 319–340.

EC. (2014). *The 2015 Ageing Report, Joint Report prepared by the European Commission*. European Union: European Commission.

Fischer, S. H., David, D., et al. (2014). Acceptance and use of health information technology by community-dwelling elders. *International Journal of medical informatics*, 624-635.

Flandorfer, P. (2012). Population Ageing and Socially Assistive Robots for Elderly Persons: The Importance of Sociodemographic Factors for User Acceptance. *International Journal of Population Research*, 1-13.

Fuller, B. (1981). *Critical Path*. New York: St Martin's Press.

González, A., Ramírez, M., & Viadel, V. (2015). ICT Learning by Older Adults and Their Attitudes toward Computer Use. *Current Gerontology and Geriatrics Research*.

Heart, T., Kalderon, E. (2013). Older adults: Are they ready to adopt health-related ICT? *International Journal of Medical Informatics*, e209-e231.

Heerink, M. (2010). *Assessing acceptance of assistive social robots by aging adults - PhD Thesis*. Amsterdam: University of Amsterdam.

Hillier, S. M., Barrow, G. M. (2014). *Aging, the Individual, and Society 10th Ed*. Cengage Learning.

Künemund, H., Tanschus, N. M. (2014). The technology acceptance puzzle. Results of a representative survey in Lower Saxony. *Zeitschrift für Gerontologie und Geriatrie*, 641–647.

Nayak, L. U., Priest, L., White, A. P. (2010). An application of the technology acceptance model to the level of Internet usage by older adults. *Universal Access in the Information Society*, 367-374.

Niehaves, B., Plattfaut, R. (2014). Internet adoption by the elderly: employing IS technology acceptance theories for understanding the age-related digital divide. *European Journal of Information Systems*, 708–726.

Park, J., Yang, S., Lehto, X. (2007). Adoption of mobile technologies for Chinese consumers. *Journal of Electronic Commerce Research, VOL 8, NO 3*, 196-206.

Peek, S. T., et al. (2014). Factors influencing acceptance of technology for aging in place: A systematic review. *International Journal of Medical Informatics*, 235-248.
Pheeraphutharangkoon, S. (2015). *The Adoption, Use and Diffusion of Smartphones among Adults over Fifty in the UK.* University of Hertfordshire.

U.S. Dep. of Health and Human Services. (2008). *Assistive technology.* Retrieved from Leonard Davis School Of Gerontology: [http://gero.usc.edu/nrcshhm/resources/fs_assitive_tech.pdf](http://gero.usc.edu/nrcshhm/resources/fs_assitive_tech.pdf)

Vekantesh, V., et al. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly, Vol. 27, No. 3*, 425-478.

Venkatesh, V., et al. (2012). Consumer acceptance and use of information technology: extending the Unified theory of acceptance and use of technology. *MIS Quarterly*, 157-178.