Bozkurt, A., Sani Bozkurt, S., Caliskan, H., Guler, E., Dincer, G. D., & Sezgin, S. (2015). Design Criteria for Interactive E-Books and Interactive Content Based Teaching Apps for Learners with Autism Spectrum Disorder. In Proceedings of *8th International Conference of Education, Research and Innovation (ICERI2015),* 16th-18th November 2015, Seville, Spain (pp. 3214-3221).

DESIGN CRITERIA FOR INTERACTIVE E-BOOKS AND INTERACTIVE CONTENT BASED TEACHING APPS FOR LEARNERS WITH AUTISM SPECTRUM DISORDER

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Abstract

Creative and innovative developments in information and communication technologies have paved the way for assistive technologies in special education in addition to other fields in education. Assistive Technologies have been used as effective, efficient, and attractive teaching tools because learners with autism spectrum disorder have difficulties to develop cognitive abilities and acquire new knowledge. Learners with autism spectrum disorder need to improve their behavior, communication and relationships with their environment and this can be succeeded through special education. New digital devices, as hardware, appear to be promising teaching/learning tools. However, hardware takes on a new significance as long as it is used with well-designed software. Within the scope of this research, software refers to any interactive e-books and any interactive content based teaching applications. On this basis, the purpose of this study is to identify design criteria for interactive e-books and interactive content-based teaching applications for learners with autism spectrum disorder through a three round Delphi study. In this study, a total of 47 criteria under 5 themes were identified and research findings were further discussed within the scope of five emerged themes. Additionally, directions for future research were presented.

Keywords: Assistive technology (AT), Autism Spectrum Disorder (ASD), individuals with special needs, interaction design, interactive tools.

1 INTRODUCTION

1.1 Autism Spectrum Disorder

The DSM-V (Diagnostic and Statistical Manual of Mental Disorders) defines autism spectrum disorder (ASD) as a neurodevelopmental disorder marked by deficits in two core areas: Social communication, and repetitive and restricted interests (American Psychiatric Association, 2012). Communication impairments are a core challenge faced by individuals diagnosed with ASD. These challenges result in difficulties in the acquisition, interpretation, and expression of language and social-emotional dynamics. Within the ASD community, expressive communication ranges from complete mutism to functional communication, to highly skilled language expression. Furthermore, communication challenges extend beyond the person themselves and affect their family, friends, and larger social network (Schlosser and Wendt, 2008). Each learners with ASD may show these difficulties at different levels and severity.

Learners with ASD need special education because they exhibit difficulties in learning due to changing characteristics and learning needs. Therefore, individualized education and evidence-based interventions are considered to be most effective strategy for these learners. Recently, with the increasing affordances and new innovate developments in Information and Communication Technologies (ICT), assistive technologies (AT) have gained great importance in teaching and learning process of the learners with ASD.

1.2 Digital hope: Assistive technologies

With the development and penetration of the ICT, AT has been used in the field of education to overcome barriers to learning (Florian and Hegarty, 2004). One of the most striking use of AT was in special education for individuals with ASD. Individuals with ASD appear to learn different from other individuals and frequently have difficulty with spoken and written communication. In addition to difficulty in communication skills, they may not be able to understand gestures, body language, and tone of voice. They can further demonstrate difficulties in motor skills. All these and many other factors

make learning as a complex and difficult task for individuals with ASD. Early computer based assistive technologies (CBAT) were proven as an effective and efficient medium. Computer-assisted instruction has also shown advantages over personal instruction for some individuals with ASD. For instance, a group of individuals with ASD were found to express more interest in computers than toys and prefer computer instruction to personal instruction (Bernard-Opitz, Sriram and Nakhoda-Sapuan, 2001). Furthermore, some people with ASD not only seem to be more attentive and less resistant to computers than to teachers (Williams, Wright, Callaghan and Coughlan, 2002), but also show superior learning results (Moore and Calvert, 2000). However, these technologies have a couple of limitations. For instance, the interface of navigation systems of these technologies requires learning and experiencing how to use them. Besides, using computer based assistive technologies requires using mouse and keyboard which requires fine motor skills. However, advent of gesture based devices was a game changer because they allow more attractive forms of input to be used and multiple interaction in different channels.

1.3 Gesture based user interaction

Gesture-based computing can be viewed as an innovative educational development in alignment with bodily-kinesthetic intelligence (Johnson, Levine, Smith, and Haywood, 2010). Presently, new devices such as tablet computers or smart phone are appearing on the market that take advantage of motions that are easy and intuitive to make, allowing us an unprecedented level of control over the devices around us. Gesture-based systems accept input in the form of taps, swipes, and other ways of touching, hand and arm motions, or body movement. Gestural interfaces allow users to engage in virtual activities with motion and movement similar to what they would use in the real world, manipulating content intuitively. Because it changes not only the physical and mechanical aspects of interacting with computers, but also our perception of what it means to work with a computer, gesture-based computing is a potentially transformative technology. The distance between the user and the machine decreases and the sense of power and control increases when the machine responds to movements that feel natural (Johnson, Levine, Smith, and Stone, 2010). It is also reported that interactive learning software with gesture based user interaction designed on the basis of universal design principles are highly effective learning materials (Bozkurt and Bozkaya, 2013a; 2013b). The promise of gesture based interaction on devices increases with highly interactive learning environments in which multimedia components are used to deliver learning content through rich channels.

2 THEORITICAL FRAMEWORK

2.1 Cognitive Theory of Multimedia Learning

The theoretical framework of this study was determined as the Multimedia Learning Theory. The theory tries to address the issue of how to structure multimedia instructional practices and employ more effective cognitive strategies to help people learn efficiently (Sorden, 2012). Cognitive Theory of Multimedia Learning states that multimedia narration and graphical images produce verbal and visual mental representations, which integrate with prior knowledge to construct new knowledge (Mayer & Moreno, 2002). According to multimedia learning, it is more effective to use words (written or spoken) and graphics (static illustrations such as drawings, charts, graphs, maps, or photos; and dynamic graphics such as animation or video) together rather than to use words only (Clark and Mayer, 2011). Multimedia principle indicate that using multimedia presentations will encourage learners to engage in active learning by mentally representing the material in words and in pictures and by mentally making connections between the pictorial and verbal representations. It is also explained that people learn better when graphic organizers are added to text (Ataizi and Bozkurt, 2014). On this ground, the multimedia content is classified as in Figure 1. Inspired by Cognitive Theory of Multimedia Learning, the content theme (Table 2) in this study is segmented according to four basic multimedia content: Textual (written), audio (spoken), Static visual and dynamic visual/graphic content.

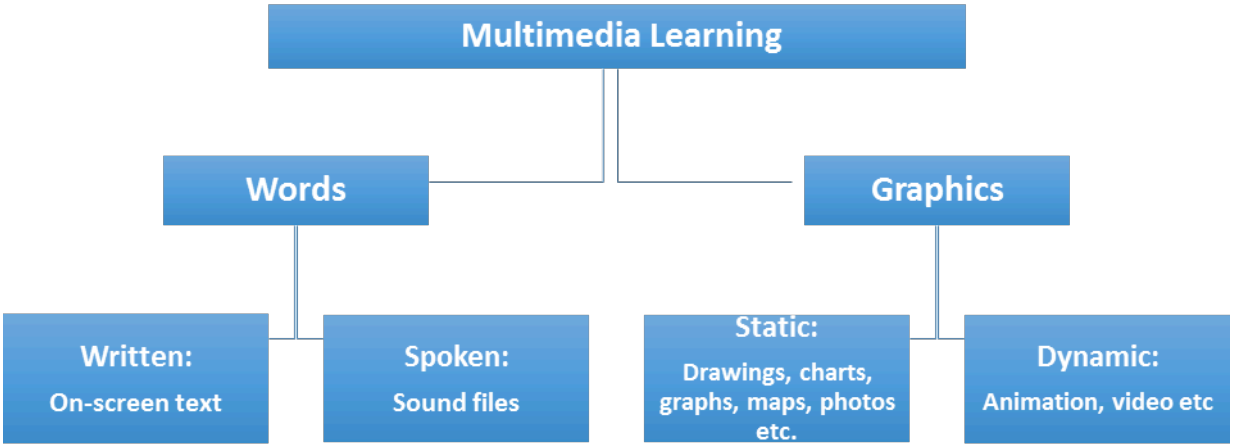

Figure 1. Classification of the multimedia content (Bozkurt, 2013).

3 AIM OF THE STUDY

The main purpose of this study is to define design criteria for interactive applications in general and interactive e-books in particular. Within this perspective, the following questions were sought to answer.

- What are the design criteria for interactive e-books and interactive content-based teaching applications?
- What are the effective digital teaching tools?

4 METHOD

4.1 Research design

To find answers for the research questions of the study, data was collected through a three-round Delphi study with a panel consisting of 12 experts in ASD. Developed by Dalkey and Hamler (1963) at the Rand Corporation in the 1950s, the Delphi Method is based on a structured process for a systematic, interactive forecasting method which relies on a panel of experts (Dalkey & Helmer, 1963; Brown, 1968; Koçdar & Aydın, 2013). The Delphi method is based on structural surveys and makes use of the intuitive available information of the participants, who are mainly experts. Therefore, it delivers qualitative as well as quantitative results and has beneath its explorative, predictive even normative elements (Cuhls, 2003). When compared to other data collecting methods, common surveys try to identify “what is,” whereas the Delphi technique attempts to address “what could/should be” (Miller, 2006). The key characteristics of the Delphi technique are defined as anonymity of respondents, controlled feedback process, and statistical response (Fowles, 1978).

4.2 Participants

Regarding the selection of subjects for a Delphi study, choosing the appropriate subjects is the most important step in the entire process because it directly relates to the quality of the results generated (Judd, 1972; Jacobs, 1996). On this ground, participants were selected according the following criteria: To have theoretical and practical experience in the field, to have published academic papers and have a background in academic research. Through literature review and snowball sampling, a total of 22 experts in special education field were invited to study. 14 experts accepted to be a panel member in Delphi rounds, however, 2 out of 14 experts never participated in any of the Delphi rounds. As a result, a Delphi panel of 12 experts was constructed and the research was completed with the data gathered from them.

4.3 Instruments, data collection and analysis

Researchers used an online questionnaire to collect data in all three rounds. In the first round, a total of five semi-structured open-ended questions were asked. Each of the questions refers to a theme

that is adopted from Bozkurt (2013) who formerly studied *interactive e-book criteria for open and distance learning*. The responses in the first round were analyzed by employing thematic analysis. In the second and third rounds, the findings appeared in the first round were delivered to Delphi panelists as 5 point Likert item. The responses in second and third Delphi rounds analyzed according to consensus agreement level, interquartile range and median (Table 1).

Table 1. Measurement of consensus

2nd round	Median ≥ 4, IQR ≤ 1, Frequency 4-5 ≥ 70%
3rd round	Median ≥ 4, IQR ≤ 1, Frequency 4-5 ≥ 80%

4.4 Procedure

A total of three Delphi rounds were conducted between April and June 2015. Four each round, two weeks' time were given to participants to reply questionnaires. For each round, three reminder mails were sent and after two week time periods, each round was finalized and the data collected was analyzed.

- 1st round were conducted in April 2015. Delphi panelists replied to 5 semi structured open ended questions. The first round was completed in two weeks with the participation of 11 panelists out of 12 (91,6% participation). The qualitative data were analyzed using NVivo10. Textual data based on Delphi panelists' responses were coded according to reference points and then placed to relevant themes (Table 2).
- 2nd round were conducted in May 2015. 50 design criteria those identified in the 1st round and additional 5 design criteria identified formerly by Bozkurt (2013) for interactive e-books (Marked with an asterisk * sign in table 2) were delivered in the second round. In sum, Delphi panelists evaluated a total of 55 criteria. Questionnaire items were analyzed according to measurement of consensus (Table 1) and four items were discarded from research. The second round was completed in two weeks with the participation of all panelists (100% participation).
- 3rd round were conducted in June 2015. Delphi panelists evaluated 51 design criteria those left after the second round. Questionnaire items were analyzed according to measurement of consensus (Table 1) and 2 items were discarded from research. The third round was completed in two weeks with the participation of all panelists (100% participation).

Table 2. Quantitative thematic analysis of 1st Delphi round.

Total words in source	2165
Total paragraphs in source	89
Number of nodes coding source	250
Coded percentage of source	0.7149
Number of text references	674

4.5 Limitations

This research findings are limited to opinions of a total of 12 expert from special education field whose expertise is children with ASD. The Delphi panel group was homogenous in terms of panelists' expertise. However, a heterogeneous Delphi panel group with experts from other disciplines such as instructional design, software design and e-learning in addition to special education can lead to harness more data regarding the design criteria of interactive e-books and apps for learners with ASD.

The distinction between interactive e-books and software and mobile applications is being blurred as a result of digital books' dependency on technology. However, these blurring borders can become distinct by applying design principles of interactive e-books and determining the purpose of the application as it refers to the user's electronic reading (e-reading) experience (Bozkurt and Bozkaya, 2015). On this ground, the findings of this research are limited to any interactive e-books in specific and interactive content-based teaching applications in general for learners with autism spectrum disorder.

5 RESEARCH FINDINGS

At the end of the three Delphi rounds, 49 criteria for interactive e-books and interactive content-based teaching applications for learners with autism spectrum disorder were identified. In the final analysis process, two criteria was decided to be merged with another two criteria after the evaluation of the research findings by a special education expert. In sum, 47 criteria were identified (Table 2).

Table 2. Design criteria of interactive e-books and interactive content based teaching applications for learners with ASD

1. Individual differences

- 1.1. Age
- 1.2. Cognitive development level
- 1.3. Social/emotional development level
- 1.4. Education level
- 1.5. ASD diagnoses and its level
- 1.6. Multiple disabilities
- 1.7. Behavioral characteristics
- 1.8. Attention/focus span
- 1.9. Communication skills
- 1.10. (Restricted) Interests and likes
- 1.11. Stereotyped and obsessive behaviors

2. Content design

- 2.1. Attractiveness of the content*
- 2.2. Textual content
  - 2.2.1. Short, clear, explicit and non-distracting concrete expressions
  - 2.2.2. Textual style features according to individual differences and learning backgrounds of the users
  - 2.2.3. Selecting style format of the textual content (letter character, type size, color, alignment etc.) according to users individual differences
  - 2.2.4. Coherence of the action verbs in the textual content according to cognitive level of the users and learning objectives*
- 2.3. Audio content
  - 2.3.1. Articulating audio content according to users receptive and expressive language abilities
  - 2.3.2. Using clear, comprehensible short audio expressions
  - 2.3.3. Tuning up sound volume (decibel) and selecting audio content in a way to motivate and not to distract users
  - 2.3.4. Selecting appropriate accentuation and intonation
- 2.4. Static visual content
  - 2.4.1. Using simple, objective oriented, presentative, high resolution static visuals
  - 2.4.2. Appropriateness of color selection and harmony
  - 2.4.3. Using short and explicit textual expressions in static visuals
  - 2.4.4. Employing realia (proximity to life) principle in static visuals
  - 2.4.5. Appropriateness of the static visuals in regard to developmental age
  - 2.4.6. Using attractive, attention-grabbing, learning objectives oriented static visuals
- 2.5. Dynamic visual content
  - 2.5.1. Using simple, comprehensible, non-distractive dynamic visuals
  - 2.5.2. Preparing length of the dynamic visuals according to users attention span

2.5.3. Appropriateness of the character design according to users individuals differences, learning objectives and cultural backgrounds

2.5.4. Integrating learning objectives and learning scenario to dynamic visuals

2.5.5. Integrating criteria emerged in textual and audio content themes

2.5.6. Preparing dynamic visuals according to development age

3. Interaction design

3.1. Providing feedback after learning activities and navigation actions

3.2. Providing opportunity for making a selection to learners

3.3. Using non-distractive, plain and melodic effects

3.4. Using distinctive audio and visual effects

3.5. Providing interaction through hardware and sensors of the interactive e-book reader/application device

4. Interface design

4.1. Using soft, pastel and non-distractive main colors in overall design

4.2. Employing simple, plain and comprehensible layout design

4.3. Employing intuitive navigation principles in which users can navigate easily by discovering and without additional support

4.4. Using short and clear instructions

4.5. Using real-like visuals appropriate to individual differences that represent learning objectives, learning activity

4.6. Legibility and usability of the interface without fatiguing eyes*

4.7. Consistency of buttons, icons and menu items*

4.8. Designing according to universal design principles to ease accessibility for individuals with special needs (e.g. voice over, scaling visuals or text etc.)*

5. Digital teaching tools

5.1. Tablet computers

5.2. Smart phones

6 DISCUSSION

This research presents 47 criteria under 5 themes (Table 2). The first theme is about individual differences of learners with ASD. It is seen that individual differences are at the center of design process. Many of the criteria in other themes are strongly related to individual differences. However, each of the criteria in individual differences theme has different variances, degrees or levels. The first challenge lies in defining these differences and then planning other criteria. The second challenge is about changing needs of learners with ASD. Therefore, adaptive system designs and customizable features are important in terms of return of investment (ROI) and using one design for many learners with ASD.

The second theme is about content design. The criteria in this theme categorized according to content classification of Multimedia Learning. Different from conventional multimedia content design, these principles related to criteria in individual differences theme. It is salient that these criteria are mainly related to dual coding and cognitive load theories that are worth for further investigating.

The third theme is about interaction design. The criteria emerged in this theme cover cognitive, sensorial, and pure physical interactions defined by Fischer and Coutellier (2005). Providing interaction in multiple dimensions and providing them in a balance is important. Considering characteristics and differences of learners with ASD, these interaction types should be chosen carefully and only if necessary.

The fourth theme is about interface design. The basic assumption in this theme is designing purposeful interfaces through which learners with ASD can navigate easily. Additionally, employing universal design principles to increase accessibility emerged as an important issue.

The fifth theme is about digital teaching tools. It is obvious that experts think that new digital devices with natural user interface with gesture based interaction have advantages because learners with ASD can use them intuitively by discovering similar to natural life experiences. Though not on the list and still in its infancy, wearable technologies worth researching with ubiquitous learning opportunities they provide.

7 CONCLUSION AND FUTURE DIRECTIONS

Interactivity contributes to successful teaching and learning. Within this perspective this study presents some design criteria for interactive e-books and interactive content-based teaching applications for learners with autism spectrum disorder. It is for sure that with emerging technologies, this checklist can be updated and new criteria can be added.

This research basically aims to be a base study for future research. On this basis, future research can focus on to:

- Effectiveness of gesture based learning materials and hardware features of these devices,
- Cultural differences in content design,
- Effectiveness and efficiency of criteria emerged in this research through experimental studies.

ACKNOWLEDGMENTS

This research was supported by Anadolu University, Scientific Research Projects Commission under the grant no: 1409E396

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