



# Comparative study on emotions analysis from facial expressions in children with and without learning disabilities in virtual learning environment

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## Abstract

Children with Learning Disabilities (LDs) show some emotional difficulties and behavioral problems in classroom compared with their peers without LDs. Emotions constitute an important part of the learning process. Recent evidence suggests that the use of Information and Communication Technology (ICT) in special education permits to remove barriers in learning for the target children. Besides, it offers a learning environment for a diversity of emotional experiences. In this present study, we explored the benefits of ICT use to identify the ways in which emotions are involved during the learning process in Virtual Learning Environments (VLE). We conducted a user study with 42 children divided into two groups; experimental group ( $n = 14$ ) and age matched control group ( $n = 28$ ) to compare their emotional experiences in VLE. We used advances in Artificial Intelligence (AI) to detect children's emotions through their facial expressions by analyzing seven basic facial emotion expressions (angry, disgust, fear, happy, sad, surprise and neutral) while playing an educational game. The initial results indicate that emotions are present in VLE and they appear to suggest that children with LDs experience the same emotions as their peers without LDs in VLE. Besides, they show that children with LDs experience less negative emotions compared to literature evidence about the presence of a higher level of negative emotions in classroom.

**Keywords** Learning disabilities (LDs) · Information and communication technology (ICT) · Assistive technology (AT) · Artificial intelligence (AI) · Virtual learning environment (VLE) · Emotion recognition

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## 1 Introduction

Children with learning disabilities are threatened by learning problems, that could lead to school failure. Learning disabilities (LDs) refer to a neurological disorders that affect a person's ability to receive, store, process, retrieve or communicate information (Cortiella and Horowitz 2014). The term 'learning disabilities' is used to describe the most common types of specific learning disabilities (SLDs) such as dyslexia, dysphasia, dysgraphia, dyspraxia, and dyscalculia.

Recently, there has been a growing interest in understanding students' emotions from facial expressions in Virtual Learning Environment (VLE). Understanding emotions from facial expressions in VLE is essential to comprehend the intent of students so that we can provide the appropriate feedback. Besides, the affective consideration of children with LDs is an important field of research in several studies. As stated by Abrams (1986) a large number of children with LDs suffer from emotional problems related to their learning difficulties such as depression and anxiety. The assessment of learners' emotional state during their interaction in VLE, permits to know their level of comprehension and satisfaction with the learning tasks.

Nowadays, the use of Information and Communication Technology (ICT) is considered as an important part of people's daily life. They have been used in different domains. ICT refers to all types of devices, applications, and technologies that allow people to use information, skill, and knowledge with a greater efficiency and effectiveness (Dillon 2004). Further, the use of ICT and assistive technology (AT) in the field of special education has become more challenging, especially for children with LDs. Recent studies (Adebisi et al. 2015; Benmarrakchi et al. 2015, 2017a), have shown the beneficial role of ICT to facilitate and improve learning for students with SLDs. ICT applications may offer many ways and opportunities to the inclusion of children in learning, and they can be a supportive tool to their learning difficulties. One example is the work of Benmarrakchi et al. (2016, 2017b) who proposed an adaptative learning approach that provides support and more learning opportunities for users with dyslexia based on their learning styles and their cognitive capacities.

Although some research has been carried out on ICT use and LDs, there have been few empirical investigations into the affective state of children with LDs. Ekman and Friesen (1971) have reported that there are six universal emotions across different cultures (angry, disgust, fear, happy, sad and surprise). This present study focuses particularly on the assessment of children's emotional state, in order to investigate the differences in recognizing the basic facial emotion expressions between children with and without LDs in VLE. Two questions were thus addressed in this study: (1) Are the emotional experiences present in VLE? and (2) does the interpretation of emotions from facial expressions differ between children with and without LDs in VLE?

This paper is organized as follows: In Section 2, the related work is introduced. Then, we present the methodology of research in Section 3. In Section 4, we discuss results. In Section 5, conclusion and future work are presented.

## 2 Related work

### 2.1 Emotions and learning

Various definitions of emotions were proposed by researchers over the years. Bowlby (1969) defined emotions as “phases of an individual’s intuitive appraisals either of his own organismic states and urges to act or of the succession of environmental situations in which he finds himself”. The difference between emotion, affect and mood has been challenged by many research studies. Gross (2010) distinguished between these concepts and considered affect as a general term including different types of affective states such as mood, emotions, and attitudes.

A number of researchers have reported that students experience a variety of positive and negative emotions in learning such as anger, anxiety, shame, enjoyment of learning, hope, confusion, frustration contentment and pride (D’Mello et al. 2007; Pekrun et al. 2002).

Studies have shown that emotions have an impact on student’s learning process and achievement. As stated by Pekrun (1992) emotions can influence learning and achievement by affecting cognitive and motivational processes. The influence of emotions on cognitive processes is the focus of many current studies. Further, emotions appear to have a strong role in the retrieval and storage of information in learning. As mentioned by Bower (1981) the activation of material that is associated in long-term memory, is improved by the activation of an emotion in learning, which facilitates the retrieval of information. Furthermore, many researchers (Forgas 2012, 2017) suggest that there is a relationship between affective states and information processing strategies. Affective states affect an individual’s way of thinking and the quality of information processing. Emotions can also affect attention. For example, negative emotions such as anxiety about failing during a task can decrease attention and reduce interest about learning. That implies a negative effect on cognitive achievements which demand an important part of working memory resources (Pekrun 1992).

In addition, emotions and motivation are essential in learning and inseparable. In other words, emotions influence motivational processes that include intrinsic task motivation and extrinsic task motivation (Pekrun 1992). Intrinsic motivation refers to be intrinsically motivated to do a task because it is enjoyable or interesting (Ryan and Deci 2000). Negative emotions such as anger, shame, disappointment, or anxiety decrease intrinsic motivation while positive intrinsic emotions facilitate learning and achievement by directing learner’s attention toward the task (Pekrun et al. 2002). Whereas, extrinsic motivation has been defined as a tendency to engage an activity in order to attain a desired outcome (Ryan and Deci 2000). According to Pekrun (1992) emotions can influence extrinsic task motivation in different ways. The prospective emotions such as hope and anticipatory joy permit to perform the task and achieve positive outcomes through activating positive extrinsic motivation, by contrast emotions as hopelessness influence motivation negatively.

Russell’s Circumplex model and Kort’s learning spiral model are the most models used for recognizing learner’s emotion. Russell’s model is used to describe user space emotions, the horizontal axis measures the valence dimension and the vertical axis

represents the arousal or activation dimension from negative to positive emotions while the outer circle shows the typical position of several types of emotions (see Fig. 1) (Russell 1980; Russell and Barrett 1999).

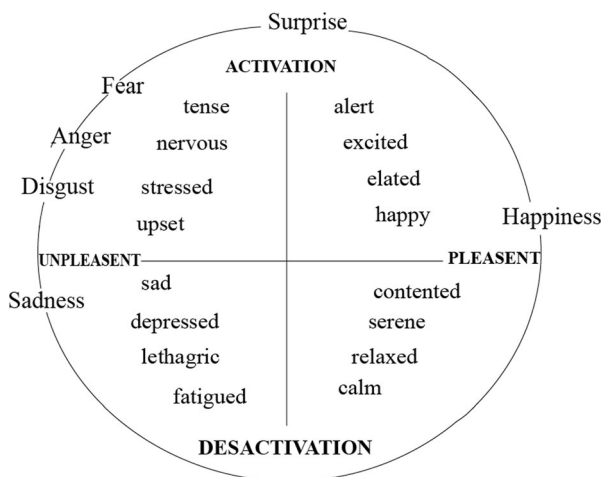
Kort's model includes four quadrant learning spiral models. Emotions change from one quadrant to another. In quadrant I the learner experiences positive emotions such as curiosity to build a new concept and knowledge. In quadrant II the learner might develop negative emotions, which impede and reduce the construction of concepts and ideas. When the learner moves to the lower half of the diagram in quadrant III, the learner may experience negative state such as frustration. In the quadrant VI the learner becomes positive again (see Fig. 2) (Kort et al. 2001).

On the basis of the evidence currently available, it seems clear that the act of learning is a result of emotions, which control students' attention and affect their motivation to learn, and they are assumed to have a great impact on students' learning and achievement.

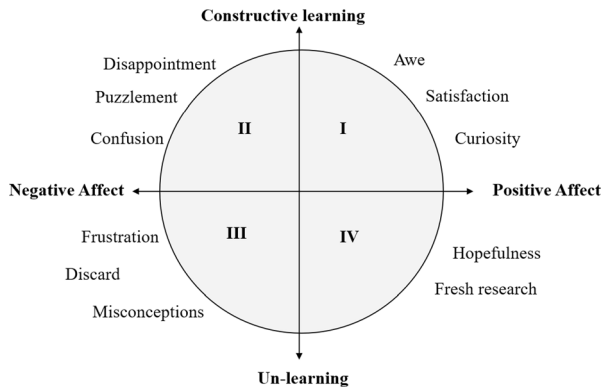
## 2.2 Emotions and learning disabilities (LDs)

LDs refer to a group of disorders that affect a wide range of academic skills, that are essential to listen, speak, write, spell, and organize information. Specific Learning Disabilities (SLDs) are the most popular type. According to The National Advisory Committee on Handicapped Children Definition (NACHC) children with SLDs have a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, that may manifest itself in the imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations (Hammill 1990).

Previous studies (Abrams 1986; Bryan et al. 2004) have reported that children with LDs may experience emotional problems related to their learning difficulties. Some of them tend to know if emotions and social difficulties of students with LDs are a result of their school failure or are a characteristic of their LDs (Cosden et al. 1999; Vaughn



**Fig. 1** Russell's Circumplex model of affect adapted from (Russell 1980; Russell and Barrett 1999) and modified from (Russell 1980)



**Fig. 2** Kort's model relating phases of learning to emotions (Kort et al. 2001)

et al. 1992). They reported that children with LDs experience negative emotions more than children without LDs such as depression and loneliness (Maag and Reid 2006; Margalit 1991; Margalit and Ben-Dov 1995; Wiener and Schneider 2002). Self-concept is one of the most important point discussed in the research of LDs emotional and behavioral problems (AL Zyoudi 2010; Kistner et al. 1987; Tam and Hawkins 2012).

Other research studies focused on social skills of the target children. Bursuck (1989) stated that children with LDs may present a higher social skills difficulty compared with Non-LDs children. In the same line, researchers (Sorour et al. 2014) revealed that children with LDs experience a great difficulty of peer relationship compared with Non-LDs peers. Also, they presented that there is a significant difference between children with and without LDs concerning classroom behavior. Furthermore, Hassan (2015) discovered that children with LDs have the following emotional problems; thinking problem, poor concentration, attention deficit, less of activity, lack of a sense of self-confidence, hyperactivity and lack of interaction. These problems differ from one child to another and depend on the type of LDs. Previous studies have denoted that in addition to the cognitive and academic remediation, there is a need to pay particular attention to social and behavioral remediation for children with LDs (Toro et al. 1990). Consequently, providing the essential emotional support for children with LDs can save them from failure and give them a chance to achieve their learning goals.

### 2.3 Children's emotions and information and communication technology (ICT)

Much of the current literature on the use of ICT pays particular attention to the beneficial use of ICT in special education to support children with LDs. Researchers (Adam and Tatnall 2017; Adebisi et al. 2015; Ismaili 2017) have shown the positive effect of ICT toward children with LDs, by improving their motivation and increasing their productivity in the classroom and home. Affirmed to Adam and Tatnall (2010), the use of ICT permits to enhance children with LDs self-esteem, by providing resources to achieve their goals and facilitating their acquisition of useful life skills. In addition, ICT is very helpful to assist children with LDs in different ways, for instance (1) Improving independence in academic and employment tasks (2) participating in classroom discussion (3) gaining access to peers and teachers (4) gaining access to the full variety of educational options

(5) securing high levels of independent learning (6) working side-by-side with peers and (7) mastering academic tasks that they find difficult (Burgstahler 2003).

Further, recent developments in the field of ICT have led to a renewed interest regarding the importance of the emotional state of learners during their interaction in VLE (Hammoumi et al. 2018). According to Sathik and Jonathan (2013) the presence of negative or positive emotions in VLE can be helpful to know learners' comprehension toward the learning task. In addition, a number of studies explore how emotions involve during the learning process, in the purpose to develop e-learning systems that are able to recognize and respond to emotions presented by learners based on Russell and Kort's affective models (see Figs. 1 and 2) (Sandanayake et al. 2011; Shen et al. 2007, 2009).

The advancement of affective computing based on researches in the field of education and psychology leads to a new evolution of Intelligent Tutoring System (ITS) called Affective Tutoring System (ATS) that understands students' emotions (Petrovica et al. 2017). Numerous studies have reported that, in addition to learners' cognitive state ITS should take into account their affective state so as to provide the appropriate action (Bahreini et al. 2016; Ben Ammar et al. 2010; Sarrafzadeh et al. 2008). Consequently, ATS aims to make ITS able to adapt according to the learners' emotional state (Alexander et al. 2006; Sarrafzadeh et al. 2003). Furthermore, emotion recognition, using facial expression in ATS can increase its feedback to adapt the affective state of learners without teachers' intervention.

The available evidence seems to suggest that depending on the emotional problems of children with LDs, their emotions recognition during their interaction in VLE might represent a very crucial role in the learning process. This may help in adjusting the environment according to their affective state and to improve their performance toward learning tasks.

### 3 Methodology

#### 3.1 Participants

A total of 42 children (native Arabic speakers) participated in this study and they were divided into two groups, control and experimental group. The experimental group composed of 14 students with a diagnosis of LDs aging between 7 and 11 years old ( $m=9.57$ ,  $SD=1.08$ ). selected from *Speech-Language Pathology Service-Health, El Jadida Morocco* by the president of the *Speech-Language Pathology Service-Health center*. The control group composed of 28 students aging between 7 and 11 years old ( $m=9.75$ ,  $SD=1.17$ ). They were selected from *Groupe Scolaire l'Ange Bleu, El Jadida Morocco*. In Table 1 below we present the distribution of participants in terms of gender and group and in Table 2 we present participants with LDs in terms of gender, age, and the type of disability.

#### 3.2 Materials and procedure

This study was in collaboration with the staff of the *Speech-Language Pathology Service-Health*, and *Ange Bleu Primary school El Jadida Morocco*. Before the

**Table 1** Distribution of participants in terms of gender and group

	Experimental group (with LDs) <sup>a</sup>	Control group (Non-LDs)	Total
Girls (n)	3	15	18
Boy (n)	11	13	24
Total	14	28	42

<sup>a</sup> Non-Learning disabilities

experiment we explained the aim and the components of this study to directors, teachers and also participants. The study carried out to assess children's emotions in real time during learning task. Both experimental and control groups participated to the experiment, each participant was tested individually in a quiet room. In this study, we used an educational game developed by Benmarrakchi et al. (2017c), that supports children with dyslexia in reading and writing in Arabic. The game includes a set of different tasks with specific aims and predefined pedagogical objectives such as recognizing letters to improve reading skills, structure of words to improve writing skills and identifying letter/word shape to improve learner's short-term memory and concentration. It is constructed around the theme of treasure island and contains three activities as follows: 'I listen and I build', 'I build and I complete' and 'I listen and I complete'. Figure 3 presents different screenshots of the educational game.

In the current study, we used a facial expression recognition system based on convolutional neural networks (CNN) developed by Hammoumi et al. (2018). It consists of three steps: preprocessing, features extraction and classification. We used two datasets to evaluate the performance of our proposed system to facial expression classification. The two datasets used to train, validate and test the proposed system in this study, are CK+ (Kanade et al. 2000), (Lucey et al. 2010) and KDEF (Lundqvist

**Table 2** Distribution of participants with LDs in terms of gender, age, and the type of disability

Participants	Gender	Age	Types of disability
Participant.1	Boy	10	Dyslexia
Participant.2	Girl	10	Dyslexia, Dysorthographia, and Dyspraxia
Participant.3	Girl	10	Dyslexia and Dysorthographia
Participant.4	Girl	10	Dyslexia and Dysorthographia
Participant.5	Boy	9	Dyslexia and Math difficulties
Participant.6	Boy	9	Dyslexia and Dysorthographia
Participant.7	Boy	9	Dyslexia and Dysorthographia
Participant.8	Boy	8	Dyslexia
Participant.9	Boy	10	Dyslexia
Participant.10	Boy	10	Dysgraphia and Dyspraxia
Participant.11	Boy	11	Dyslexia
Participant.12	Boy	7	Dyslexia
Participant.13	Boy	10	Dyslexia
Participant.14	Boy	11	Dyslexia





Fig. 3 Different screenshots of the educational game (FatimaEzzahra Benmarrakchi et al. 2017c)

et al. 1998). Each of these datasets are widely used for facial expression recognition. The extended Cohn-Kanade datasets (CK+) is included 593 image sequences (327 have emotion labels) of 123 subjects. The Karolinska Directed Emotional Faces – KDEF dataset included 4900 images of facial expression of 70 subjects, 35 females and 35 males aged between 20 and 30. The two datasets are combined, we took only straight images from the KDEF dataset and all the 327 labelled images from the CK+ dataset. The custom dataset was divided into 683 training samples, 81 validation samples and 81 test samples as shown in Fig. 4.

The preprocessing stage seeks to normalize the dataset and facilitate the classification process for the system, in which we converted all images to grayscale to reduce the dimension of the data. To detect face we used a method in OpenCV proposed by Viola and Jones (2001) called Haar Cascades for object detection. We cropped them and gave the images a fixed size. After the face has been detected, the next step is extraction. we fed the images to the features detection system that is based on Convolutional Neural Networks (CNN). The system is composed of five convolution layers responsible for extracting features such as edges, corners, and shapes to generate feature maps. Two pooling layers responsible for reducing the dimension of the images and two fully connected layers which are responsible for classification.

The experiment is as follows, we worked with two groups of children (experimental and control group), each child with a laptop wearing a headset and they used the mouse to play the game not the touchpad. Their interactions with the game were recorded using Camtasia Studio's Screen Recorder. for the experimental group it took about 15 to 30 min for each participant to finish the game while the control group took about 8 to

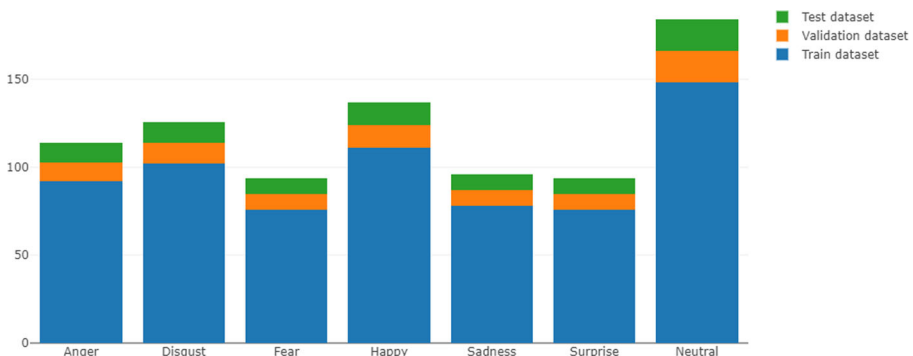


Fig. 4 The custom database (Combination of KDEF and CK+) (Hammoumi et al. 2018)



15 min. When the game finishes we turn off the camera and the results of the emotion recognition system are saved in a spreadsheet file.

## 4 Results and discussion

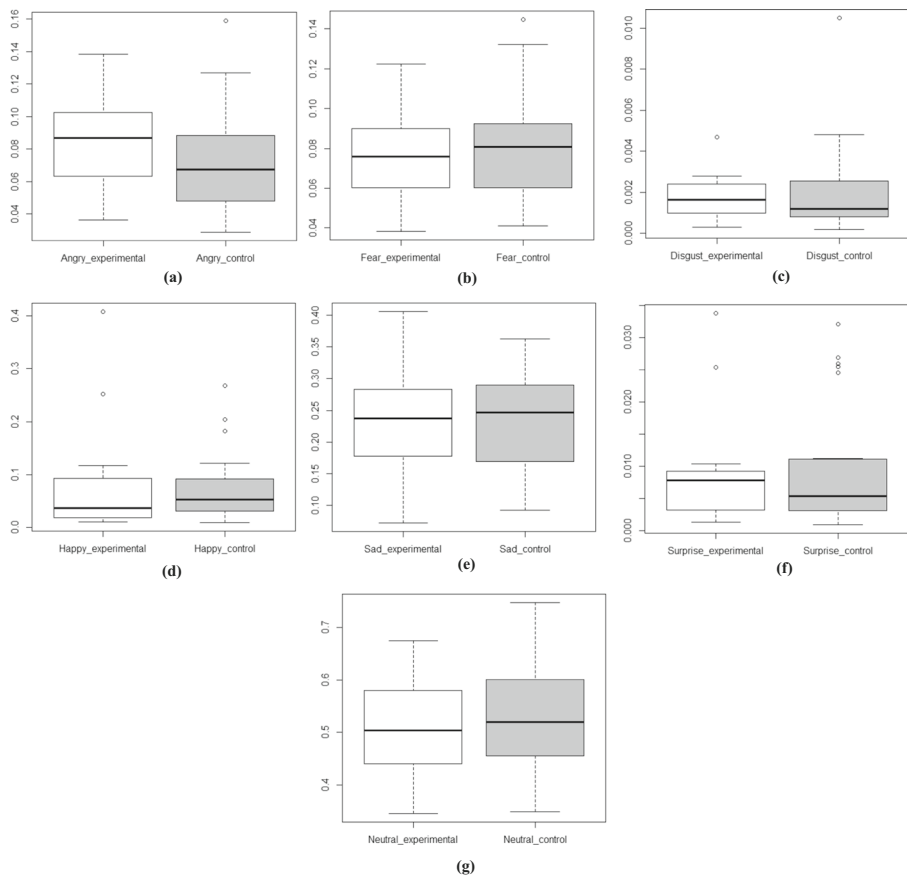
The obtained data was analyzed with R statistical software version (3.4.3). We applied Welch t-test since Shapiro-Wilk test showed that the data follow a normal distribution and Fisher test showed that the variances were not equal. Table 3 presents the results of t-test and descriptive statistics for emotions experiences in VLE by groups. At 95% confidence level. There is no statistically significant mean difference, the  $p$  value is higher than 0.05 in the seven emotions. Figure 5 illustrates the emotional experiences of children with and without LDs throughout performing the game presented by box plots.

The main goal of this present experiment is to compare the emotional state of children with LDs with peers without LDs in VLE. Recently, the role of emotion in learning has received much attention, especially the way in which emotions form students' engagement and learning (Linnenbrink-Garcia and Pekrun 2011). The findings of this experiment show no statistically difference in emotions between children with LDs and peers without LDs in VLE. The seven boxplots seen above showing the distribution of the emotional experiences between children with and without LDs throughout performing the game in seven emotions: angry, fear, disgust, happiness, sadness, surprise and neutral. Box plots indicating median, interquartile range, sample minimum and maximum. Therefore, if we see comparative between emotions Fig. 5a–g the medians are almost at the same level, the differences between control and experimental group are not visible.

However, during the experiment we noticed that each child experiences emotions with a different level such as sadness, happiness, fear, surprise, neutral, angry and disgust while performing the educational game. It is possible that the types of emotions involved in VLE vary according to each child and may depend on two factors; the first factor is the individual's differences such as personality and character. As mentioned by researchers (Carver and Scheier 2012; Stemmler and Wacker 2010), personality is a dynamic organization, inside the person, of

**Table 3** Results of t-test and descriptive statistics for emotions by groups

Emotions	Experimental group (LDs children)		Control group (No-LDs children)		Confidence interval	t-test result at 95% CI for Mean Difference		
	Mean	SD	Mean	SD		t	df	p value
Angry	0.0840	0.0093	0.0720	0.0145	0.0081,0.0332	1.2406	29.905	0.2244
Disgust	0.0017	0.0008	0.0020	0.0020	0.0014,0.0008	0.5465	34.483	0.5882
Fear	0.0770	0.0058	0.0811	0.0103	0.0211,0.0129	0.4885	33.38	0.6283
Happy	0.0851	0.0852	0.0755	0.0655	0.0576,0.0801	0.3430	18.019	0.7355
Sad	0.2355	0.0132	0.2303	0.0227	0.0534,0.0637	0.1814	23.91	0.8576
Surprise	0.0093	0.0653	0.0097	0.0172	0.0069,0.0061	0.1147	29.09	0.9094
Neutral	0.5061	0.0454	0.5286	0.0316	0.08969,0.0446	0.6847	30.552	0.4986



**Fig. 5** Emotion experience of children with and without LDs in VLE, **a** boxplot of anger, **b** boxplot of fear, **c** boxplot of disgust, **d** boxplot of happiness **e** boxplot of sadness, **f** boxplot of surprise, **g** boxplot of neutral

psychophysical systems that creates the person's characteristic patterns of behavior, thoughts, and feelings. Besides, during the experiment, we observed that the character and the personality traits differ from one child to another some children are quiet, shy, attentive. While others are brave, active, confident or nervous. Children with LDs who are curious and have a strong personality they make more effort to complete the educational game tasks and they don't let their learning difficulties impede their desire to succeed, also they take the challenge to achieve a positive outcome despite their LDs. While, children with LDs who are characterized by shame, anxiety, and fear their motivation to complete the educational game tasks is decreased, they feel tired over the time and they don't have the desire to complete learning tasks. Also, the motivation to complete the educational game and the period of time expended in the educational game is higher in the experimental group than in the control group. The second factor is environment situation that can affect the affective state of children. Graetz (2006) presented that the physical characteristics of learning environments can affect learners emotionally, while emotional reactions to environmental stimulus can vary depending on the individuals and activities. Also, He stated that most student may find learning

difficult in the classroom. On the other hand, a learning environment that provides a positive emotional response may improve students' learning and their emotional attachment to the learning environment (Graetz 2006).

Our results show that the emotional presence appears in both groups in VLE. In agreement with the findings of the current study, Cleveland-Innes and Campbell (2012) found that emotion is present in the online learning environment. Our results also indicate, that while the two groups play the educational game, they experience the same emotions in VLE with no statistical significance in emotions degrees. It is likely that children with LDs express less negative emotions in VLE compared in the classroom. A number of researchers (Gallegos et al. 2012; Nelson and Harwood 2011) have reported that some children with LDs may display some behavioral problems and emotional difficulties in the classroom. They assume that children with LDs experience a high level of anxiety and depression than their non-LDs classmates. Therefore, sometimes anxious and stressful children reject to participate in the class activities. Also, depressed children are always feeling sad and they present decreased interest in daily class activities. Besides, researchers (Vodopivec and Bagon 2016) found that students with LDs are motivated and have a good attitude toward the use of modern educational technology compared with traditional method teaching. As claimed by authors (Ahmad et al. 2010; Kah and Lakhouaja 2018), the use of Game-based Learning for children with LDs provides an active engagement and fun environment for learning.

Further, the educational game that we used in this present study creates an environment of emotion experience. It contains different multimedia contents for emotion elicitation such as pictures, sounds effect, video, animation and even text that evoke emotional responses. As stated by many authors (Horvat et al. 2015; Jacko 2012) any multimedia element can produce positive, negative or neutral emotions that vary in intensity and duration. The target children have mentioned during their interaction with the game that they liked the use of multimedia contents and the presence of the animated character represented by a monkey in different game interfaces. Crutzen et al. (2015) discovered that the character attachment is one of the most key factors related to enjoyment in games. Furthermore, the game uses sounds effect and verbal encouragements when the child makes wrong or right answer. For instance, for the right response 'good job' or 'you are doing well' and 'try again' or 'try more' in the wrong response to encourage the child to make more effort to achieve the task. It uses also a number of stars that light up when the child makes a progress in the game and a short-animated video that shows the reward when the child achieves all tasks. As was mentioned earlier the game was constructed around the theme of treasure island. Some children have expressed their appreciation and pleasure for the theme of treasure island. In addition, they said that it gives them the desire to achieve all tasks, in order to win the treasure at the end. Emotional state could also change depending on task difficulty, all these elements can elicit positive, negative or neutral emotional responses. In the same line Calleja (2011), reported that games that contain a variety of elements can be used as a source of emotion arousal. And the type of content can be adapted to influence the player emotion and experience (Yannakakis and Paiva 2014). An issue that was not addressed in the game that we used in this study is the social interaction. Children can be influenced by social pressure in natural environment classroom. Especially, social comparison with peers, social interaction and the fear of being judged

by others can create negative emotions and behavioral problems in the classroom. This also accords with our earlier observations in the *Speech-Language Pathology Service-Health El Jadida Morocco*, which showed that children become angry when other children make fun of them when they make mistakes. And they encounter verbal insults such as ‘I am doing well than you’ or ‘you are not smart’, which make them feel bad for not doing well in the task. As stated by Hill and Wigfield (1984) peer pressure in school can lead to high level of anxiety and negative emotional and behavior issues.

In addition, studies that focused on social gaming (Ekman et al. 2012; Gajadhar et al. 2008) show the importance of the presence of others to influence the quality and the type of emotions provoked during play. Thus, it is important to incorporate the multiplayer mode in the educational game. Also, the game non-player character can be used as a stimulus of desired emotions for the player. As mentioned by Yannakakis and Paiva (2014) the presence of these characters in the game allow the player to establish relations with them, which lead to special reactions when something good or bad happens in the game. Therefore, further work is needed to investigate the social dimension in educational games.

These results may not be applicable if the educational game is not appropriate for the target learners and does not respond to their learning needs. Consequently, children may have difficulties to interact with the game and they will find it frustrating and they may be unsatisfied to use it. This may take children away from the use of ICT applications in learning and negatively affect their emotional state.

Another possible limitation of our research is, that the survey was conducted by using only emotion recognition from facial expressions system to analyze emotion. It might be that the system does not provide an efficient result about the actual learner’s emotional state. Because probably there are some other types of emotions that the system cannot detect. For instance, the measure of emotions by analyzing head movement, eyelid movement, facial expressions, tone of voice or all of them. Furthermore, the use of adaptative scales for the target learners in VLE to measure emotional state, behavior, motivation, self-esteem can be very helpful and powerful tools in the assessment of children with LDs during their interaction in virtual learning environment. At this stage, emotion recognition from facial expressions system should not be the only tool to assist the target children emotional state in VLE.

In sum, learners might experience different types of emotions in VLE. According to the diversity of the target children’s emotional problems, it is important to ensure ICT applications that provide the appropriate learning environment to motivate and give them the psychological support.

## 5 Conclusion and future works

The integration of ICT in special education may have a positive impact on the emotional state of children with LDs. The outcomes of this study support the idea that children experience many types of emotions and the use of ICT may help them to express less negative emotions during their interaction in VLE.

There is no doubt that children with LDs suffer from emotional and behavioral problems that lead to lack of motivation in learning and there is still a great lack of studies on the psychological impact of ICT on children with LDs. For that the

motivational state of the target children in VLE and the psychological impact of ICT are an important issue for future research. Future studies on the current topic are therefore recommended, especially to investigate how children with LDs perceive, accept, and adopt technology in learning.

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