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Collaborative Learning through Facial Expression for Special Children

Nia Valeria and Lau Bee Theng
Swinburne University of Technology, Sarawak Campus
Jalan Simpang Tiga, 93350 Kuching, Sarawak, Malaysia
nvaleria@swinburne.edu.my; blau@swinburne.edu.my

ABSTRACT

Due to communication impairment and delay in cognitive development, children with cerebral palsy and autism require special educational needs (SEN), where the one- to- one learning relationship is believed to be a good method in teaching them. However, limited numbers of educators are not equal to the numbers of children with disabilities. To cope with the limited manpower in teaching children with disabilities, development of a collaborative learning program, *Learn with Me,* is introduced in this paper to assist the children in their learning, where the development concept is inspired from CVLE and ATS, where communication is done by adapting users' facial expression. The main goal of our research is to investigate the use of collaborative learning communicated through facial expression can assist the learning of children with disabilities. Testing was conducted on 20 participants, with 10 children with cerebral palsy, and 10 children with autism. Pre-test and post-test experiment was used in conducting this research. The overall results show that children gain improvement in using the collaborative learning program.

KEYWORDS

Affective computing, autism, cerebral palsy, collaborative learning, disabled children, emotions, facial expression

1 INTRODUCTION

Communication is one of the vital skills that human beings take for granted. It allows a person to express their thought and socialize with other people. However, not all humans are granted with communication skills. Some people with disability, such as people with cerebral palsy and autism, find communication as one of the challenges in their life.

Children with cerebral palsy and autism are two different types of disorders. Yet, they have similar impairments that cause them to have some difficulties when it comes to academic performance. Children with cerebral palsy and autism have similar impairments in communication [1, 2] cognitive development [3, 4]. The cause of their communication impairments appears to be not the same. Communication in children with cerebral palsy is caused by motoric and muscles problems which limit them in producing speech, whereas children with autism are faced with their inability to understand and socialize with others which delay them to develop speech.

Communication impairment hinders children to express their thought and idea when learning is conducted as some of the children who fall into low-functioning category (severe disability)

have non-verbal communication. As an alternative, children use gesture, eye-gaze, facial expression, or signed-language as a way for them to communicate in their daily life. Besides that, delay in cognitive development affects children's performance in learning. Children's performance is slower compared to normal children [5-7]. As they have delay in cognitive development, some abilities such as memorize, understand, and solve problems, may be lower. They may spend more time to absorb and understand the learning content delivered to them. Moreover, repetition of learning may be required in teaching those children.

As children with cerebral palsy and autism have similar problems in communication and cognitive development, competent special educator needs (SEN) are required in teaching those children [8]. Educators take vital roles in teaching those children as they are the main figure in shaping the children to become better individuals. As special educator needs, ability to observe is important in communicating with the children. Besides, patience, motivation, commitment, and empathy towards the children are strongly required since children with disabilities are dissimilar with normal children [8-10]. More repetitions may be required when dealing with children with disabilities due to the delay of their cognitive development. More time need to be allocated and educators have to keep their patience in re-explaining to them. Some children may get response and understand the learning, whereas some children may just sit there without giving responses regarding the learning that has been delivered to them. In this situation, educator may get a hard time since they have to entertain other children as well.

As a result of delay in learning, one-to-one learning relationship is the best method in teaching individuals with disabilities as educator can focus more one child [11-13]. Educators can get closer with child and understand the communication that they made. However, problem is faced with the limited amount of manpower. As it requires one-to-one learning relationship, the numbers of children with disabilities with teachers or caretakers are not same. As a result, one-to-one learning relationship is hardly to be conducted.

To cope with the limited manpower, computer technology is introduced in education field. With the advanced of Information and Communication Technologies (ICT)'s development, integration of avatar or user representative in computer learning is not something impossible. User representative allows the computer to provide one-to-one learning relationship to its users. Many computer-assisted learning (CAL) have been developed learning program with a user representation within the learning program, such as Virtual Harlem [14], Elearn [15], NICE [16], and Sam System [17]. Through this virtual tutor, problem of the limited manpower can be reduced as it can be used as a substitute in assisting children's learning. However, development of the CAL is believed to be lacked in providing intelligence and affective to children with disabilities. Just like human educator, he/she can adapt the needs and emotions of children with disabilities in the teaching and

learning process. However, CAL did not have the ability [18].

Therefore, in order to solve the problem of limited manpower and ability to teach and adapt to children's situation during the learning, *Learn with Me* program was proposed in this research. *Learn with Me* is a collaborative learning program which is able to adapt to users' emotions during the learning process. Development of collaborative learning program was focused on the creation of virtual tutor or user representation and adaption of facial expression in the learning. Virtual tutor was developed as a substitute of educator, in order to achieve the one-to-one learning relationship. Adaption of facial expression was implemented in the program to allow the program to have the ability to adapt with children's situation during the learning. Facial expression is chosen as a way for the children with disabilities to communicate with the program because it plays essential role in perception, learning, etc, where people usually do not notice it.

The overall goal of this research is to evaluate whether the collaborative learning program developed with facial expression as the communication tool is useful to assist children with disabilities to improve their learning.

2 AFFECTIVE COMPUTING

According to Sarrafzadeh, Alexander, & Shanbehzadeh (2011) [19], "ATSs are ITSs that are able to adapt to the affective state of students in the same ways that effective human tutors do". ATS is able to response to non-verbal language such as facial expression, heartbeat, fluctuations in voice, and eye and body movements [20]. Enhancement made to the ITS allows the system to react and give response by sensing the non-verbal language made by the user. From the researches that had been done, ATS showed positive result in educational area as one of the teaching tool [21-24].

Concept of ATS was inspired from the affective computing, "computing that relates to, arises from, or deliberately influences emotions" [25]. According to Picard (1997) [26], "if we want computers to be genuinely intelligent and to interact naturally with us, we must give computers the ability to recognize, understand, and even to have and express emotions". Ability of computers to have and express emotions has been developed by many researchers by providing an agent or user representation as a companion within the learning program [14-17]. However, development of computer learning that integrates with the ability to recognize and understand human's emotions just been discovered its effectiveness lately.

2.1 Emotion and learning

According to Darling-Hammond et al. (2003) [27], emotions are "thought of as irrational or 'non-intellectual' feelings that are beyond our control". Emotions are triggered from our brain, and it can be expressed through our behavior or expression. Emotions come according to the feelings that we have, where the feelings originally come from our brain [28]. When we face difficulty in doing some tasks, we feel depressed and without our knowing, stress emotion is showed on our face. When we have a fight or argument with someone, we feel angry, and usually the angry emotion is expressed through our actions and

expression. When we face a good situation, we feel happy, and smile is expressed on our face. In a nutshell, emotion describes or portrays someone feeling.

Information of emotions is used by the educators to adapt their teaching strategies when conducting learning session [29]. For instance, during the learning session, students may feel confused when dealing with complicated learning, and without their notice, confused expression is shown on their face. Through their facial expression, educator can know that the way that the learning conveyed is too hard for them to understand. Therefore, educator will naturally change the way to deliver the learning by simplifying it. Through this, educators improve the effectiveness of their interaction with students and ensure their ability in receiving the materials that have been delivered [24].

In fact, there are many ways to express emotions. Emotions can be expressed and recognized through voice, actions, and facial expression [25]. However, a famous study done by Mehrabian (1971) [30] showed that 93% of communication was done non-verbally. Sometimes, actions and facial expression come first before words are produced. For instance, when we face a surprised situation, expression is shown first through our facial expression, and words will come later as sometimes we suddenly do not know how to express it by using words. This is because when an emotion is felt, brain triggers action before words, where all the impulses are sent to the facial muscles in natural. In education, when students face difficulty in learning, before they speak out their problem, through their face, educator is able to tell whether they understand the learning or not as educator recognizes the facial expression made by students. Therefore, it can be said that educator obtains feedback from students not merely from verbal communication, but also from non-verbal communication as it also provides important information which can be used to describe the current situation of the students.

2.2 Usefulness of facial expression

Facial expression and body language play important role in expressing one's thought. Through facial expression, we can know someone's feeling. For instance, when someone gets surprised or shocked, his/her eyebrows will go up, the eyes getting bigger, and the mouth will open and make an 'O' letter. By looking at his/her expression, people can direct tell that he/she feels surprised / shocked. These are the natural things that human will have. Instead of using language, the non-verbal signals are used as one of the communication ways. It was found that face is a good indicator of pleasure/displeasure, liking/disliking, and joy/sadness [31].

As mentioned earlier, 93% of communication is through non-verbal, with 55% of the total is through facial expression [32]. From researches conducted, there are many studies that have applied facial expression into their study. Yang, Cheng and Shih (2011) [33] used the facial expression in order to analyze the learning status of their students during the learning as they believed that an important clue could be obtained from there. Whereas, Theonas, Hobbs and Rigas (2008) [34] studied how the facial expression made by the virtual lecturer could affect students' learning. From their study, results

showed that learning become interesting and motivating and students increased their enthusiasm towards the learning. On the other hand, facial expression is also used in teaching pre-school children. Dağ (2010) [35] studied the significance of the use of facial expression in the illustrated pre-school children books in teaching children. Result from the study showed that the availability of facial expression of characters in the pre-school children books were efficient in shaping the mind and imaginations of the children. From those samples above, it shows how useful facial expression is in providing information in education.

3 DESIGN AND DEVELOPMENT

3.1 Concept of Learn with Me

Development of the *Learn with Me* was inspired from the ATS and CVLE concept. ATS (Affective Tutoring System) is a tutoring system that has the ability to response to users' needs according the emotion shown by the users. It was believed that computer learning would perform better if it could adapt users' emotion into the learning [19]. Many studies that applied the concept of affective computing showed positive result in educational area as one of the teaching tool [21-24].

Apart from it, concept of applying user representation was inspired from CVLE (Collaborative Virtual Learning Environment). CVLE has been well known in education field. From the researches that had been done about the use of user representation in CVLE, influence of the expressive user representative was able to improve its users' learning and provide effective feedback [36, 37].

Learn with Me is a collaborative virtual learning that allows the user to learn and get response at the same time from the responsive virtual tutor. Figure 1 shows the pedagogical cycle of the overall program.

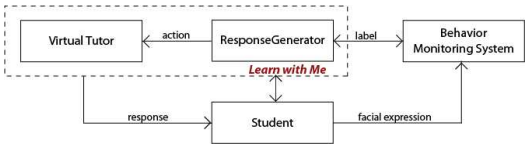


Figure 1 Pedagogical cycle

3.2 System Architecture

System architecture of *Learn with Me* is built from some components (Figure 2). User performs interaction with the learning program, Learn with Me, and camera as the medium to communicate with the Behavior Monitoring System (BMS). BMS recognizes facial expression made by the user by processing the information of the images. Images that have been captured by the camera are matched with the template for each user resided in the local database. If image is matched, information or label of the particular facial expression is sent to ResponseGenerator.

Learn with Me program contains 4 components with their own responsibilities. LearningContent component is responsible to provide learning content to the user. AssessmentContent component is responsible to provide assessment related to the learning content. ResponseGenerator component is responsible to match the label of facial expression sent by MappingModule component and provide a suitable response to the VirtualTutor component. VirtualTutor component has the

responsibility to respond back to user according to their needs.

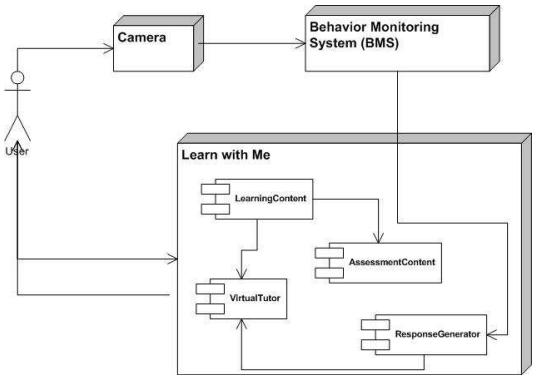


Figure 2 System architecture

3.3 *Learn with Me:* Interface Design

There are 4 components can be found on the interface at the learning section (Figure 3). The screen in the middle contains the learning contents for the users to learn. At the top of the right side is a placed for displaying the virtual tutor. The purpose of having the virtual tutor is to deliver the learning content to the users. Narration is read by the virtual tutor where at the same time text form is displayed on the screen as well. The reason to have two modes of communication was to train their reading and listening skills. Besides reading out the learning materials to the users, virtual tutor is responsible in responding to the user according to the facial expression that they made.

At the bottom of the right side is a placed for displaying the user's facial expression during the learning. Throughout the learning, user is able to see him/herself on the screen. The intention to have this component on the leaning section is to allow the users to learn their own expression. As we know that, children with autism has deficit in Theory of Mind, which include difficult in understanding and recognizing facial expressions. Through this program, it hopes that the targeted children can learn to recognize other people's facial expression starting from their own face.

Lastly is the label of the facial expression which is placed at the top of the user's video monitoring. Through the combination of the label of facial expression and user's video monitoring, it allows them to know what type of facial expression that they show at the moment.

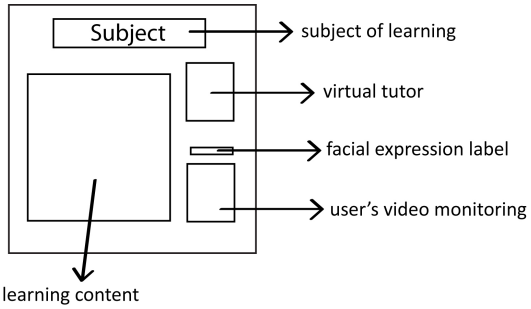


Figure 3 Interface design at learning section

Learning Content

Learning content is divided into 2 types which are the learning content itself and singing session. Song given in the singing session is designed in a way that it is related with the learning content. Teaching is conveyed visually and audio. Virtual tutor read out the storyline of the content, where at the same time text is presented on the screen.

Learning Material: video clips

Video has been chosen as a way to deliver and present to the learning content. Learning through video clips is believed can attract more attention from the users since it can portrait better information [38]. From the research done by Charlop-Christy, Le, and Freeman (2000) [38], testing was conducted in comparing of the

effectiveness for video modelling with in vivo modelling was conducted in teaching developmental skills for children with autism. Result showed that video modelling was more effective and had better results towards the children with autism. Moreover, it was effective in motivating and increasing attention from the children.

Figure 4 Screenshot of learning with video for Happy subject

Singing Session

Right after the content is complete, learning is continued with singing session. Song that has been chosen to teach emotion subject to the children was 'if you are happy and you know it'. The reason to choose this song is because it is simple and known well by children. In order to match the song with other emotion subjects, lyrics of the song have been modified and animation is created and matched the lyrics of the song.

Figure 5 Screenshot of the singing session for Happy subject

Assessment

In the assessment session, each emotion subject was given 2 questions for the users to answer. Each question is given 2 options for them to choose. The reason to give merely 2 options is to not confuse them with too many choices. Assessment contents were inspired by Moore et al. (2005) [39] who used the CVE technology in assisting people with autism. First assessment required the user to predict the situation that triggered particular emotion (Figure 6). The reason behind this learning is to teach them appropriate facial expression in various situations happen around them. Options for the answer are provided in animation and text format. This allowed the children to have a view of the situation happened and can decide the answer according to the situation given.

In second assessment, children are required to choose a particular expression given in the list of images according to the question given (Figure 7). Children need to choose the correct facial expression to match the question. The rationale reason behind this assessment is to help children in recognizing the basic emotions. Options for the answer are provided in images with the facial expression that have been captured before.

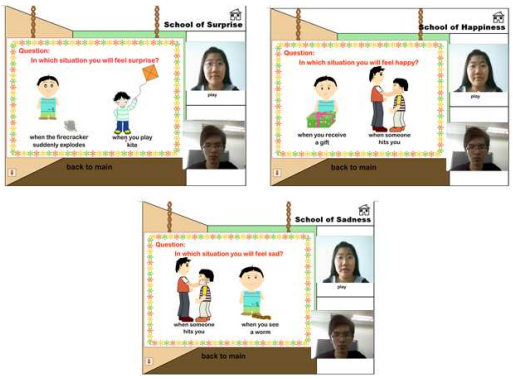


Figure 6 Assessment question 1

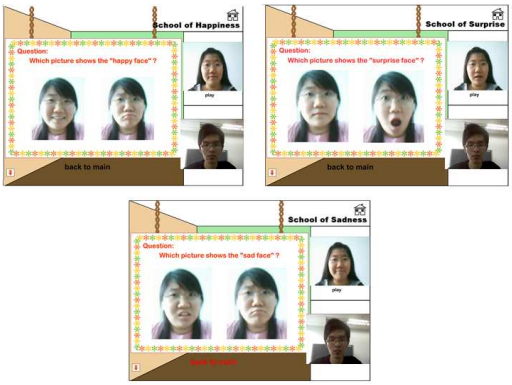


Figure 7 Assessment question 2

Virtual Tutor

Creation of virtual tutor is in video format. It is not a typical web based learning system or virtual environment where the avatar was displayed in a 3D form of image or customizable object. Purpose to choose the video format is to present a real educator to give a feeling of real learning for the users. Through this format, educator or trainer is able to record and present their learning materials. Moreover, records of the responses or messages to encouragement the children in their learning could be presented as well.

Figure 8 Screenshot of virtual tutor

Behavior Monitoring System (BMS): FacEx-Comm

Behavior monitoring system utilized in this learning program is called FacEx-Comm [40]. It is a monitoring system used to detect and recognize human facial expression especially for children with communication and physical disability. System involved three major stages in processing the information which are face detection stage, feature extraction stage, as well as expression recognition and classification stage [40].

As it has been discussed earlier (section 3.2), in order to identify the expressions shown by users, Learn with Me has to work with FacEx-Comm, in order to attain the specific label of expression shown during the learning. Label that has been obtained determined the response given by the virtual tutor. Application has to be trained before it is used to ensure that it has the intelligence to recognize the user's expression.

4 EXPERIMENT

4.1 Aims

The overall goal of this research is to evaluate the collaborative learning communicated through facial expression in assisting the children with disabilities to improve their learning. Through this experiment, there are 2 aims that have been set in order to achieve the goal of this research.

1 To find out that collaborative learning that adapts participants' emotions will significantly increase participants' learning and improve participants' performance.
2 To find out that collaborative learning that adapts participants' emotions will affect participants' perceptions in answering the questions.

4.2 Participants

Participants are recruited from one of the local schools for children with disabilities located at Kuching, Sarawak. There are 20 participants in total who

have participated in the final testing, where 10 participants are diagnosed with cerebral palsy (1 girl and 9 boys) and the other 10 participants are diagnosed with autism (1 girl and 9 boys). Participants' age are ranged from 8 – 17 years old. Recruitment of participants is based on the requirements that have been set as below:

1. Participant has to understand brief or simple instructions in English, Malay, or Mandarin language
2. Participant has to be able to focus or give their attention to an object or task for at least 5 seconds
3. Participant has communication problem(s) or incomprehensive speech
4. Participant understands English, Bahasa Malaysia, or Mandarin
5. Participant can control their facial muscles to express emotions
6. Participant has intention to learn
7. Slow in learning

Before conducting the experiment, a consent letter was sent out to the parents or guardian of participants to ensure permission was given to conduct an experiment on their child with the agreement from the school principal.

4.3 Methodology

Pre-test and post-test experiment is applied in conducting the final testing. This experiment was chosen to measure the assistance of the collaborative learning program in assisting children's learning by evaluating the result of before and after. Pre-test experiment referred to experiment without implementing the behavior monitoring system. Post-test experiment referred to experiment with implementing the behavior monitoring system.

Measurement tools:

Measure the participants' performance

Participants' performance is measured by the result that they achieved in answering the assessment questions given to them. Pre-test result is obtained from the last session (session 3) of the experiment. This result is used as the control result (benchmark) in measuring or evaluating the result, whereas the post-test result is attained from the average result of the 1st session till the last session (session 3), as the overall result for that experiment.

Measure participants' emotions towards the learning

Participants' emotions / facial expression towards the learning are measured by observing the sequence of facial expression and respond that they made with the numbers of false attempts made in answering the question. Data for the sequence of facial expression and results of participants in answering the questions are recorded during the experiment.

4.4 Procedures and setup

Procedures

There are two types of experiment conducted, which are pre-test and post-test experiment. Pre-test experiment is carried out without implementing the behavior monitoring system (FacEx-Comm) while running the learning program (Learn with Me). While, post-test experiment is carried out with implementing the behavior monitoring system (FacEx-Comm) while running the learning program. Learning contents and participants tested for pre-test and post-test are the same. Each types of the experiment have 3 sessions of learning.

Before experiment is conducted, brief explanation is given to the participant so that they can know their tasks in performing the experiment. Explanation is given in a way that it can be understood by participant. Explanation that has been interpreted can be seen at Appendix 1.

Setup

Testing is conducted in an unused section room within the participants' school. The reason is to avoid any distractions to the participant or disruption to the class.

Hardware and software

In conducting the testing, two USB 2.0 cameras with 1.3 Megapixel are used to perform the test. Installation of the webcam's software into the computer or laptop are required prior of the testing so that testing can be conducted successfully.

Besides USB camera, speaker is highly needed in this testing. Contents of the learning program are mostly narrated by the virtual tutor. Lastly, FacEx-Comm [40] has to be installed into the computer prior the testing. This system is required to monitor and detect the facial expression made by the participants.

5 RESULTS

Results of the experiment are divided into 2 according to the aims that have been stated earlier (section 4.1). Results that have been obtained below represent the achievement for each of the aims.

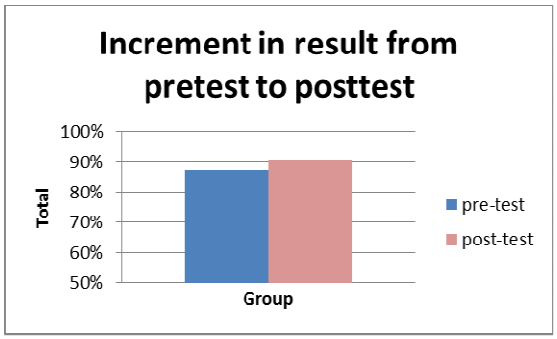
5.1 Participants' performance

In analyzing the results of the experiments, participants' performance is categorized into 2:

Participants' performance for 6 emotions' subjects

Throughout the experiments that had been conducted, Figure 9 shows the overall improvement through the differences result obtained from pre-test (learning without implementing behavior monitoring system) and post-test (learning with implementing behavior monitoring system).

Plotted charts (Figure 9) showed that total mean of the learning are improved from pre-test ($\bar{x}$ = 0.8722, *SD* = 0.08756) to post-test ($\bar{x}$ = 0.9093, *SD* = 0.09398). Figure 10 presents the errors result of participants made throughout the learning. From the figure, nearly all participants gained improvement in post-test, which is indicated by the lesser errors made in attempting to get the correct answers. 10% of total participants show the same result as the one done in pre-test. Meanwhile, 25% of total participants showed minor decrement in post-test compared to previous test.



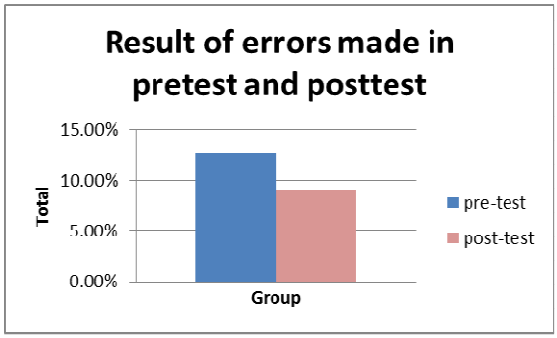


Figure 9 (above) increment mean result from pre-test to post-test; (below) mean errors made in pre-test and post-test

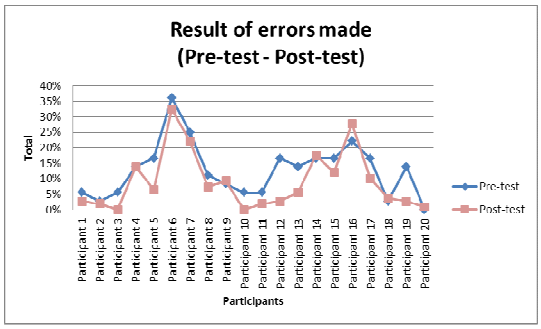


Figure 10 Result of errors made by participants in pre-test and post-test

On the other hand, Figure 11 shows the mean results of participants in answering the questions correctly at 1st attempt (*pre-test:* $\bar{x}$ = 8.45, *SD* = 1.959; *post-test*: $\bar{x}$ = 9.45, *SD* = 2.058). From the distributed line mark (Figure 11), nearly 70% of total participants are able to get the correct answer at the 1st attempt. Participant 5, 10, 11, 12, 13, and 19 show great improvement in answering the question.

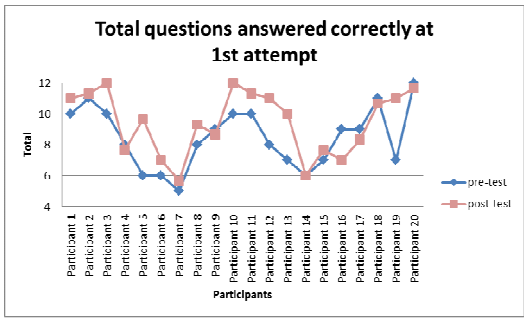


Figure 11 mean of total questions answer correctly for each participant in pre-test and post-test

Participants' performance for summative section

Summative section contains all the emotions that had been taught in the prior learning. From the 3 attempts given in answering each question, Figure 12 showed the total result obtained by each participant in pre-test and post-test.

Out of the 3 attempts/chances given for each question, some participants scored low result in pre-test. Full score were attained merely by 15% of total participants. Major improvement was made by approximately 75% of total participants in post-test. 40% of total participants made great progression in post-test by scoring 10 out 10 questions given.

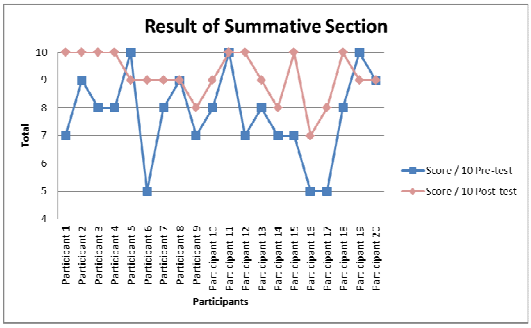


Figure 12 Result obtained by participants from the all attempts done in pre-test and post-test

From the above score obtained by each participant, average of the false attempts

made for all questions is presented at below graph (Figure 13). Number of false attempts made by participants in pre-test is higher compared to the post-test. Nonetheless, participant 19 showed opposite result compared to the rest, where false attempts in post-test increased almost 20% compared to pre-test.

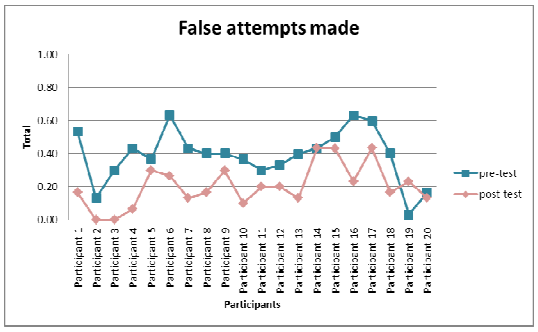


Figure 13 False attempts made by each participants in getting the correct answer

5.2 Relation of sequence of responses made towards participants' performance

Recorded data was analyzed to identify the relationship between the numbers of occurrences for each of the sequence of responses with total number of false attempts made by participants. Cumulative data is presented at
Table 1. Each of the sequence of responses has it total number of occurrences and total number of false attempts made for that response. Total numbers of occurrences for each sequence of response were calculated from session 1 until session 3.

In order to examine the association of the total number of occurrences for each response and the total number of false attempts made, Pearson's correlation coefficient 'r' is calculated. Calculation showed the correlation result (r) for both data was 0.920, with 0.000 for the p-value (significant (2-tailed), 1% significance level). This correlation showed that there was a strong relation between the sequences of responses occurred with the false attempts made by participants in answering the questions.

For instance, in
Table 1, it shows that from the whole session of learning, 'opt 1' was occurred 38 times, with 23 false attempts made. On the other hand, 'opt 1, opt 1, opt 1' was occurred 7 times with 2 false attempts made. Through the observation, the more sequences made for 'opt 1' in 1 learning, the lesser false attempts participants encountered. Through this, it ensured that participants understood the learning since many responses had been given. As for 'opt 1', since it occurred once in 1 learning, it could not ensure that participants have complete understandability towards the learning. Therefore, the number of false attempts made for 'opt 1' was quite high.

Table 1 Number of occurrences vs. number of false attempts

No. of responses	Sequence of response	Total no. of occurrences	Total no. of false attempts
1	opt 1	38	23
2	opt 1, opt 1	8	2
3	opt1, opt1, opt1	7	2
4	opt1, opt1, opt1,opt1	4	3
5	opt1,opt1,opt1,opt3, opt1	1	0
6	opt1,opt1,opt4	6	5
7	opt1,opt1,opt5	1	0
8	opt1,opt1,opt1,opt4	2	3
9	opt1,opt2,opt1,opt4	1	0
10	opt1,opt2,opt4	1	0
11	opt1,opt2,opt5,opt2, opt1,opt3	1	0
12	opt1, opt3	2	0
13	opt1,opt4	10	17
14	opt1,opt5	3	2
15	opt1, opt5, opt1	2	0
16	opt1,opt5,opt1,opt1, opt4	1	2

17	opt1,opt5,opt4	1	1
18	opt1, opt5, opt5, opt4	1	0
19	opt1,opt5,opt5,opt5	2	2
20	opt2	3	2
21	opt2,opt1	7	2
22	opt2,opt1,opt1	1	0
23	opt2,opt1,opt3,opt1	1	1
24	opt2,opt2	1	0
25	opt2,opt2,opt1,opt1	3	3
26	opt2,opt2,opt4	2	1
27	opt2,opt2,opt5	2	3
28	opt2,opt2,opt5,opt5, opt4	1	1
29	opt2,opt2,opt2,opt1	1	0
30	opt2,opt3	1	0
31	opt2,opt3,opt4	1	0
32	opt2,opt4	6	5
33	opt2,opt5	4	3
34	opt2,opt5,opt1	1	0
35	opt2,opt5,opt1,opt1	1	1
36	opt2,opt5,opt5	3	3
37	opt3	3	2
38	opt3,opt1	1	2
39	opt3,opt3	2	0
40	opt3,opt5	1	0
41	opt3,opt5,opt4	1	2
42	opt3,opt5,opt5	1	0
43	opt3,opt1,opt1,opt3	2	0
44	opt3,opt1,opt3,opt4	1	0
45	opt4	29	26
46	opt5	37	24
47	opt5,opt1	3	1
48	opt5,opt1,opt1	1	0
49	opt5,opt1,opt1,opt5	1	1
50	opt5,opt1,opt1,opt1, opt1	1	1
51	opt5,opt1,opt5	1	0
52	opt5,opt1,opt5,opt3	1	0
53	opt5,opt2,opt1,opt1	1	1
54	opt5,opt2,opt4	2	6
55	opt5,opt3	3	7
56	opt5,opt4	1	0
57	opt5,opt5	6	2
58	opt5,opt5,opt1	2	0
59	opt5,opt5,opt3,opt5	1	0
60	opt5,opt5,opt5	6	0
61	opt5,opt5,opt3,opt3	1	0
62	opt5,opt5,opt4	1	0
63	opt5,opt5,opt5,opt4	1	0
64	opt5,opt5,opt5,opt5	6	1
65	opt5,opt5,opt5,opt5, opt1	1	0
66	opt5,opt5,opt5,opt5, opt5	1	0
	Total	250	163

6 DISCUSSIONS

6.1 Participants' performance towards the learning

Result study that had been evaluated showed that participants made overall improvement in their learning which was proved with the number of false attempts decreased from pre-test to post-test learning (Figure 9). However, not all of the participants showed the similar results. Line chart presented at Figure 10 showed that participant 16 made the most difference with others participants, whereby more false attempts in answering was produced at post-test learning compared to the pre-test learning.

From the observation, most of the false attempts were made at 'sad' and 'angry' subjects. At pre-test learning for angry subject, participant 16 was able to answer question 2 correctly at 1st attempt, whereas question 1 was completely wrong. However, participant showed decrement in learning which was shown with the inability to answer the question correctly. In session 1 and session of post-test learning, participant 16 completely could not answer the question even though she had tried all the 3 attempts for each question. A little bit of improvement was shown at session 3, where participant could get the correct

answer only at the last attempt for both questions. Same problem was faced when participant answered questions for 'sad' subject. Question was able to be answered correctly at 1st attempt in pre-test learning. However, performance was dropped in post-test learning, where participants required more than 1 attempt in getting the correct answer in all sessions.

There was a possible factor that could explain this situation. Participant get distracted with the virtual tutor as it always triggered response that required participant to answer. Concentration of participant could be lulled because when virtual tutor was triggered to provide a response, learning would be stop and it would merely continue when participant answered the response. This caused the participant could not get the whole message of the learning. This factor could be possible because the total numbers of facial expression detected for sad and angry subjects were more compared to the other 4 subjects. Moreover, participant's learning ability was lower compared to others. Therefore, when it came to learning, participant might need more concentration and time to absorb the whole learning.

For the 1st attempt in answering the questions for all subjects, the most improvement was done by participant 5 and 19 with total 4 additional questions was answered correctly at 1st attempt in post-test learning compared to pre-test learning. Participant 5 showed that she made a lot of improvement for happy, sad, surprised, and scared subjects. When participant showed a confused expression, with the help of the virtual tutor in repeating the learning, participant was able to gain better understanding towards the learning. This was match with participant's personality as she was able to improve if she truthfully concentrated on the learning. As for participant 9, a lot of improvements were made for sad, surprised, scared and angry subject. He showed great improvement after multiple times learning. Most of the time, FacEx-Comm recognized participant's facial expression as confused emotion. However, when virtual tutor gave response to ask whether participant understood the learning, answered that participant gave was 'yes', meaning that he was able to understand the message sent by the learning content. As participant showed a great understandability when he was asked, results that he obtained in the assessment matched his ability in learning. Participant's understandability could be obtained through the singing session.

6.2 Facial expression communication in the collaborative learning program

In this research, the reason of adapting facial expression in *Learn with Me* program is to provide another alternative of learning for children who could not produce speech, whereby the sample used in this research was children with cerebral palsy and children with autism. Besides, it is also aimed to identify whether the use of facial expression could assist children to improve their learning. And from result above, it showed a significant improved made in participants' scores from pre-test (learning without implementing FacEx-Comm) to post-test (learning with implementing FacEx-Comm). Besides it could be used to assist participants to

improve their learning, facial expression could assist educators in identifying participants' learning status.

Through the facial expression, continuous recognition could produce a sequence of expressions which could be useful in identify participants' learning status. In post-test learning, behavior monitoring system was executed runtime. Runtime execution allowed the system to detect and recognize participants' facial expressions in every second. Recognized facial expression's label would be written on the learning screen with the aim to allow the participants to learn facial expression from their own face.

As the facial expression's label written on the screen, this could provide the educators information regarding participants' status whether they were happy, confused, bored or neutral. Moreover, through the sequence of facial expressions it could educator could identify how much learning that participants had obtained for 1 learning, and how this learning assist them in answering the question.

For instance, a participant produced a sequence of response 'opt 1, opt 1, opt 1, opt 3, opt 1' with total false attempts made was 0 (Appendix 9, raw result for sequences of responses). 'Opt 1' referred to ability to understand the learning, whereby 'Opt 3' referred to bored feeling, however participant did not wish to stop the learning, meaning that he/she still enjoyed his learning. From the sequence of responses, it indicated that participants really understood the learning content, which was shown with a good result that he/she could attain.

Other sample for this was a participant with the sequence of responses of 'Opt 5, Opt 2, Opt 4', where the false attempts made was 5 over 6 (Appendix 9, raw result for sequences of responses). 'Opt 5' referred to a response of No for the bored feeling detected. 'Opt 2' referred to the inability to understand the learning, therefore learning was repeated. 'Opt 4' referred to bored feeling with the attempted to stop the learning. From the sequence of response which was 'opt 5, opt 2, opt 4', it could be noticed that participant were really not into the learning. Learning was started with a bored feeling. However, participant wished could finish the learning. As the time moved, participant expressed the inability to understand the learning, and prompted the program to repeat the learning. As the learning was repeated, participant could not stand on it and asked to stop the learning. From this process, it was not a surprised that participants came out with the high number of false attempts in answering the 2 questions given for a subject. Total false attempts made was 5, meaning that out of 2 questions given, he/she could not answer 1 question correctly at the 3rd attempt.

However, these sequences of responses were unable to portrait the learning status for all the participants. Through the observation, some participants simply answered the question without waiting until the virtual tutor finish asking the question. There were 2 meaning that could be drawn here. First, participants felt distracted with the recognition as it always triggered the responses from the virtual tutor. Therefore, once they saw the virtual tutor asked them question, they would quickly turn it out without noticing if the

question asked was for continue the learning or stop the learning. Second, participants completely understood the content of the learning, therefore they wished could end the learning earlier and move to the assessment part. However, because they did not wait the question asked by virtual tutor till the end, sometimes they chose the answer which was to repeat the learning. This action caused the participants needed to spend longer time for learning one subject.

7 CONCLUSION AND FUTURE WORKS

Based on the results obtained above, it can be seen that those results show a positive outcome for both aims which have been set prior the experiment was conducted. Since both of the aims are achieved significantly, therefore, it concludes that collaborative learning communicated through facial expression is able to assist children with disabilities to improve their learning. However, there are many areas that still lack of, especially in the development. Future improvement can be on creating an intelligence virtual tutor that can adapts to the users in any situation. This improvement can help in providing better results in future.

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Appendix 1

Procedure scripts:

*"**Pre-test:***

(Explanation to conduct pre-test)

In this learning program, we are going to learn about emotions subject. There are 6 subjects that we are going learn: happy, sad, surprised, disgust, scared, and angry emotion. Each of the learning consists of video learning, singing session, and assessment. You have to understand the video learning in order to answer the assessment. Two questions were allocated for each of the emotion. Each question contains 2 options, where you have 3 attempts to try in order to get the correct answer.

(After 3 sessions done for pre-test)

Before we finish our experiment, you need to answer questions in summative section. There are 10 questions provided in this section with 4 options given for each question. You are given 3 attempts to answer each of the questions given. Those questions contain all the knowledge that you have had from the previous learning. Result would be displayed at the end of the test.

Post-test:

(Training for FacEx-Comm)

This test required you to show your facial expression during the learning session. Your face will be captured by the system throughout the learning. So, before we conduct the learning, we need to train the system so that it has the ability to recognize or identify your facial expression.

(Explanation to train the FacEx-Comm. system)

So, I am going to capture your facial expression so that the program can recognize your emotion. I will key in the text indicating an emotion, and you need to respond to it in front of the webcam. You need to express 4 emotions, which are neutral, happy, bored, and confused. You are required to hold your expression around 10 seconds in order to let the system capture your emotion. For each of the emotion I will demonstrate short video or action related to it so that you can express that emotion.

So, first, I will capture your neutral face. (Capturing process – No action made during capturing)

Next, I will capture your happy face. (Capturing process – Show funny video to attain that expression)

Next, I will capture your bored face. (Capturing process – Show blank document for quite long time to attain that expression)

Next, I will capture your confused face. (Capturing process – Show some actions that participant could not understand)

(Explanation for the learning session)
Ok, so now we are going to move to the learning session. I will show you 6 subjects. Throughout the learning, your facial expression will be captured and recognized, and there will be a response from the virtual tutor according to your expression. For certain expressions that had been captured, virtual tutor will give a response on it. You need to response it back by choosing the options given. You have to understand the video learning in order to answer the assessment. Two questions were allocated for each of the emotion. Each question contains 2 options, where you have 3 attempts to try in order to get the correct answer.

(After 3 sessions done for post-test)
Before we finish our experiment, you need to answer questions in summative section. There are 10 questions provided in this section with 4 options given for each question. You are given 3 attempts to answer each of the questions given. Those questions contain all the knowledge that you have had from the previous learning. Result would be displayed at the end of the test.
"