Using Bioloid Robots as Tangible Learning Companions for Enhancing Learning of a Semaphore Flag-Signaling System

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Abstract
The tangible learning companion (TLC) with anthropomorphic and tangible characteristics is expected to enhance learner's attention and motivation to increase learner's learning performance. Thus, this paper uses a humanoid robot as a TLC to assist learners to participate in Semaphore Flag-signaling System (SFS) learning activities to explore their learning performance and cognitive load. The subject of this paper includes 76 students assigning to two experimental groups. Group 1 learned semaphore by watching videos on computer screen and group 2 used bioloid robot as TLC to learn semaphore. These two groups both used Kinect sensor as motion-sensing input device to do interactive learning with computer screen or bioloid robot. The results showed that these two group learners do not have significant difference on learning performance, but learners of group 2 who used bioloid robot have significant lower cognitive load than group 1. Therefore it can be concluded that TLC can effectively reduce learners' cognitive load and prevent their cognitive overloading during the learning process.

Keywords: Robot, Tangible Learning Companion, Cognitive Load, Semaphore Flag-Signaling System, Learning Performance

Introduction

For the past few years, with the incessantly technological progress and development of robots, robotic applications were also widely popular like the industries for aerospace, manufacture and home care. Recently, robots were increasingly applicable to educational researches. Numerous research results indicated in the learning process, robots could be served as the aids for learners. It could effectively promoted the attention of learners and enhance learning motives (Draper & Clayton, 1992; Hsu, Chou, Chen, Wang, & Chan, 2007). It was featured with human-like characteristics available to draw the attention of learners effectively (Chen, Liao, Chien, & Chan, 2011). In view of interactive interfaces, it was further integrated with tangible interactive interface with visual stimulation excellently favorable for learners (Xu, Read, Sim, & McManus, 2009).

Therefore, the objects designed with human-like characteristics and their own tangibility were suitably served as the aids for learners. In terms of past researches with the comparison focusing on the variance of the teaching activities separately conducted by human teachers, robots and videos to learn the knowledge of birds, research results indicated the attentive extents of learners were ranked as the highest for those learners receiving the instruction from human teachers and then orderly followed by robots and videos (Draper & Clayton, 1992). Through robotic aids, learners showed stronger attention and motives to receive robotic aids in learning mathematics than those conducted by virtual learning companions (Hsu et al., 2007). In view of the English lessons of Korean elementary schools, robots could effectively draw the attention of students (Lee, Lee, Kye, & Ko, 2008). To sum up the aforesaid contents, this study would make robots served as learning companions and featured with humane characteristics. Also, added with robotic tangibility, an interactive learning way could be designed available to enhance the attention of learners. Also, through highly concentrated attention, excellently learning effect was achievable.

The Design of Learning Systems and Teaching Material

This study focused on the learning of semaphore. Semaphore was a communicative way by using flag signs. Flag holders with flags grasped in both hands communicated different messages by using different directions and locations of flags. The message contents were ordinarily numerics or alphabets. The combination of messages could be vested with more complex meaning inside. The settings of semaphore were often applicable to remote environment unavailable for communication by using sounds like the frequently-seen occasions of mountaineering, sailing and scout activities. This study stochastically selected 5 different numerics and 5 different alphabets serve as learning contents. They were separately 4, 1, 7, 3, 6, R, J, Y, T and L. The teaching materials were composed of the flag motions corresponding to different numerics and alphabets, acting points and actual practicing activities. In this study, there were 2 different learning systems, namely the interactive learning of videos and the interactive learning of robotic aids.

In the System of the Interactive Learning of Videos, teaching videos and learning contents were shown in the computer screen. After learners finished seeing the instructive videos of semaphore, they started the practicing stage. In the practicing stage, computer screens acted like a mirror showing the motions of a learner himself or herself. They could practice with both hands touching the red dots in computer screens. The system was installed with a Microsoft Kinect sensor to determine whether learners could pose correct motions in their practicing activities. If learners posed wrong motions, the system would feedback and guide learners with correct motions. The operational environment of the interactive learning system of videos was illustrated as Figure 1.

Figure 1:

The Interactive Learn System of Robotic Aids was equipped with BIOLOID robots served as learning companions. Robots prompted learners about semaphore motions by using actual motions and audio cues. Also, the robotic head was further installed with a smartphone to show learning contents as Figure 2 illustrated. After learners finished seeing robotic instruction, they started the practicing stage and this learning stage requested learners to pose correct semaphore motions. The system was installed with a Microsoft Kinect sensor to detect the motions and sounds of learners. Both robotic arms waved with both arms of learners available for learners to determine whether their motions were correct or not. After learners posed correct motions, they should shout “OK” for confirmation. If learners posed wrong motions, robots would show correct motions to guide learners for correctness.

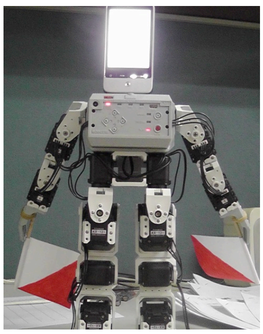

Figure 2:

Before the learners of both systems started learning, it was required to get familiar with the operational ways of systems previously. The learning process was divided into 2 different stages, orderly the learning stage and the practicing stage. During the learning stage, learners start learning the motions and meanings of semaphore. During the practicing stage, learners practiced the motions of semaphore that they had learned earlier. After learners posed correct motions, learners started entering the next learning stage of another numeric or alphabet. Whenever any wrong motion found, the system would feedback a correct answer. It was required for the learner to repeated a correct motion and then it was just allowable to enter the learning stage of nothing numeric or alphabet.

Research Method

This study aimed to explore the possible influence on the learning effect and cognitive load about learning semaphore by using different interactive learning ways. The interactive learning ways were classified with 2 different ways, namely video learning and robotic learning. Video learning was available for learners to watch actual humane motions in tutorial videos. Robotic learning was available for learners to watch the tutorial contents provided by robots. Learning ways meant the independent variables, while learning effect and cognitive load meant dependent variables. Because when compared with the 2D motions shown in videos, robotic learning could provide more intuitive motional contents, learners with interactive robotic aids could comprehend the contents more easily. Compared with the learners of interactive learning videos, more effort was saved with lower cognitive reachable.

In this study, there were 40 undergraduates or graduate school students without learning semaphore in the past recruited for this experiments wherein males occupied 95% and females occupied 5% separately. The subjects of both genders were stochastically allocated into different learning groups. After learners finished the experiment, each one was rewarded a supermarket coupon valued at 100 NTDs. Those with excellent learning achievement could be rewarded another bonus coupon valued at 100 NTDs.

The measurement ways of learning effect was evaluated by referring to the pass criteria of the signal training of scout specialties. It aimed to tests whether learners could remember 10 different semaphore motions and their corresponding meanings during the learning process with correct motions posed. The test was designed with continually unlimited numbers of questions in the duration of a minute. Whenever computer screens showed a numeric or alphabet previously learned during the learning process, learners had to answer the corresponding motion of the shown numeric or alphabet. It aimed to sum up the total number of the correct answers given by learners to serve as the measurement for learning effect. During the learning process, the answering performance of a learner was served as the basis for scoring reference.

The cognitive load scale was further modified by referring to the proposals of Paas (1992) Amadieu (2011). They were divided into 2 dimensions, namely mental effect and perceived difficulty. Mental effect was meant to measure the effort spent by learners during the learning process equivalent to the holistic cognitive load. Perceived difficulty was meant to measure the perception about learning difficulty when learners conducted learning activities equivalent to external cognitive load. The measurement was designed by using a 9-point Likert Scale with the range from 1 (extremely less and easy) to 9(extremely much and difficulty).

Before experimental commencement, there was a 5-minute experimental debrief to inform students about experimental contents and procedures. It was allowable for learners to get familiar with the operational ways of systems. Thereafter, learners were stochastically assigned to 2 different learning groups, namely the group of interactive learning videos or the group of interactive robotic aids. The learning duration for 2 different groups was appropriately 10 minutes. After learning was finished, a 2-minute debrief, a 1-minute measurement of learning effect and a 3-minute questionnaire answering duration of cognitive load were started immediately.

Result and Discussion

The comparison of learning effect for 2 different groups was analyzed by means of independent sample T-tests. As Levene's test of homogeneity, there was no significant variance found ($F = 0.144$, $p = 0.706$) conforming to the basic hypothesis of T-tests. Results indicated there was no significant variance of learning effect between 2 different groups ($t = 1.263$, $p = 0.214$). This result was incongruent with as expected earlier. Therefore, by repeatedly observing the video records of learners, it was found a learner of robotic aids showed the situations of unclear identification when using audio confirmation; the successful identification of the system was required for 2 shouts of audio confirmation. Therefore, it was conjecture whether there was any defective design happening to the operational ways or procedures of robotic aids to cause unexpected results could be exactly the problematic key issue. The interactive learning systems with robotic aids show the learned numerics or alphabets on the screens of Smartphone.

Because of the smaller sizes of Smartphone screens, learners had to take a close look to identify real situations and cognitive load was naturally higher to impede learning effect. Thereafter, other learners of the group of robotic aids were inquired about any similar problems happening. Actually, there was only a learner complaining about smaller sizes of computer screens with strenuous effort spent for identification. However, no other learner reported a complaint like this. Thereafter, some learners showing confused identification during the learning process were inquired about whether such a situation would impede learning effect. All the respondents reported no significant problems and influence found. Therefore, we further analyze and compare these 2 different groups to testify whether there was any defective design happening to procedures or operational ways.

Cognitive load was conducted with independent sample T-tests to compare the cognitive load of 2 different groups. Levene's homogeneity tests of variance indicated there was no significant variance found between mental effect ($F = 0.029$, $p = 0.865$) and perceived difficulty ($F = 1.449$, $p = 0.236$) conforming to the basic hypothesis of T-tests. In view of both groups, there was no significant variance in the averages of mental effect ($t = 0.946$, $p = 0.350$) and perceived difficulty ($t = 0.371$, $p = 0.713$) incongruent with earlier expectation. It meant when compared with the learners of the group of interactive video learning, comprehension was never easier for the learners of the group of robotic aids but it was assured with lower cognitive load. However, it was probably because the learning way of interactive video learning had been developed for a long time. Learners had got well accustomed to the interactive learning ways of video watching but they were not well familiar with the learning way of robotic aids to cause no significant variance in cognitive load between 2 different groups. Such a result also indicated there was no factor of defective design happening to the procedures and operational ways in the interactive learning group of robotic aids to impede learning effect.

Conclusion

The results in this study revealed when robotic aids were applied to the learning to memorize semaphore motions, no significant improvement in learning effect and cognitive load superior to those learners of the group of video watching. Also, such a result indicated robotic aids to learn semaphore motions could be served as another new learning way. In view of the past researches focusing on the learning activities of robotic aids, most experimental subjects were recruited from the students of elementary schools. It was probably because robotic aids showed no stronger attraction to the learning activities of adults. On the other hand, the learning contents for this study was the learning activities of semaphore motions. However, these were the motions under a stationary state. Through a displaying way with ordinary static images, it was available to clearly demonstrate the contents of semaphore motions. Therefore, probably robotic aids could not bring with a better demonstrating way of semaphore motions. In the future, it would be available make some trials with some robotic aids added into the researches on the learning effect of continually dynamic motions. Perhaps robotic aids could well exert their advantage in such learning subjects.

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