A Throw Training System Utilizing Visual and Sound Effects

Kaoru Sumi(✉) and Yuki Tsukamoto

Future Universiyu Hakodate, Hakodate, Japan
kaoru. sumi@acm. org

Abstract. This study introduces a throw training system that aims to improve the athletic performance of children who see themselves as not good at sports. The lack of exercise among children has become more severe in recent years, the main causes being fewer opportunities and environments in the neighborhood that enable children to play outside and engage in sports activities. The authors of this study have developed a throw training system that utilizes visual and sound effects. The system is designed for use in elementary school physical education (PE) classes and allows for enjoyable use, training, and learning. The effectiveness of the system was evaluated by elementary school students who participated in a set of experiments in a PE-class setting.

Keywords: Visual effect · Sound effect · Throw training

1 Introduction

The lack of exercise among children has given rise to declining athletic performance in recent years in Japan. The average record of a softball throw declined by 5.2 m among boys and 3.4 m among girls in the 2012/2013 school year compared to the mid-1980s. The widening gap between children who exercise and those who do not has become a social issue. While the frequency of exercise is an important factor to maintain a healthy level of fitness, many children who consider themselves not good at sport or physical activity in fact like to exercise but have fewer opportunities to engage in physical activity because they do not want to be made to feel incompetent in comparison to their peers. The goal of this study was to develop a training system that would improve children's perceptions of physical competence and provide them with an intrinsic motivation to become more involved in physical activity.

In related studies, sample movement and a first-person perspective for effective motion training [1] and anticipation in tennis were examined using realistic film simulations, movement-based response measures, and a portable eye movement recording system [2]. In sports, learning every part of the movement involved in a physical action is an effective training procedure [3]. Recent years have seen a wide range of studies on sports, exercise, and the applications of motion capture. These studies form the basis for support systems aiming to improve sports skills and attitudes toward exercise. In a study [4], a system that learns the movements of a user's dominant hand is developed. The system then uses these movements to make a mirror image, which the user can utilize to acquire motor skills with their non-dominant hand effectively. A system using

R. Poppe et al. (Eds.): INTETAIN 2016, LNICST 178, pp. 136–145, 2017.
DOI: 10.1007/978-3-319-49616-0_13

the Kinect motion-sensing device to learn how to throw darts accurately focuses on darts, which is an activity that requires very consistent movements, aims to improve a user's throwing mechanics by clarifying how the user's throwing motion differs from an ideal throwing motion [5]. In a study [6], the authors introduced a devised interaction method using an acceleration sensor and a noren-turned-screen, which uses the surface of a split shop curtain (noren) to project video images. These enabled more accurate representations of pitches thrown, by accommodating a wider range of ball behavior and the throwers' body movements.

Recent years have seen a rise in learning tools and methods that involve games, such as serious games [7–9] and gamification [10–12]. Serious games are computer games that aim less to offer entertainment than to solve social problems, and they are used in areas such as education and medicine to advance learning, practical experience, and the arousing and development of interest. The current study's training system is similar to serious games in that it aims to improve performance in physical activity and to enable enjoyable training through the use of a system. There is increasing attention being turned toward the educational applications of games, such as serious games and gamification.

Leveraging the power of serious games and other games, this study succeeded in developing a throw training system that motivates users through the use of visual and sound effects.

2 A Throw Training System Utilizing Visual and Sound Effects

Our research group has been implementing system-based throw training programs in PE classes in schools [13]. Our past studies have shown that by using visual and sound effects in the feedback provided by the system that records the student' throws, students can improve their throwing distance while enjoying the practice. This study takes a closer look at the training system and examines the effectiveness of each set of visual and sound effect.

Microsoft Kinect was used to record each student's throwing motion, which was then evaluated and scored based on an ideal throwing motion (Fig. 1). Unity 5 was used to develop the entire system. The system is made up of three main segments, which can be defined by user-interface screens: the Start Screen, the Training Screen, and the Special Effect Screen.

When the Training Screen appears after the Start Screen, the student is asked to do three throwing motions, each of which is given a score. The Training Screen segment of the system is made up of a session for learning through observation and a practice session (when the student does the throwing motions). One practice session involves three sets of three throws, providing nine chances to do throwing motions in total. The practice only involves the motion, or gesture, of throwing a ball, without actually throwing it. The reason is that by doing the throwing motions while looking at the ideal throwing motion, the student can pay more attention to and hence improve their motion. The Training Screen displays the ideal throwing motion together with a projected image of the student's motion (Fig. 2).

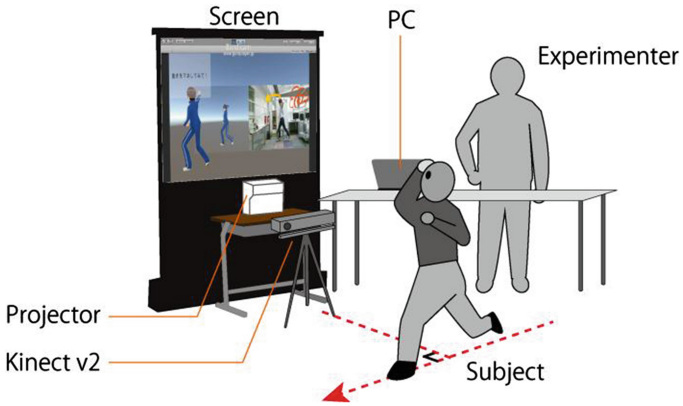


Fig. 1. System settings.

Fig. 2. Training screen.

The ideal throwing motion was based on the motion of a college student with five or more years of experience in baseball. This throwing motion was shot using Opti-Track's Motive. The projected image of the student was laid over the college student's ideal throwing motion to help the thrower (student) understand their motion. The display with the image was placed in a position such that the student could see where they were throwing and the image at the same time.

Throwing motion was broken down into three stages, each of which was subject to evaluation, according to the pitching biomechanics [14].

1. First half of cocking: In this stage, the evaluation is based on whether the arm is pulled back fully and whether the position of the hand is lower than the elbow.
2. Second half of cocking: The evaluation of this stage is based on whether the elbow is raised high enough and on the position of the elbow relative to the shoulder.

3. Acceleration: The evaluation of this stage is based on whether the thrower is taking a stride forward as they throw and on how big the stride is relative to the distance between their feet at stage 1.

The scores for the evaluations of the three stages were added up (one point per stage) for each of the three throwing motions done by a thrower in a set, and the next Special Effect Screen was determined and displayed based on this total score for the set (out of a maximum of nine points). Scores took into account whether the timings of the stages of the throwing motion by the student were in line with those of the ideal throwing motion. Each student received a total of nine scores for the nine throws that were graded (three scores per set). The Special Effect Screen provided the student with feedback, communicating how well the student was able to imitate the ideal throwing motion.

The special effect was designed to appear after the Training Screen. The system's camera device could follow a ball's trajectory as instructed by the student who threw a ball. As feedback, a student was shown one of three special effects: SE_Poor, SE_Good, and SE_Excellent. SE_Poor was shown when the throwing motion was done poorly, and SE_Excellent was shown when the throwing motion was done very well. A student was shown one of the three special effects based on the total score of the three throwing motions recorded while on the Training Screen: SE_Poor for 1–3 points, SE_Good for 4–7 points, and SE_Excellent for 8–9 points.

In this study, we prepared three types of special effects to see whether performance and behavior during practice would vary depending on the special effect used. The three kinds of special effects involved: manga "speed lines" (Fig. 3), cheering voices (Fig. 4), and a "flashy" animation (Fig. 5).

Fig. 3. Special effect screen (speed lines, SE_Excellent). The animation of a ball in a straight line accompanied by the sound of a thrown a ball.

Fig. 4. Special effect screen (cheering voices, SE_Excellent). The animation of a ball in a straight line along with people shouting and applauding, accompanied by the sound of a thrown ball, and cheering and applause.

Fig. 5. Special effect screen (flashy, SE_Excellent). The animation of a flying phoenix accompanied by the sound of flaring up.

3 Experiment 1

We divided 80 sixth graders (39 boys and 41 girls) into six groups to examine the effects of training and special effects. The students' scores in the nationwide sports test that the students took while in fifth grade (the "Shin-tairyoku test") were taken into account when deciding the groups. For this experiment, each student did three minutes of training using our system. The six groups are the following.

Group 1: Control group, Group 2: Special effects-only group, Group 3: Training-only group, Group 4: Training-and-speed-lines group, Group 5: Training-and-cheers group, Group 6: Training-and-flashy group.

Group 1 served as the control group to gauge the effectiveness of the system. Group 1 members did the throwing motion ten times as they saw themselves projected on the screen, without using the training features of our system. Group 2 members were shown special effects at predefined intervals as they did the throwing motions. Group 3 members did the throwing motion ten times while using the training features. Members of Groups 4, 5, and 6 were shown their respective special effects in addition to using the training features.

The purpose of Group 2 was to see whether scores improve just by seeing special effects. The purpose of Group 3 was to see the effectiveness of the training features of our system. The purpose of Groups 4, 5, and 6 was to examine differences in how scores improve after seeing the respective special effects after using the training features.

At the start of the experiment, the students were explained about the different user-interface screens, using the training manual. The following are the guidelines for the softball throw in the Shin-tairyoku test, which were largely followed in the experiment.

Use a "Type 1" softball (with a circumference of 26.2–27.2 cm and a weight of 136–146 grams) and a tape measure. A circle with a diameter of 2 m is drawn on flat ground. A mat is placed on the ground, with one end at the center of the circle, orienting it in the direction in which the ball should be thrown, so that students could all throw in roughly the same direction.

The rules when doing a throw were that: (1) the thrower must stay inside the circle to throw the ball, (2) the thrower must not step on or outside the circle both while and after throwing the ball, and (3) the thrower may only leave the circle after coming to a

complete stop after releasing the ball. A speed gun was used at a certain distance away from the circle to take measurements. Each measurement was rounded to the nearest kilometer/hour. Five sets of throws and measurements were recorded. All measurements were documented and kept.

As for additional notes: 1. There is no set way one must throw, but throwers are encouraged not to throw underhand, 2. To enable equal conditions, supervisors were asked not to provide advice or practice after making the measurement before treatment.

As a result, improvement was quantified by calculating an improvement rate based on a score before treatment and a score after treatment. An analysis of variance was then carried out in order to compare the improvement rates between the groups. The analysis showed that the differences in improvement rates were not significant ($F(5,74) = 2.11$, n.s.). T-tests were carried out to see whether there were significant differences between the improvement rate of Group 1 (control group) and those of the other groups. A significant difference was found for Group 1 and Group 6 ($t = -1.75$, $df = 17$, $p < .05$), suggesting that Group 6's treatment was an effective training method.

4 Experiment 2

Experiment 2 was designed to study the impression one receives when shown the special effect used in Group 6 of Experiment 1. We asked 13 people (12 male and 1 female) from a University to participate in a survey to evaluate impression. We aimed to use the results of this impression evaluation survey to obtain a quantitative understanding of the special effects used in our system. We hypothesized that the impression made by the special effects with speed lines and cheers would be different from the impression made by the special effect with a flashy animation. In the survey, a participant was shown a special effect after doing a throwing motion. The participant was then asked to associate their impression of the special effect with a number (on a scale of 1 to 5) in terms of eight impression variables (these were the same variables as those used in Sect. 5).

A factor analysis (exploratory factor analysis and Promax rotation) was conducted for the eight variables. Eight factors had at least one variable for which the factor loading was 0.40 or more (Table 1). Two factors were chosen based on the magnitude of the initial eigenvalue and eigenvalues after rotation (3.919, 1.141, and 1.065). The first factor was interpreted to be the "Success" factor, and the second factor to be the "Evaluation" factor. The results are shown below. Factor scores were calculated for the two factors and were averaged in terms of "Display" (content displayed on the Special Effect Screen), as shown in Table 2. The values were then used to perform a cluster analysis, the results of which are shown in a dendrogram (Table 4).

The mean factor scores for Displays show that the special effects with "speed lines" and "phoenix" scored high on the "Success" factor while the display with SE_Poor (Display A) was characterized by a weak "Success" factor" (Table 3). The special effect with cheers had a strong "Evaluation" factor while the special effects with "block destruction" and "phoenix" had a weak "Evaluation" factor. The results supported the hypothesis that "the impression made by the special effects with speed lines and cheers

Table 1. Factor loadings.

Variable/adjective	Factor 1	Factor 2
Powerful (distance thrown)	0.88	−0.04
Cool	0.85	−0.04
Pleasant/delightful	0.84	0.18
Fast	0.82	−0.03
Flashy	0.76	−0.28
Natural	−0.03	0.69
Praiseful	0.48	0.55
Light/casual	0.39	−0.55
Rotation sums of squared Loadings (a)	3.89	1.31

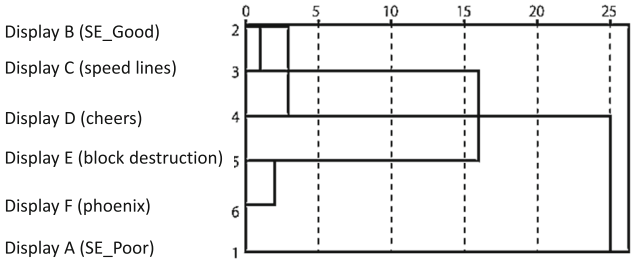
Table 2. Variables and interpretation of factor meanings.

Factor	Variable	Rotation sums of squared loadings (a)	Interpretation of factor meaning
1	Powerful, cool, pleasant/comfortable, fast, flashy	3.89	Success
2	Friendly, natural, light	1.31	Evaluation

Table 3. Mean factor scores.

	"Success" factor	"Evaluation" factor
Display A (SE_Poor)	−1.73	0.19
Display B (SE Good)	0.06	0.34
Display C (speed lnes)	0.59	0.17
Display D (cheers)	−0.15	0.95
Display E (block destruction)	0.24	−0.57
Display F (phoenix)	0.99	−1.07

Table 4. Dendrogram.



would be different from the impression made by the special effect with a flashy animation." The results therefore suggest that the special effects with flashy animations used in the group that experienced improved performance can be characterized by a strong "Success" factor and a weak "Evaluation" factor.

5 Discussion

Our experiments showed that effective training was achieved in the group that used our training features and a special effect with a flashy animation (Group 6). Students in this group showed signs of continued engagement in practice and seemed to be enjoying the practice as well. The use of a special effect that has elements to draw attention and arouse interest may have played a role to achieve continued practice and improved athletic performance. A special effect that introduces a sense of newness or originality to the practice seems to have enabled the students to practice continuously. However, the standard deviation of the improvement rates in this group was larger than in other groups, implying a large gap between those who were improving and those who were not. This disparity in improvement suggests that the training method may have been difficult to understand for some members. Future efforts should therefore be directed toward adjusting the training method so that all users may improve scores and performance.

No significant difference was found between the improvement rates of the control group and the group that did training only without special effects. Some members of this group found the training too monotonous and lost the motivation to continue. A significant difference was also not found between the improvement rates of the control group and the group that only used special effects without using the training features. The group members seemed to be enjoying the practice but were not able to improve their scores. They may have enjoyed the special effect itself but may not have been able to utilize the enjoyment for the improvement of their scores. No significant differences were found between the improvement rates of the control group and the "training-and-speed-lines" group (Group 4) and between the improvement rates of the control group and the "training-and-cheers" group (Group 5). The behavior of the students in these groups suggested that seeing these special effects during practice had no effect on sustaining the motivation to practice. This may be because the special effects were not appealing or interesting enough. The behavior of the students in these groups suggested that they had lost the motivation to continue practicing, and some students stopped doing the throwing motions in the middle of practice. This may account for the decline in scores after treatment compared to before treatment.

The impression survey administered to college students showed that the special effects that improved performance were those that scored high on impression variables that were associated with the "Success" factor extracted through factor analysis (i.e., powerful, cool, pleasant, fast, and flashy) and scored low on impression variables that were associated with the "Evaluation" factor (i.e., praiseful, natural, and light).

The flashy special effect may have caused an extrinsic motivation during practice. Human behavior based on extrinsic motivation is motivated by external factors such as evaluation, reward, punishment and coercion, while behavior based on intrinsic

motivation is motivated by motives that occur from within, such as interest, enthusiasm, and desire. While extrinsic motivation is generally considered to have a temporary effect that does not necessarily lead to character development, behavior that is initially based on extrinsic motivation may eventually give rise to interest and enthusiasm and hence lead to intrinsic motivation-based behavior. This suggests that, while practice based on the training system we developed alone may not improve performance, the concurrent use of special effects may enable the user to engage in continued practice, which may in turn lead to improved performance.

6 Summary

We developed a training system that utilizes visual and sound effects. Results of experiments involving elementary school children showed a group of students who experienced improved athletic performance. A survey to evaluate the impression of the special effect that caused improved athletic performance showed that the effective special effect/could be characterized more by "Success" (associated with the impressions of powerful, cool, pleasant, fast, and flashy) than by "Evaluation" (associated with the impressions of praiseful, natural, and light).

References

1. Yang, U., Kim, G.J.: Implementation and evaluation of "just follow me": an immersive, VR-based, motion-training system. Presence **111**(3), 304–323 (2006)
2. Williams, M., Ward, P., Knowles, J.M., Smeeton, N.J.: Anticipation skill in a real-world task: measurement, training, and transfer in tennis. J. Exp. Psychol. Appl. **8**(4), 259–270 (2003)
3. Grosser, M., Neumaier, A.: Techniktraining. Theorie und Praxis aller Sportarten. BLV Buchverlag GmbH & Co., Munich (1996)
4. Ishii, K., Soga, M., Taki, H.: Proposal and development of reversal motion skill leaning support environment. In: 2011 International Conference on Information Technology Based Higher Education and Training (ITHET), Kusadasi, Izmir, pp. 1–6 (2011)
5. Nagata, Y., Hashiyama, T., Tano, S., Ichino, J.: A novice support system for the darts throwing. In: 28th Fuzzy System Symposium, pp. 572–573. Japan Society for Fuzzy Theory and Intelligent Informatics (SOFT)
6. Iyoda, A., Kimura, H., Takei, S., Kakiuchi, Y., Xiaodong, D., Fujii, S., Masuda, Y., Masuno, D., Miyata, K.: A VR application for pitching. J. Soc. Art Sci. **5**(2), 33–44 (2006)
7. Abt, C.: Serious Games. The Viking Press, New York (1970)
8. Aldrich, C.: The Complete Guide to Simulations and Serious Games, p. 576. Pfeiffer, San Francisco (2009). ISBN 0-470-46273-6
9. Reeves, B., Reed, J.L.: Total Engagement: Using Games and Virtual Worlds to Change the Way People Work and Businesses Compete. Harvard Business School Publishing, Boston (2009)
10. Zichermann, G., Cunningham, C.: Introduction. In: Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps, 1st edn., p. xiv. O'Reilly Media, Sebastopol (2011). ISBN 1449315399

11. ab Huotari, K., Hamari, J.: Defining gamification - a service marketing perspective. In: Proceedings of the 16th International Academic MindTrek Conference 2012, Tampere, Finland, 3–5 October (2012)
12. Deterding, S., Dixon, D., Khaled, R., Nacke, L.: From game design elements to gamefulness: defining gamification. In: Proceedings of the 15th International Academic MindTrek Conference, pp. 9–15 (2011)
13. Yuki, T., Kaoru, S.: Study of a system for training in pitching form to improve throwing distance using kinect. In: The 28th Annual Conference of the Japanese Society for Artificial Intelligence, JSAI 2014 (2014)
14. Sakakibara, N.: Pitching biomechanics. http://www.chiro-journal.com/wp-content/uploads/2014/02/sportschiro_09.pdf