South African Journal for Research in Sport, Physical Education and Recreation, 2021, 43(2): 69 - 84.
Suid-Afrikaanse Joernaal vir Navorsing in Sport, Liggaamlike Opvoedkunde en Ontspanning, 2021, 43(2): 69 - 84.
ISBN: 0379-9069

EFFECT OF IMAGE FEEDBACK BY DRONES ON ELEMENTARY SCHOOL STUDENTS' SATISFACTION WITH AFTER-SCHOOL SOCCER CLASSES

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ABSTRACT

The purpose of this study was to examine the effects of video feedback using drones on elementary students' satisfaction with after-school soccer classes and to verify the effectiveness of teaching and learning using drones to improve the quality of physical education (PE) instruction. Participants were fourth-grade boys (n=90) attending after-school soccer classes from three elementary schools in Seoul, South Korea. Participants were divided into an Experimental Group (image feedback group using drones), a comparative group (image feedback group using mobile phones) and a Control Group (oral feedback group). All groups underwent the same four lessons on each school day. The independent variables of this study were the three groups listed above. The dependent variable was learners' satisfaction level. This study examined students' educational, physical and psychological satisfaction. The results revealed that the group to receive image feedback using drones had higher educational, physical and psychological satisfaction than did the groups that received image feedback using mobile phones or oral feedback [$F(2.89)=25.900$, $p<0.001$]. Drones provide wide and high images from various angles to provide novel visual feedback. PE classes would benefit from utilising drones more often as the images provided promote students' satisfaction with PE.

***Keywords*:** Drone video feedback; Mobile video feedback; Satisfaction; School physical education.

INTRODUCTION

With the progress of the fourth industrial revolution, the use of drones, virtual reality and augmented reality, which were typically only seen in science fiction movies, is becoming commonplace due to technology development. Furthermore, the Internet of Things (smartphones, smart TVs, and smartwatches) is being utilised as a means of communication because of the expansion and constant changing of Information Communication Technology (ICT) (Bae, 2011; Rosen, 2011).

People realised technology's tremendous growth and development by watching the 2018 Pyeongchang Winter Olympics opening ceremony, where 1218 drones made the Olympic rings. The shape of the rings was elaborately depicted as a computer graphic. Drones, originally developed for military use, have become a device that anyone can use. Recently, they have been used in various fields (education, videography, weather management, performance, life

sciences, agriculture, construction) and the interest in and research on drones is growing globally (Jung *et al*., 2007; Koo *et al*., 2018).

The growth and development of these technologies has had a great impact on both social and educational changes (Park & Ma, 2019). Elementary and junior-high school students are well-versed in digital language and they are familiar with these technological tools, therefore, the importance of technology is highly emphasised in education. According to Koo *et al*. (2018), the integration of technology into the teaching and learning process has a positive impact on learning effectiveness. Specifically, elementary school students are much more receptive to visual information than textual information (Park & Yoo, 2007) and they actively participate in class by familiarising themselves with feedback provided by images (Jang, 2017).

The extent of technological applications in physical education (PE) ranges from video technologies, stationary and mobile measurement systems including ubiquitous computing technologies, tools for communication and collaboration, animations and simulations, multimedia learning systems (MLS), augmented reality (AR), virtual reality (VR) and tools for self-reflection to game technologies (Weimeyer & Muller, 2016; Nien *et al*., 2020). In practice, there are many examples of teaching using those kinds of technologies. Jeong *et al*. (2017) examined using technology in geometry lessons among middle-school students, and students' improvements in mathematical thinking were observed through visualisation using technology.

Additionally, Kim and Han (2003) studied the effects of middle-school moral instruction using ICT on teaching-learning. Their results indicated that the programme positively influenced students' moral judgment and its improvement. Lee and So (2004) and Rodriguez-Garcia *et al*. (2019) conducted research on the learning effects of ICT-based instruction, and they found that with problem-based learning (PBL), ICT effectively improved students' learning achievement of social studies. Research concerning the use of technology in the arts and PE has also been conducted. Ki and Kwon (2019) studied the ADDIE model teaching method in secondary art education and Hong (2004) studied the advantages, disadvantages and problems of music education using technologies. Moreover, Kim (2014) studied the effects of smartphone-based self-monitoring on academic self-efficacy and motor skill performance.

Concerning drones, Yun *et al.* (2017) studied the development and application of drones in mathematics, while Choi (2018) examined drones in geography classes at elementary schools on an island on the west coast of South Korea. Lee (2017) conducted research on developing experiential tasks and making drones in a middle-school technology and home economics class. The results of these studies are the basis for presenting new teaching and learning methods using drones, however, there is a lack of research on the educational value of drones. Although drones can be used to provide feedback and measure students' physical activity, there is no research on the use of drones in PE. Therefore, the value of image feedback using drones with PE students was examined.

The Korean Ministry of Education, Science and Technology (2015) requires teachers to avoid unilateral communication (teachers teach, students listen) when teaching PE. Teachers are required to design, modify and apply appropriate and diverse teaching and learning methods that are appropriate to the learning environment and its characteristics (Yoo & Lee, 2017). Successful learning is impractical if learners do not understand and encode the instructions. Helping learners understand is essential (Kim, 2015). According to Bae (2011), the provision of visual feedback in PE, which includes information on body movement and exercise performance, can help students use their bodies more efficiently and improve the effectiveness of learning.

In general, when a video is taken in a PE class and included as class material, it is necessary to obtain information about the learner's exercise performance and provide feedback (Park, 2011). The positive effects of feedback provided by videos about physical activity have been consistently verified (Jeon & Jeong, 2007; Sul, 2007; Lee *et al*., 2008; Kim *et al*., 2010; Ha & Ahn, 2013). Researchers have also examined the effectiveness of providing video feedback using mobile technology, like smart phones, camcorders, digital cameras (Kim & Yun, 2001; Lee, 2005; Lee & Jung, 2017; Yu & Lee, 2017; Jo, 2019).

Through these studies, the positive effects of using video equipment and providing visual feedback in physical activities were supported. However, most of the used imaging devices were limited to providing ball movements and tactical feedback in ball games, by capturing body movements at fixed heights and angles. In studies that examined soccer (Hong, 2014), basketball (Lee *et al*., 2008) and volleyball (Kim, 2015), the researchers focused on the visual effects in a fixed space, such as throwing, strokes and swings, in which only a specific motion technique is analysed in a small amount of space (Kim, 2006; Park, 2011; Yu & Lee, 2017).

According to Park (2018), the drone is a filming tool that allows the photographer to express freely the desired position, height and angle. It is possible to overcome the limitations of the imaging devices used in previous studies. It is also possible to analyse the motions of individuals by using the 'zoom-in' function of the drone per the photographer's need without discrimination between team or individual sports. Furthermore, more diverse and richer feedback can be provided, including overall team strategies, tactics and player behaviour.

This study attempts to overcome the limitations of previous studies that analysed only specific motions at a fixed height and angle when providing image feedback. Further, the educational utility of video feedback provided by drones and verified its effectiveness as a teaching and learning method, were examined.

PURPOSE OF RESEARCH

This study was conducted to scientifically verify the effects of providing feedback using drones on elementary school students' satisfaction with after-school soccer classes. The aim was to elucidate novel teaching and learning methods using drones in sports education and inform effective instructional design. The following research hypotheses have relevance:

1. There will be a difference in students' satisfaction level between the video feedback group using the drones and the video feedback group using the mobile phones;
2. There will be a difference in students' satisfaction level between the video feedback group using the drones and the oral feedback group.

METHODOLOGY AND MATERIALS

Participants

The criteria for selecting study participants were 4th grade, boys and in a healthy medical condition. Participants were recruited using convenience sampling (Table 1). A group of 90 fourth-grade boys attending after-school soccer classes in three elementary schools in Seoul, South Korea were selected. The living standards around the three schools were similar. Thirty participants were in the experimental group ('A' elementary school; image feedback using the drones); 30 participants were in the comparison group ('B' elementary school; image feedback using mobile devices); and 30 participants were in the control group ('C' elementary school; oral feedback).

Table 1. **COMPOSITION OF 4th GRADE PARTICIPANTS**

Group	Treatment	n
Experimental Group	Image feedback using **drones**	30
Comparison Group	Image feedback using **mobile** devices	30
Control Group	**Oral** feedback	30
	Total:	90

Ethical considerations

All study participants provided their informed consent, and the Ethics Review Board of Chung-Ang University approved the study design.

Measures

Drones

Drone specification

A Phantom 4 Pro, a shooting drone by Dji was used. It was possible to photograph the whole playground. The specifications of the drone are shown in Table 2 and Figure 1

Table 2. **DRONE SPECIFICATIONS**

Feature	Details
Name of device	Phantom 4 Pro
Weight	1.3kg
Maximum flight time	27min
Maximum flight distance	7km
Pixels	1 200
Video resolution	H.264 4K/60 fps, H.265 4K/30 fps
Video file format	MP4/MOV (MPEG-4 AVC/H.264, HEVC/H.265)

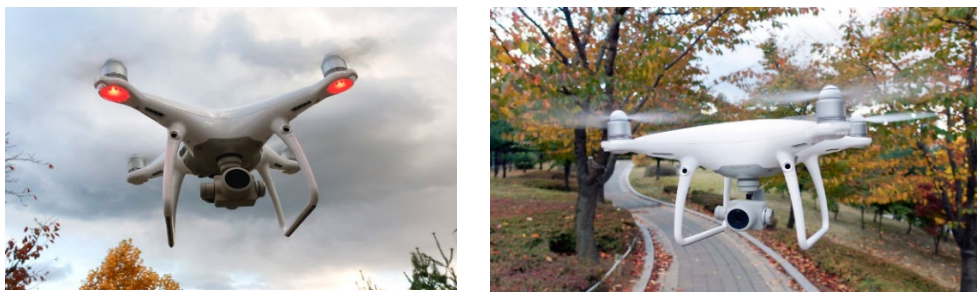

Figure 1. **Dji PHANTOM 4 PRO DRONE**
(https://m.post.naver.com/viewer/postView.nhn?volumeNo=16984175&memberNo=481955)

Video shooting method

Before using a drone to take aerial photographs, it is necessary to check the airspace and ensure that it is legally possible to fly and shoot (Park, 2018). Additionally, the aircraft with a weight of 12kg or more, must be approved for a pre-flight plan. However, for aircrafts weighing less than 12kg, it is possible to fly without approval from the Regional Aviation Flight Plan, South Korea (Yun *et al*., 2018). The drones used in this study weighed less than 12kg, therefore, with the permission of the 'A' elementary school principal, 10 minutes of video was shot using the drone during the after-school soccer class.

Soccer classes were held at each school playground, and the contents of the activities corresponding to the instructional goals were photographed for 10 minutes each. The height of the drone and the angle of the camera were set differently, per the contents of each activity, in advance by a drone specialist. After filming for 10 minutes, the drone and the tablet PC were linked to display the images to the students and provide feedback.

Mobile device (smartphone)

Specification of the smartphone

The research tool used in the mobile image feedback group was the iPhone 6 (Apple). Approximately 5 hours of video can be filmed. Additional specifications are shown in Table 3. In the 'B' elementary school group, ten minutes of video shooting using the smartphone was used, with the same contents as the drone feedback group. The camera angle of the mobile (smartphone) was set differently according to different lesson contents for each class and the value was set through pre-simulation. After the experiment, the images were shown to the students and feedback was provided immediately.

Table 3. **MOBILE PHONE: VIDEO CAPTURE DEVICE**

Features	Details
Name of device	Apple iPhone 6
Size	138.3mm × 67.0mm
Thickness	6.9mm
Weight	129g
Video resolution	1080p HD
Video file format	H.264, MPEG-4, Motion JPEG
Storage capacity	64GB

Questionnaire

To compare and verify the satisfaction of each group, questionnaires were used to evaluate students' satisfaction with the classes. The questionnaire comprised 23 items, based on Kim's (2008) 30-item questionnaire, which was modified and supplemented by Lee (2017) and Choi and Jo (2019): 8 items concerning educational satisfaction, 6 items concerning physical satisfaction and 9 items concerning psychological satisfaction. Responses were provided using a 5-point Likert scale from 1 (*strongly disagree*) to 5 (*strongly agree*).

Two physical education professors and two PE teachers were consulted. The validity of the questionnaire and the appropriateness of the questions were discussed, and the questionnaire was completed based on the outcome. The reliability of the questionnaire items was analysed with Cronbach's α: educational satisfaction, α=0.790; physical satisfaction, α=0.871; and

psychological satisfaction, α=0.947. Consequently, the questionnaire was considered reliable (Table 4)

Table 4. **SATISFACTION QUESTIONNAIRE RELIABILITY**

Factor	Question no.	Cronbach's α	Question no.	Cronbach's α
Educational satisfaction (8 questions)	1	0.786	5	0.863
	2	0.775	6	0.761
	3	0.780	7	0.787
	4	0.779	8	0.792
Physical satisfaction (6 questions)	9	0.854	12	0.881
	10	0.879	13	0.861
	11	0.866	14	0.887
Psychological satisfaction (9 questions)	15	0.949	20	0.954
	16	0.950	21	0.945
	17	0.945	22	0.943
	18	0.945	23	0.950
	19	0.947		

Research design

Treatment and class satisfaction surveys were conducted over one month. After-school soccer classes were held four times (one a week) and each group was organised on different days per the school curriculum. Four lessons were conducted with different contents for each class. The independent variable was the feedback group (drone, mobile, oral), and the dependent variable was learners' satisfaction level. The schedule for this study is shown in Table 5.

Table 5. **RESEARCH SCHEDULE**

Trials	INTERVENTION Day 1	Day 2	Day 3	Day 4	Questionnaire
Drone image feedback group	$T_{1\text{-}1}$	$T_{1\text{-}2}$	$T_{1\text{-}3}$	$T_{1\text{-}4}$	O_1
Mobile image feedback group	$T_{2\text{-}1}$	$T_{2\text{-}2}$	$T_{2\text{-}3}$	$T_{2\text{-}4}$	
Oral feedback group	$T_{3\text{-}1}$	$T_{3\text{-}2}$	$T_{3\text{-}3}$	$T_{3\text{-}4}$	

$T_{1\text{-}1}$ to $T_{1\text{-}4}$: DRONE image feedback classes $T_{2\text{-}1}$ to $T_{2\text{-}4}$: MOBILE image feedback classes
$T_{3\text{-}1}$ to $T_{3\text{-}4}$: ORAL feedback classes O_1: questionnaire (class satisfaction test)

Class design

Classes were held for 90 minutes per class for 4 weeks, and all three groups completed the same class contents. One professor of PE, one soccer coach and two soccer leaders were asked to conduct a content validity test on the contents of the classes. The composition of the lesson was organised as follows: introduction and warm-up (10 minutes), development (70 minutes),

and discussion and cool-down to finish class (10 minutes). Drones and mobile imaging and feedback were provided within the development (70 minutes) process (Table 6).

Table 6. **CLASS DESIGN**

Group	Day	*Topic* and Content
DRONE image feedback	1	*Through passes*: Drone shooting; Feedback; Replaying activity.
	2	*Two-to-one shooting*: Drone shooting; Feedback; Replaying activity.
	3	*Attack & defence activity*: Drone shooting; Feedback; Replaying activity.
	4	*Soccer game*: Drone shooting; Feedback; Replaying activity.
MOBILE image feedback	1	*Through passes*: Mobile shooting; Feedback; Replaying activity.
	2	*Two-to-one shooting*: Mobile shooting; Feedback; Replaying activity.
	3	*Attack and defence activity*: Mobile shooting; Feedback; Replaying activity.
	4	*Soccer game*: Mobile shooting; Feedback; Replaying activity.
ORAL feedback	1	*Through passes*; Observation: Oral feedback; Replaying activity.
	2	*Two-to-one shooting*: Observation; Oral feedback; Replaying activity.
	3	*Attack and defence activity*: Observation; Oral feedback; Replaying activity.
	4	*Soccer game*; Observation: Oral feedback; Replaying activity.

Data collection and analysis

Data were collected using a self-administered questionnaire. Data were excluded for questionnaires that were deemed unacceptable, such as those that included responses to the numerical batch or non-responses, as were data from students who were absent due to personal reasons. The collected data were analysed using SPSS for Windows Version 23.0 (SPSS Inc., 2015). First, Cronbach's αs were examined to determine questionnaire reliability. One-way analyses of variance (ANOVA) were performed to verify the effects of providing feedback using drones. The Scheffé's post-test was conducted to confirm the significance of differences between the three groups. Statistical significance was set at $p<0.05$.

RESULTS

Tables 7 and 8 display the data concerning the satisfaction level of each group. All three groups showed a normal distribution and the group provided with video feedback using drones had higher satisfaction levels than those who received mobile or oral feedback (Figure 2).

Table 7. **CLASS SATISFACTION PER FEEDBACK GROUP**

Feedback	n	Mean±SD	SE	95% confidence interval		Min.	Max.
				Lower	Higher		
Drone	30	4.760±0.429	0.078	4.600	4.920	3.5	6.2
Mobile	30	4.129±0.575	0.105	3.914	4.343	2.9	5.0
Oral	30	3.636±0.768	0.140	3.349	3.923	2.3	5.0
Total	90	4.175±0.758	0.080	4.016	4.334	2.3	6.2

SD=Standard Deviation SE=Standard Error Min=Minimum Max=Maximum

Table 8. **ONE-WAY ANALYSES OF VARIANCE: STUDENTS' SATISFACTION WITH CLASS FEEDBACK**

Comparison	Sum of squares	df	Mean squared	F	p
Within	32.021	87	0.368		
Between	19.065	2	9.533	25.900	<0.001
Total	51.087	89			

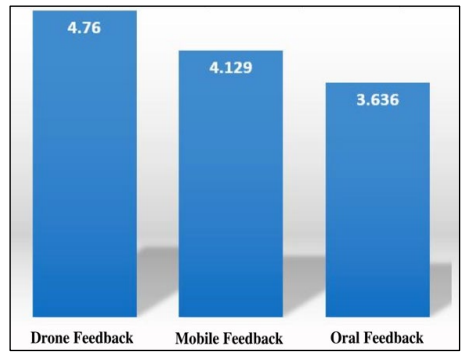

Figure 2. **CLASS SATISFACTION BY GROUP**

Scheffé's post-hoc tests revealed significant differences between the experimental and control groups and between the experimental and comparison groups (Table 9). Thus, the experimental group had higher satisfaction levels than did the comparison and control groups. Further, the satisfaction level of the comparison group (mobile feedback) was higher than that of the control group (verbal feedback).

Table 9. **SCHEFFÉ'S POST-HOC TEST FOR CLASS SATISFACTION PER FEEDBACK GROUP**

Feedback group		Mean difference (I–J)	SE	p	95% confidence interval	
					Lower	Higher
Drone	Mobile	0.6318	0.1566	0.001	0.242	1.022
	Oral	1.1245	0.1566	<0.001	0.734	1.515
Mobile	Drone	-0.6318	0.1566	0.001	-1.022	-0.242
	Oral	0.4927	0.1566	0.009	0.103	0.883
Oral	Drone	-1.1245	0.1566	<0.001	-1.515	-0.734
	Mobile	-0.4927	0.1566	0.009	-0.883	-0.103

SE=Standard Error

Group differences for sub-factors of class satisfaction

The descriptive statistics for the differences between each group concerning the sub-factors of satisfaction (educational, psychological and physical) are shown in Table 10. One-way ANOVAs were performed for each sub-factor to determine whether there was a significant difference in the sub-factors of satisfaction per group.

Table 10. **DESCRIPTIVE STATISTICS FOR SUB-FACTORS OF CLASS SATISFACTION**

Satisfaction	Feedback	Mean±SD	n
Educational	Oral	3.700±1.033	30
	Mobile	4.221±0.630	30
	Drone	4.929±0.860	30
	Total	4.283±0.987	90
Physical	Oral	3.656±0.799	30
	Mobile	4.106±0.677	30
	Drone	4.644±0.465	30
	Total	4.135±0.770	90
Psychological	Oral	3.552±0.871	30
	Mobile	4.059±0.848	30
	Drone	4.707±0.405	30
	Total	4.106±0.872	90

SD=Standard Deviation

Table 11. **SCHEFFÉ'S POST-HOC TEST FOR CLASS SATISFACTION PER FEEDBACK GROUP**

Satisfaction Sub-factor	Feedback Group		Mean Difference	SE	p	95% confidence interval	
						Lower	Higher
Educational	Oral	Mobile	-0.527	0.222	0.065	-1.08	0.03
		Drone	-1.23	0.222	<0.001	-1.77	-0.68
	Mobile	Oral	0.527	0.222	0.065	-.026	1.08
		Drone	-0.707	0.222	0.008	-1.26	-0.15
	Drone	Oral	1.233	0.222	<0.001	0.68	1.79
		Mobile	0.707	0.222	0.008	0.15	1.26
Physical	Oral	Mobile	-0.457	0.172	0.034	-0.88	-0.03
		Drone	-0.990	0.172	<0.001	-1.42	-0.56
	Mobile	Oral	0.457	0.172	0.034	0.03	0.88
		Drone	-0.533	0.172	0.010	-0.96	-0.10
	Drone	Oral	0.990	0.172	<0.001	0.56	1.42
		Mobile	0.533	0.172	0.010	0.10	0.96
Psychological	Oral	Mobile	-0.517	0.192	0.031	-0.99	-0.04
		Drone	-1.163	0.192	<0.001	-1.64	-0.68
	Mobile	Oral	0.517	0.192	0.031	0.04	0.99
		Drone	-0.647	0.192	0.005	-1.12	-0.17
	Drone	Oral	1.163	0.192	<0.001	0.68	1.64
		Mobile	0.647	0.192	0.005	0.17	1.12

SE=Standard Error

Scheffé's post-hoc test was conducted to determine the difference between the groups (Table 11; Figure 3). The results revealed that there were significant differences between the groups in physical and psychological satisfaction, but not educational satisfaction.

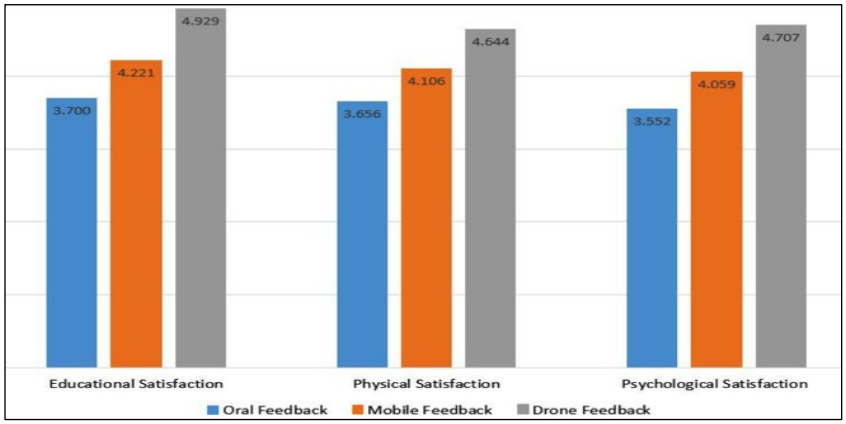

Figure 3. **MEAN DIFFERENCE BETWEEN GROUPS FOR SUB-FACTORS OF CLASS SATISFACTION**

The mean difference for educational satisfaction between the three groups was significant. The feedback group using drones showed higher educational satisfaction than did the mobile feedback and oral feedback group. On the other hand, there was no significant difference in educational satisfaction between the comparison group and the control group.

Physical satisfaction

The difference in physical satisfaction between the experimental group (drone feedback) and the comparison group (mobile feedback) was significant, as was the difference between the group that received drone feedback and the group that received oral feedback. In both analyses, the drone-feedback group displayed higher physical satisfaction than did the other two groups. The level of physical satisfaction between the comparison group (mobile feedback) and the control group (oral feedback) was also significant; specifically, the mobile feedback group showed higher physical satisfaction than did the oral feedback group.

Psychological satisfaction

Concerning psychological satisfaction, there was a significant difference between all three groups. Specifically, the image feedback group using drones showed higher psychological satisfaction than did the mobile or oral feedback groups. Further, the difference in psychological satisfaction between the comparison group (mobile feedback) and the control group (oral feedback) was significant: the mobile feedback group showed higher psychological satisfaction than did the oral feedback group.

DISCUSSION

The purpose of this study was to investigate the effect of video feedback using drones on

elementary school students' satisfaction with after-school soccer classes. To achieve this purpose, 90 fourth-grade boys from three elementary schools in Seoul, South Korea were divided into an experimental group (image feedback using drones), a comparison group (image feedback using mobile phones), or a control group (oral feedback).

The results revealed a significant difference in the satisfaction of the students depending on their group. The group that received feedback from drones, mobile phones, and orally expressed feedback group showed positive attitudes toward the class. In other words, visual feedback was more effective than oral feedback in promoting class satisfaction. This result was comparable to that of previous studies (Kim & Yuk, 2003; Kim, 2006; Jeon & Jeong, 2007; Sul, 2007; Kim *et al*., 2010), which verified the effectiveness of using image feedback in elementary PE classes.

Sul (2007) showed positive effects on learners' interest and knowledge level when video feedback was provided. Many other studies (Lee, 2005; Kim, 2006; Park, 2011; Kim, 2015) also confirmed the effectiveness of image feedback for not only elementary school, but also middle- and high-school students. Most of the video devices used in the previous research that validated the effectiveness of using video in PE classes were limited to smart phones (Kim, 2015) and digital cameras (Kim & Yun, 2001). On the other hand, this study proposes the use of an effective new medium, drones, to provide image feedback to students.

The mean difference in class satisfaction between the experimental group (image feedback using drones) and the control group (oral feedback) was larger than was the difference between the comparison group (image feedback using mobile phones) and the control group. This means that the class satisfaction was higher when the drone was used as the image feedback as compared to the mobile phone. Analysing the differences in class satisfaction per its sub-factors (educational, physical and psychological satisfaction) also showed that students' satisfaction was highest in the image feedback group using drones than the other feedback groups.

These results reveal that drones can be used to replace mobile phones to provide feedback to students. This is advantageous as drones can shoot from a relatively high position, thus providing a wider field of view than mobile phones. These advantages can enable richer feedback on team strategies and tactics in after-school soccer classes, and students can utilise this information to enhance their cooperation on the field. Such benefits will most likely further increase students' satisfaction with the experience.

Among the sub-factors of satisfaction, the students in the drone-feedback group expressed significantly higher physical satisfaction than did the other two groups. This result can be attributed to the feedback difference caused by the shooting angle of the drones and mobile phones. Phones must be fixed on a tripod; consequently, the angles that can be viewed are limited. Therefore, it is not possible to capture the whole movement of an individual, and it is difficult to continuously observe one's movement. This is not true for drones that can track a player's movement better thus providing more detail on how to improve his or her physical skills.

Among the sub-factors of class satisfaction, the image feedback group using drones expressed greater psychological satisfaction than did the image feedback group using mobile phones, which is considered related to the amount of fun students have using the new teaching tools. As suggested by Shin (2017), elementary school students are interested in curious flying objects, especially expensive drones, which until lately were only fictional. It was noticed how fixated the students were with the drone. Choi (2018), who conducted geography education using drones, noted that students' satisfaction level was generally high, and that most claimed the class was 'interesting.' This is consistent with previous studies by Kwon and Jung (2014)

and Seo (2016) who noted that the 'fun factor' of a class had a positive effect on students' motivation and satisfaction. Students' interest in the drone and the use of new teaching tools may have contributed to their psychological satisfaction with the soccer lessons.

A significant difference in educational satisfaction between the experimental group and the comparison/control groups, was revealed; however, the difference between the mobile and oral feedback groups was non-significant. In fact, among the three sub-factors, educational satisfaction was the most effective result of using drones to provide feedback.

The conclusions of Lee and Jeong (2017) were somewhat contradictory to these findings. They used smart learning with male, fourth-grade, PE students and revealed that students' psychological and physical satisfaction were significantly improved; however, they revealed no significant difference in students' educational satisfaction. The difference in the results may be attributed to group characteristics because this study examined boys who were participating in *after-school* soccer; therefore, they may have had a greater baseline interest in the sport.

The satisfaction level of the comparison group (mobile feedback) was higher than that of the control group (verbal feedback), which was consistent with the results of previous studies (Jeon & Jeong, 2007; Sul, 2007; Lee *et al*., 2008; Kim *et al*., 2010; Ha & Ahn, 2011; Lee, 2011). The above points are consistent with the hypotheses that there will be a difference in students' satisfaction level between the video feedback group using the drones and the video feedback group using mobile phones and the oral feedback group.

CONCLUSIONS AND SUGGESTIONS

In order to investigate the difference in class satisfaction of the three groups (image feedback group using drone; image feedback group using a mobile; oral feedback group), the study was conducted with soccer classes with the same contents consisting of four sessions once a week for four weeks. In the middle of each session, the EG was exposed to image feedback using the drone, while the comparison group received image feedback using the mobile, and the CG maintained the traditional teaching method and feedback only verbally. After four classes, the results were compared and analysed through the questionnaire about satisfaction of the class.

The questionnaire of Kim (2008) was revised and supplemented according to the purpose and topic of this study. The questionnaire consisted of 23 items, which consisted of three sub-factors: educational satisfaction 8 items, physical satisfaction 6 items, and psychological satisfaction 9 items. The responses in the questionnaires were divided into 5 levels by the Likert scale. One-way ANOVA was performed through the window SPSS 23.0 program after data were coded and analysed to verify the research hypothesis.

Firstly, in order to test hypothesis 1 [the video feedback group using the drone and the video feedback group using the mobile would have differences in class satisfaction (educational, physical, and psychological)] of this study, thus sub-factors of class satisfaction according to group were analysed. As a result, there was a statistically significant difference between the image feedback group using a drone and the image feedback group using a mobile in educational, physical and psychological satisfaction. Satisfaction of the video feedback group using the drones was higher than video feedback group using the mobile. It might be said that the images taken using the drone had a more positive effect on students' educational and physical satisfaction than the mobile images provided by the same location, height, and angle of view. Also, the students' interest in the new device may have influenced the research results. The results regarding hypothesis 1 were accepted;

Secondly, in order to test hypothesis 2 [the video feedback group using drone and the oral

feedback group would differ in the satisfaction level (educational, physical, psychological)] of this study, the satisfaction of the class according to group was analysed. There was a statistically significant difference in satisfaction. As in previous studies, video feedback using drone improved student satisfaction. As a result of analysing the sub-factors of class satisfaction, there was the largest difference in educational satisfaction, and there were significant differences in physical and psychological satisfaction. Satisfaction with the video feedback group using drones was higher than that of the traditional oral feedback group. The statement of hypothesis 2 was accepted.

With hypotheses 1 and 2 being accepted, it can be concluded that in this study the provision of image feedback using drones positively affects elementary school students' satisfaction with after-school soccer classes. Notably, students' satisfaction may promote students' interest in and practice of physical activity.

LIMITATIONS AND IMPLICATIONS

The findings have several key limitations and future implications. Firstly, considering that this study was restricted to only 4th grade elementary school boys who participated in after-school soccer classes in South Korea, the generalisation of the results is limited. It is thus necessary to expand this research to girls, different age groups, and diverse locations. Secondly, this study only examined four lessons over one month; therefore, the study period was brief, and this study likely measured *short-term* satisfaction. A follow-up study is needed to verify the long-term effectiveness of using drones to provide feedback. Thirdly, this study only examined class satisfaction. Further research is needed to verify the effectiveness of using drones on other variables. Fourthly, this study employed quantitative research methods, however, qualitative research methods, such as interviews with students may prove valuable. Fifthly, this study only examined soccer, thus the results may differ depending on the sport.

Further research should examine other sports played in physical education classes. Lastly, the drone (Phantom 4) used in this study was heavy and bulky, which could cause practical problems. It may be necessary to develop a drone that is easy to carry and operate so that it is suitable for use at schools.

In conclusion, the 2015 revised National Physical Education Curriculum, physical education should promote students' health management ability, physical training ability, sports performance ability and body expression ability. The benefits of using drones to provide image feedback to students are apparent and drones should be utilised in physical education classes to further examine their educational effects.

Conflict of interest

No potential conflict of interest was reported by the authors.

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(*Subject editor: Prof Maya van Gent)*