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Animated micro-sequences and auto-observational learning: an experiment in physical education and sports classes

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ABSTRACT

Our experimental protocol aims to study short moving images (GIF format) played in looping mode and their possible effects on learning in a school context, as compared to the conventional method. Pre-service teachers created GIF-format moving images with their learners (N = 158), then integrated those images into the teaching process during classes on the starting position of a running race. The experimental groups showed significantly better results than the control groups ($p = .043$; $\eta^2 = .026$): the students who participated in the creation of GIF images and self-observed their performance showed overall better performances than those who were placed in conventional learning conditions.

Introduction

Moving images have become a widely used learning tool in education. As schools entered the digital era, moving images became a central cognitive artifact for conveying information: LCDs, simulation devices, tablets, digital whiteboards, etc. Our research aims to study whether such moving images can help teaching and learning in physical education and sports classes. More precisely, we will examine to what extent learners can benefit from watching moving images of themselves when looking to improve their body movements in a given sports-related task, i.e. during sprint start training sessions. For Bandura (1977), self-observation and visual feedback are an integral part of the learning process, as the learner uses them to correct his/her movements. The Erbaugh experiment (1985) put this statement to proof by having primary school children perform motricity tasks then receive visual feedback through a video recording of their movements. Children in the experimental group were able to subsequently correct their movements, while those in the control group - without video - were less successful in improving their tests. The mirror neuron system theory proposes that the human motor system has a mirroring capacity that is activated by observing motor actions being performed by others (Rizzolatti and Craighero 2004, cited in Van Gog et al. 2008). As such, "dynamic visualizations automatically trigger an effortless process of embodied simulation by the neuron mirror system" (Van Gog et al., 2008). The hypothesis is that the mirror neuron system mediates imitation by preparing the brain for the execution of the same action (Buccino et al., 2004; Craighero et al., 2002; Iacoboni et al., 1999; Vogt et al., 2003, cited by Van Gog et al., 2008). In addition, the Patuzzo et al. (2003) experiment on the modulation of the motor cortex excitability during action observation did not find conclusive evidence of differentiation between self and non-self-action observation. Few studies have been conducted about multimedia use in sports learning, in comparison with more general sports learning settings. The studies often use video-based training (Farrow and Abernethy, 2002; Fadde, 2006; Khacharem et al., 2014; Milazzo and Fournier, 2015; Broadbent et

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al., 2017), or multimedia support (Vernadakis et al., 2004; Vernadakis et al., 2006; Vernadakis et al., 2008). Tversky et al. (2002) suggest that congruency and apprehension play a key role in the successful dynamic visualization of human movement. Self-observation through recordings of their performances could enhance the students' learning by facilitating adequacy and conformation between the conveyed information and its visual representation. Our aim is to study the effect of introducing an educational use of moving images in the context of school sports training.

Studies on multimedia and sports teaching

We conducted a review about studies on multimedia in the teaching of physical education and sports, compiled according to the learning settings involved and the results obtained (table 1). In line with our paper subject, we only considered physical training, and put aside studies about rules or knowledge learning in sports.

Table 1. Studies on multimedia and sports teaching

Study	Learning setting	Sport task	Results	Conditions of experiment
Farrow and Abernethy 2002	Two video-based perceptual training	Anticipatory skills of junior tennis players	Significant improvement in their prediction accuracy but disappears 32 days after the training intervention	Temporal occlusion observations and video-based training
Wiksten et al. 2002	Computer-assisted instruction	Techniques of Athletic Training	No significant differences	Traditional lecture vs CD-ROM groups
Vernadakis et al. 2004	Multimedia application	Shooting in basketball	No significant differences	Preparation and use of the CD-ROM
Fadde 2006	Interactive Video Training	Decision-Making in Baseball	Significantly better batting averages	Mediated pitch recognition training
Vernadakis et al. 2006	Multimedia application	Long jump skills	No significant differences	Preparation and use of the CD-ROM
Vernadakis et al. 2008	Multimedia application	Shooting in basketball	No significant differences	Preparation and use of the CD-ROM
Leser et al. 2011	Online platform: slow-motion videos and animations	Soccer technique and tactics	No significant positive effects	Video presentations of the ideal execution of the technique or tactic
Khacharem et al. 2014	Animated presentations	Soccer tactics	Novices benefited more from the static presentation whereas experts benefited more from the animated presentation	Video projections
Milazzo and Fournier 2015	Videos	Karate's decision making	General improvement in decision time and decision accuracy	Video-based training sessions
Robinson et al 2015	Multimedia demonstration	Test of Gross Motor Development	No significant differences for motor skill performance or participants' enjoyment between the two demonstration conditions	Live and multimedia demonstration
Hisao and Chen 2016	Interactive game	Motor skills	Improved learning performance and motor skills	Simulation game playing
Broadbent et al. 2017	Life-sized video of tennis rallies across practice	Perceptual-cognitive skills in tennis	The sequential group was significantly more accurate in their anticipatory judgments	Video-based retention test in either a sequential order or a non-sequential random order

Table 1 reveals very mitigated results. Each study involved an experimental, mediated group learning a sports-related task, and a control group placed in a traditional learning setting. One may take note of the positive results achieved by the most recent experiments, which used video-based training (Farrow and Abernethy, 2002; Fadde, 2006; Khacharem et al., 2014; Milazzo and Fournier, 2015; Broadbent et al., 2017), in comparison with the experiments that used earlier multimedia devices involving control of and interactivity with a given tool. More importantly, in those latter experiments, the authors first had participants learn how the play a game or use a platform, and those learning sessions with technology were separated in time from the actual physical training (Wiktsen et al., 2002; Vernadakis et al., 2004; Vernadakis et al., 2006; Vernadakis et al., 2008; Leser et al., 2011; Khacharem et al., 2014). In contrast, where studies achieved significant results in favor of multimedia in sports teaching, the technology was directly integrated to the physical training session (Farrow and Abernethy, 2002; Fadde, 2006; Milazzo and Fournier, 2015; Broadbent et al., 2017). According to those studies, using video-based training during the learning activity increases the chance of achieving positive results. In line with the recommendations of Bétrancourt et al. (2000) concerning the usage of discrete microsteps to convey temporal change, we conducted an experiment integrating video to the learning activity in sports classes. The GIF image format enables the creation of animated images that show the discrete microsteps of movements and gestures that the body goes through during a sprint start. Our hypothesis is that a learning setting using moving images with discrete microsteps, help students in physical education and sports class have better results than a traditional learning setting.

Researches on animated images and learning

Generally, animated pictures provide more information than static pictures, and allow viewers to better visualize that information, especially when it is broken down into discrete microsteps (Hegarty 1992, cited by Bétrancourt, Bauer-Morrison and Tversky, 2000). In the experiments that prove it, graphics or other types or visual materials were used to describe different types of processes or procedures using a step-by-step breakdown, which added information that was previously nonexistent in static images (Hegarty 1992, cited by Bétrancourt, Bauer-Morrison and Tversky 2000). Each shot in the animation represents a step. The shots follow each other, separated by cuts or crossfade transitions. Hegarty (1992) recommends using animation when representing temporal change. Bétrancourt, Bauer-Morrison and Tversky (2000) state two principles for the integration of animated pictures in the learning process: apprehension – using an animation that is easy to perceive and understand, with simple and realistic graphics favoring 3D – and making the underpinned conceptual model apparent (with an animation or short and discrete steps). The authors do not exclude using a static model to re-inspect and compare the materials, which is always possible thanks to the asynchronous modality enabling permanent examination (Goody, 1979). Those findings highlight the need of conducting studies in real school contexts, the majority of them being done in experimental situations. A meta-analysis conducted by Höffler and Leutner (2007) on 26 studies from 1973 to 2003 regarding learning with animated and static pictures found, with a mean weighted effect size of d=0.37 and a 95% confidence interval, a rather substantial overall advantage of animations over static pictures. More importantly, they found evidence that “animations seem to be especially effective for acquiring procedural-motor knowledge” (Höffler and Leutner, 2007). In 2016, another meta-analysis conducted by Berney and Bétrancourt on 61 studies found that studying with animated visualizations yields higher learning gains than studying with static graphics (with a weighted mean effect size of g = 0.226 and 95% confidence interval). Contrary to what has been found by the Höffler and Leutner study, Berney and Bétrancourt did not find that procedural knowledge yielded better results than conceptual knowledge. They drew this conclusion based on the 41 additional studies they took into consideration, and the introduction of cognitive variables into the procedural knowledge variables used as a methodological framework (Anderson and Krathwohl’s 2001 Bloom revisited taxonomy), which the previous meta-analysis had not taken into consideration. Furthermore, one can argue that the studies which found positive conclusions regarding the introduction of technology in teaching and learning have more chances of being reported than the ones showing no such evidence.

The animated GIF: microsteps and perception of reality

The idea of visually breaking down movement has fascinated scientists since the 1830s. The synthesis of movement is obtained by a succession of images (drawings, then photographs) perceived continuously through retinal persistence. Chronophotography, a sequential recording technique, was first used in 1874 by astronomer Jules Janssen to capture the passage of Venus in the sky. As early as in the 1880s, French physiologist Etienne-Jules Marey used photography to study the movement of athletes. This method breaks down motion by capturing images at strictly regular time intervals (Fig 1). One can argue that this form of editing was meant to break movements down into discrete steps.

Fig 1. Georges Demeny. (1850-1917). Chronophotographie d’un coureur. ©Collection Iconothèque de l’INSEP.

The idea is that precisely visualizing the breakdown and variation of a movement makes it possible to understand its mechanics. The painter Meissonier, impressed by Muybridge's demonstration that a galloping horse at times had no support on the ground (Fig 2), is said to have modified some of his historical scenes (Jablonka, online). Before Muybridge, it was impossible to comprehend the running horse's leg moves through the naked eye.

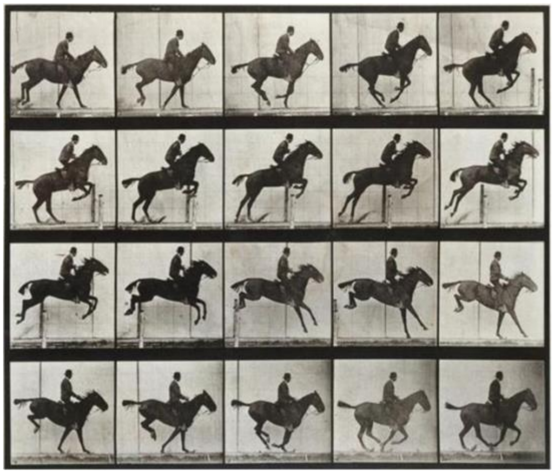


Fig 2. Muybridge Eadweard (1830-1904). Obstacle jump, black horse (1887). ©RMN-Grand Palais (musée D'Orsay).

From a cognitive perspective, Compte and Daugeron (2008) quote the studies conducted by Salomon (1981), which "show how much mental perceptions favor an immediate and richer decoding of the information. (…) Thus, the richness and diversity of our mental perceptions have a direct consequence on our level of comprehension" (Compte and Daugeron, 2008, p.40). The adjustment between those perceptions and the observed images corresponds to the mental "supplantation" mechanism operated by the subject. The objects or situations are quickly treated and internalized, in order to correspond to the person's mental perceptions (schematas, outlines, scenarios, etc.) (ibid.). The symbol replaces the object and becomes the model (Salomon, 1979). The GIF image format can either be static or animated, and it is lighter (a few kilo bytes, only 256 colors) than a video or a simulation object (Memon and Rodila, 1997). There are in fact many learning scenarios that integrate GIF images, and which can be found in several online databases. The GIF format image can be used to simulate a movement, create animated pictures, or bring a diagram or a drawing to life (Peterson, 1999). It is made of a succession of layers read according to the speed lecture that was set up. As such, the GIF image makes it possible to animate diagrams or drawings for educational purposes. But animated diagrams or drawings obey to the same pedagogical and semiotic principles than static diagrams: they don't represent objects, but ways of functioning or reasoning, or processes to be followed (Cuny and Boyer, 1981). If we consider again the pedagogical example given by Cuny and Boyer's study (ibid.), we first make sense of the diagram or drawing itself, before making sense of the object it represents (ibid., p.137). Those types of visual representations could be used in a school context to illustrate the notion to be learned. For instance, water cycle or photosynthesis could be visualized discretely, step by step. The teacher could show the totality of a movement, a cycle, etc. instead of displaying static images, which would not allow the learners to see the succession of different states of objects, phenomena or living beings. The dynamics are thus reified through:

- A conversion from an abstract state to a concrete one: notions, ideas, theorem modelling.
- A symbolic representation of the object: the affordance of the object to be learned (Gibson, 1977) that suggests a function or a logic different than prior to the "supplantation" process.

As listed by Tversky et al. (2002), animations can convey different objects: 1. the configuration of a system or a structure; 2. system dynamics, "by explicitly representing the behavior or movement of its components (Schnotz & Lowe, 2003)", and 3. "the causal chain underlying the functioning of dynamic systems". The modelization of body movement can fit in these three categories. If we consider the body as a system, and body parts as "components", the movement that is being performed triggers a chain action in the system, leading to the execution of the physical action, in our case the sprint start. Each of the three steps that has to be executed in order to propel the body the right way is photographed into a static image, with each image constituting a microstep that will be part of the final animation. An action research with the use of the GIF format image in a physical education course will help us verify whether this cognitive artifact (Norman, 1993) can lead to better learning.

Method

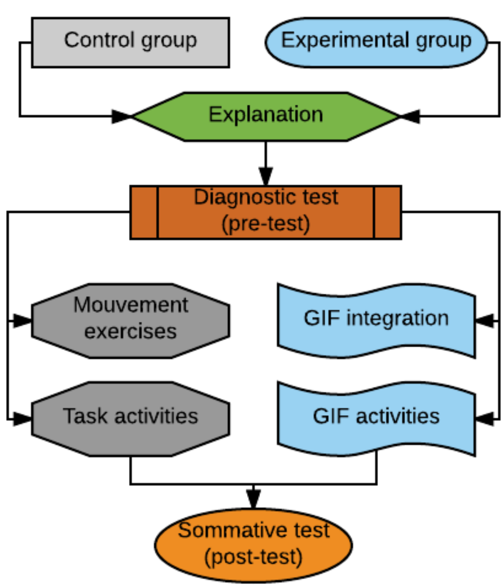
Students from the Physical Education and Sport Master at the Lebanese University conducted the experiment along with the researcher, during their pre-service internship, with learners aged from 9 to 10 years old. There were 4 students for 12 groups: 6 experimental groups (N=76) and 6 control groups (N=84) were set up. The configuration was as follows: teacher 1 had 2 experimental groups (N=2x21) and 2 control groups (N=2x21), teacher 2 had 2 experimental groups (N=2x10) and 2 control groups (N=2x10), teacher 3 had one experimental group (N=6) and one control group (N=10), and teacher 4 had one experimental group (N=11) and one control group (N=11). The sports-related objective was to learn the different steps of a sprint start and how to execute these steps correctly. All the children were novices.

Table 1. Experiment set-up

Experiment set-up	Teacher 1	Teacher 2	Teacher 3	Teacher 4	Total by group
Control group	N= 42	N= 20	N= 10	N= 9	N= 82
Experimental group	N= 42	N= 20	N= 6	N= 11	N= 76

As shown in Figure 3, the control groups were trained with the conventional method used in physical education and sports classes (Metzler, 2017): the teachers verbally introduced the learning objectives and described the action to accomplish. They executed the gestures, then had the students repeat them during the session. The teachers then organized activities around that task (repetitions, games, etc.). In the experimental groups, the teachers announced from the beginning of the first session that the class would generate GIF images based on photographs taken of their gestures as they executed each of the three positions of the sprint start. Children had to contribute to the creation of the moving images: their photographs were taken as they executed the gestures, breaking them down it into different steps. They then had to look at themselves on a screen (usually a tablet) in order to adjust their gestures after rendering of the GIF. In both situations, the students first took a diagnostic test (the pretest), and a final summative test (the posttest) at the end of the lesson (which went on for 4 sessions). This then allows us to assess the progress of the scores of each learner, taking into consideration the delta.

Figure 3. The experimental protocol.



The assessment criteria were decided collectively during one session of the Master-level course, in order to neutralize the bias of a differentiated evaluation criteria. As shown in Table 3, the assessment criteria were split into three categories corresponding to the breakdown of the sprint start gestures, where step 1 is “Ready”, step 2 is “Set” and step 3 is “Go”. The students, along with the researcher, decided to attribute 3 or 4 precise criteria to each step. As granularity is an issue for a reliable and consistent evaluation (Faulkner et al. 2014), we used a fine-grained assessment method (Cunningham and Coy, 2014). Each criteria was assessed out of 1, for a total of 10 points. The goal was to calculate, at the end of the last assessment, the difference of scores between pretest and posttest for the subjects of each groups.

Table 3. Assessment table for the task: "running race start", for both pretest and posttest

			Student 1	**Student 2**	**Student 3**	**Student n**
Step 1	Ready	Body position				
		Limit-line respect				
		Take-off foot				
Step 2	Set	Body position				
		Straight arms				
		Horizontal vision				
Step 3	Go	Body position				
		Reflex				
		Rule respect				
		Push				
		Total	/10	/10	/10	/10

After the last assessment, each pre-service teacher conducted a 20-minute focus group session with their experimental group, in order to retrieve qualitative information about the action research. A comprehensive approach is necessary (Asher, 1996) in order to better understand and interpret the quantitative results. Focus groups are a direct method of obtaining rich information within a social context (Robinson, 1999). The main questions asked were:

1. "What did you think of the photo session?", in order to verify Leser et al.'s 2011 study on the positive attitude towards and the incentive to use multimedia learning materials in sports.
2. "Did you feel it helped you reach the objective?", in order to link the children's vocabulary to Bandura's self-efficacy theory (Bandura, 1977).
3. "Did it change the way you look at your physical gestures?", in order to verify Erbaugh's study according to which motricity tasks that are followed by visual feedback through a video recording help the learner to subsequently correct his movement (Erbaugh, 1985). We also wanted to collect verbal data on the learners' perceived affordance (Gibson, 1977) of their own bodies.
4. "What would you think of using the same method for other sports moves?", in order to verify whether the GIF animation can act as a cognitive tool (Norman, 1993) for further use in other sports.

As shown in Figure 4, the GIF images created were animations that showed the body movements during the running race start through three discrete steps. The shots were cut together to produce a short animation, instead of making a one-shot video. Thus, each shot/step appears for a few seconds on screen, with crossfades as transitions.

Figure 4. An example of the pictures of the three sprinting start steps that have been used to co-create the GIF animation.

Step 1 : Ready	Step 2 : Set	Step 3 : Go

The teachers double-checked that the learners executed each of the three moves correctly, and took a picture of each step. The children immediately applied the model after observation. The successive steps helped them understand the process of a body movement, the idea being that each gesture plays an important role in the proper execution of the whole movement. The teachers used an online program (giphy.com©) to generate each GIF animations using the three pictures of the sprint start steps. The pupils were thus able to take a critical look at their own bodies, and modify their movements according to the teachers' instructions in order to make them correspond to the photographed steps. Afterwards, each learner compared the subjective vision of his/her own body with the animated version. Bandura (1977) proposes that auto-observation, or visual feedback, is an important part of the process of understanding a model because the learner uses it to correct his/her movements. In our set-up, the learner participated in the co-construction of the pedagogical tool (the GIF image) used for learning.

Results

Multivariate tests

We first examined the global variations of means of both experimental and control groups.

Table 4. Mean and standard deviation of the scores (/10) by learning setting and test.

Learning setting	With teacher demonstration and animated GIF		With teacher demonstration and classic exercises	
	M	SD	*M*	SD
Pretest	6.2	1.20	6.2	1.10
Posttest	7.4	1.30	6.9	1.10

Table 4 shows that the mean of the subjects in the experimental group goes from M = 6.2 (SD = 1.2) at the pretest to M = 7.4 (SD = 1.3) at the posttest. As for the control group, the mean goes from M = 6.2 (SD = 1.1) at the pretest to M = 6.9 (SD = 1.1) only at the posttest. The overall average score of the group that used animated pictures increased more than the score of the group that used classic demonstration. We conducted multivariate tests (table 5) in order to verify if significant differences were observed between the different classes, which could have constituted a bias. The aim was to verify if there was a class effect, but also a group effect (experimental or control) on the students' scores.

Table 5. Multivariate tests

Effect		Value	F	df	error df	Sig.
Class	Wilks' test	0.0	120.0	6.0	1.0	0.70
Group	Wilks' test	0.4	9.1	1.0	5.0	0.30

There is a significant effect between experimental and control group when considered jointly on the variables pretest and posttest scores, Wilk's Lambda = .40, F(1,5) = 9.1, p = .030. There is no significant effect between the classes when considered jointly on the variables pretest and posttest scores, Wilk's Lambda = 0.0, F(6,1) = 120, p = .070. We conclude that there is no class effect. In other words, disparities in levels between students of different classes do not constitute bias. A repeated measures ANOVA was conducted in order compares the delta between pretest and posttest scores subject by subject (table 6).

Table 6. Repeated measures ANOVA within-subjects and between-subjects.

Effect		Value	F	df	error df	Sig.	Partial Eta Squared
Score	**Wilks' test**	.634	90.6	1.0	156	.000	.377
Score*Group	**Wilks' test**	.974	4.16	1.0	156	.043	.026

The results of the ANOVA indicated that both scores of the experimental and control group increase significantly between pretest and posttest (within-subjects): Wilk's Lamba = 634, F(1, 156) = 90.6, $p < .001$, $\eta^2_p = .377$ (table 6). Which means that 37.7% of the total variance of the scores can be attributed to the learning setting in general. *Thus, in both control and experimental groups, the learning sessions had a significant effect on the scores of the students*. The results also showed an interaction effect between group and score (between-subjects): Wilk's Lamba = .974, F(1,156) = 4.16, $p = .043$, $\eta^2_p = .026$, which shows that 2.6% of the total variance of the test scores can be accounted for by group membership. *Thus, the difference of scores between experimental and control groups is significantly related to the learning setting.*

ANOVA test between delta and group

Table 7 shows the progress of scores between the diagnostic test and the summative test for both groups:

Table 7. Mean and standard deviation of Δ by presentation format.

Learning setting	**With visual explanation and animated GIF**		**With visual explanation and classic exercises**	
	M	SD	*M*	**SD**
Δ (posttest – pretest)	1.20	1.50	.8	1.0

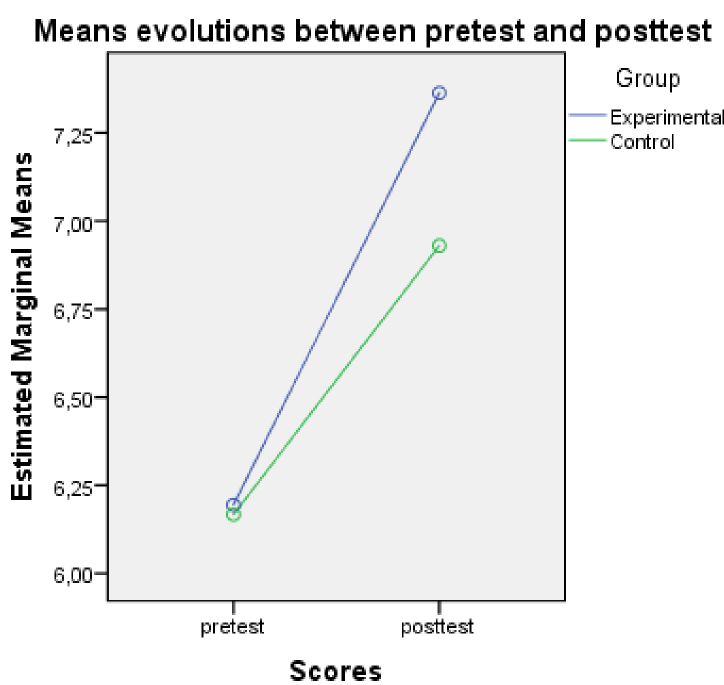
The Δ, between pretest and posttest, of the experimental group (M = 1.2, SD = 1.5) is higher than the Δ of the control group (M = .80, SD = 1) (Table 5). Table 8 shows the one-way ANOVA between the Δ and the groups:

Table 8. One-way ANOVA between Δ and group.

	SS	**df**	**MSE**	**F**	**Sig.**	**Eta squared**
Between-groups	6.5	1	6.5	4.2	.043	.026
Within-groups	243.3	156	1.6			
Total	249.8	157				

Table 8 shows that the one-way ANOVA performed between the Δ and the groups revealed a significant difference according to the group, with a limited effect, F (1, 6.5) = 4.2, MSE = 6.5, *p* = .043, η2 = .026. This indicates that 2.6% of the variance of the within-groups Δ is explained by the learning setting. We thus conclude that there is a significant effect between the evolution of the scores from pretest to posttest and the group, *the scores being significantly higher for the experimental group*, as illustrated in Figure 5. We therefore reject the null hypothesis.

Figure 5. Means evolutions between pretest and posttest.



Qualitative results: the focus groups

Each pre-service teacher conducted focus group sessions with their experimental groups (N=76) in order to understand what kind of effect the integration of the GIF animations had on the teaching sessions. Six semi-structured group interview processes of 20 minutes took place (one interview per

experimental class) after the last assessment (or at the beginning of the next course, in certain cases). This data collection method allows us to develop and understand complex concepts beyond the vocabulary abilities of children (Wetton and McWhirter, 1998).
Answers to question 1: "What did you think of the photo session?"

The students had very positive global feedback concerning the set-up of a photo shoot during the first sessions of the activity. This confirms Leser et al.'s 2011 findings on multimedia in sports courses. The photo shoot certainly was something very new and surprising to them. This surprise effect led them to fully cooperate during the shooting session. The teachers often observed solidarity between the learners during the implementation of an unusual learning setting, as they helped each other perform the right movements and gestures in order to take the photo.

Answers to question 2: "Did you feel it helped you reach the objective?"

Several teachers heard their learners say: "repeatedly seeing the same movement made me memorize and understand better". Integrating a looping video of their own gestures helped them see their mistakes (which, in turn, helped them correct them), and better comprehend the body mechanics, and how the body works as a system. The self-efficacy (Bandura, 1977) expressed in their own language helped them achieve better learning.

Answers to question 3: "Did it change the way you look at your physical gestures?"

Looking at their body changed their perception of their own gestures (body affordances), which made it easier for them to correct their movements. They also found it fun to look at themselves. This could be explained by the fact that they are more used to being photographed (or to photographing themselves) outside of school than during class hour and for an educational purpose. Two learners were also surprised to learn that pictures can be used in a "serious way". The visual feedback (Erbaugh, 1985) helped them understand the affordance (Gibson, 1977) of their body and gestures. The "supplantation" effect (Salomon, 1983) led them to consider the information conveyed by the cognitive tool (Norman, 1993) as carrying meaning. They could also better see the mistakes of their friends: the teachers witnessed more collaborative work and socialization among the learners.

Answers to question 4: "What would you think of using the same method for other sports moves?"

Many asked why they couldn't use the same method in other sports courses. They realized the method used had a positive effect on their motivation to engage in learning, and on the atmosphere of the learning session as a whole. From these sessions, they were able to generalize the use of the cognitive tool (Norman, 1993) to other pedagogical purposes.

We can conclude that integrating photo sessions and GIF animations added motivation and generated positive attitudes, both towards the use of technology in education and the movement learned itself. The same question was often asked: "why don't we also use this method in other disciplines?".

Discussion

Supporting our hypothesis, the learners of the experimental group performed better than those of the control group. The animated micro-sequences enabled students – all novices at the beginning of the experiment – to significantly improve their physical performance. The result is consistent with prior research that compared learning motor skills with digital tools and without (Farrow and Abernethy, 2002; Fadde, 2006; Milazzo and Fournier, 2015; Hisao and Chen, 2016; Broadbent et al., 2017). Taking into account the fact that the way information is presented influences understanding (Norman, 1993), we could then argue that the animated GIF acts as a cognitive artifact. *Thus, the animated representation of the "body" object suggests a new logical function: the learner then perceives unseen affordances of his/her own body (new possibilities of actions and movements).* Our experiment made it possible to demonstrate that bodily affordances can be addressed through cognitive artifacts modeling gestures and physical postures, with those postures being represented through successive discrete steps. Short animated images were used to carry out sports actions, after having been co-created by the teachers and the learners and then used as a pedagogical tool for learning. The explanation we propose is the following: GIF animation, through schematic modeling, breaks down the body movement into several discrete microsteps, which makes the learning objective easier to understand. Tversky et al. (2002) recommend that educational animations only depict changes that match the learning objectives and not provide extra information (such as sounds, etc.). Animations in GIF format focus on one single learning objective, which is solely centered on the motor skill to be acquired. In addition, our findings match the levels 3 and 4 of the active mode of learning engagement of the Chi and Wylie (2014) ICAP framework: construction and interactivity. Indeed, the students were involved in the creation of the learning tool, which paved the way to interactions and discussions about the task, as they compared similarities and differences. On the other hand, in the conventional method, the children were active but only repeating and rehearsing the physical task as shown by the teacher. The loop mode, through infinite repetition, also allows information to be integrated by association between the signifier and the signified, between the objects of reality and their representation. The role of repetition in associative learning was put forward in 1956 by Irvin Rock, who stated that repetition reinforces the associations once made (Rock, 1956). The GIF image would then play an interesting role in the consideration of mental imagery, as an essential element in learning by association and memorizing information (Paivo, 1969). Finally, we also argue that self-animation triggered the mirroring capacity of the students' motor system, leading to learning by self-observation and imitation (Molenberghs et al., 2009).
For Bandura (1977), modeling plays an important role in the process of constructing a cognitive representation of a behavioral "pattern" from observation. The learner uses his/her representation of movement as a basis for future performance. The co-creation of the animated sequences motivated the students.

Motivation is an important factor in the motor learning process, along with retention and reproduction of gestures (Erbaugh, 1985). Statistical analyses showed better test results for the group that used the GIF than the conventional group, as the averages were higher for the experimental than the control group (respectively M = 1.20; M = .80). For this experiment, we used animations made of fine-grained, discrete microsteps to emphasize the division of movements. This enabled better learning, through better memorization of the chronology of gestures, as well as a better understanding of the body layout. The experiments were conducted in situ, with tests scores being taken into consideration for the official assessment of the learners. The use of this image format in pedagogical situation highlights the importance of pedagogical principles that are usually treated separately: affordances, learning by imitation and repetition, and the strengthening of associations. This cognitive artifact has thus the particularity to act as a common building block of pedagogical techniques. For further research, it is still necessary to investigate the role of the cognitive load in such an experimental setting.

REFERENCES

Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., & Pintrich, P. R. (2001). A taxonomy for learning and Teaching.

Asher, J. J. (1977). *Learning Another Language through Actions: The Complete Teacher's Guidebook*.

Bandura, A. (1977). Self-efficacy: toward a unifying theory of behavioral change. *Psychological review, 84(2)*, 191.

Berney, S., & Bétrancourt, M. (2016). Does animation enhance learning? A meta-analysis. *Computers & Education, 101*, 150-167.

Broadbent, D. P., Ford, P. R., O'Hara, D. A., Williams, A. M., & Causer, J. (2017). The effect of a sequential structure of practice for the training of perceptual-cognitive skills in tennis. *PloS one, 12(3)*, e0174311.

Castro-Alonso, J. C., Ayres, P., & Paas, F. (2016). Comparing apples and oranges? A critical look at research on learning from statics versus animations. *Computers & Education, 102*, 234-243.

Chi M. & Wylie R. (2014) The ICAP Framework: Linking Cognitive Engagement to Active Learning Outcomes, *Educational Psychologist, 49:4*, 219-243.

Compte, C., & Daugeron, D. (2008). Une utilisation sémio-pragmatique de l'image animée cinématographique et télévisuelle pour l'apprentissage des langues. Eléments pour un plaidoyer. *Pratiques langagières dans le cinéma francophone*, (12).

Cunningham, C., & Coy, N. (2014). Understanding the need for fine-grained assessment. *Australian Educational Leader, 36(3)*, 6.

Cuny X., Boyer M. (1983). Analyse sémiologique et apprentissage des outils signes : l'apprentissage du schéma d'électricité, in *Communications : Apprendre des Médias. N°33*, Le Seuil, Paris. 103-142.

Erbaugh S. (1985) Role Of Visual Feedback In Observational Motor Learning Of Primary-Grade Children. *Perceptual And Motor Skills: Volume 60*, Pp. 755-762.

Fadde, P. J. (2006). Interactive video training of perceptual decision-making in the sport of baseball. *Technology, Instruction, Cognition and Learning, 4(3)*, 265-285.

Farrow, D., & Abernethy, B. (2002). Can anticipatory skills be learned through implicit video based perceptual training? *Journal of Sports Sciences, 20(6)*, 471-485.

Falkner, N., Vivian, R., Piper, D., & Falkner, K. (2014). Increasing the effectiveness of automated assessment by increasing marking granularity and feedback units. In *Proceedings of the 45th ACM technical symposium on Computer science education* (pp. 9-14). ACM.

Gibson, J. J. (1977). Perceiving, acting, and knowing: Toward an ecological psychology. *The Theory of Affordances*, 67-82.

Hegarty M., Mental animation: Inferring motion from static displays of mechanical systems, *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 1992, p.1084-1102.

Höffler, T. N., & Leutner, D. (2007). Instructional animation versus static pictures: A meta-analysis. *Learning and instruction, 17(6)*, 722-738.

Hsiao, H. S., & Chen, J. C. (2016). Using a gesture interactive game-based learning approach to improve preschool children's learning performance and motor skills. *Computers & Education, 95*, 151-162.

Jablonka I., « La décomposition du mouvement », Histoire par l'image [online], URL : http://www.histoire-image.org/etudes/decomposition-mouvement?i=454&d=1&m=chronophotographie

Khacharem, A., Zoudji, B., Spanjers, I. A., & Kalyuga, S. (2014). Improving learning from animated soccer scenes: Evidence for the expertise reversal effect. *Computers in Human Behavior, 35*, 339-349.

Leser, R., Baca, A., & Uhlig, J. (2011). Effectiveness of multimedia-supported education in practical sports courses. *Journal of sports science & medicine, 10(1)*, 184.

Memon, N., & Rodila, R. (1997). Transcoding GIF images to JPEG-LS. *IEEE Transactions on Consumer Electronics, 43(3)*, 423–429.

Metzler, M. (2017). *Instructional models in physical education*. Taylor & Francis.

Milazzo, N., & Fournier, J. (2015). Effect of individual implicit video-based perceptual training program on high-skilled karatekas' decision making. Movement & Sport Sciences, (2), 13-19.

Norman, D.A. (1993). *Things that make us smart. Defending human attributes in the age of the machine*. New York: Addison-Wesley.

Paivo A. (1969). Mental imagery in associative learning and memory. *Psychological Review, 76, n°3*, 241-263.

Peterson, M. P. (1999). Active legends for interactive cartographic animation. *International Journal of Geographical Information Science*, 13(4), 375-383.

Robinson, N. (1999). The use of focus group methodology—with selected examples from sexual health research. *Journal of advanced nursing, 29(4)*, 905-913.

Robinson, L. E., Palmer, K. K., Irwin, J. M., Webster, E. K., Dennis, A. L., Brock, S. J., & Rudisill, M. E. (2015). The use of multimedia demonstration on the test of gross motor development–second edition: Performance and participant preference. *Journal of Motor Learning and Development, 3(2)*, 110-122.

Rock I. (1957). The role of repetition in associative learning. *American Journal of Psychology, 70, 2*, 186-193.

Salomon, G. (1979). Media and symbol systems as related to cognition and learning. Journal of Educational Psychology, 71(2), 131.

Tversky, B., Morrison, J. B., & Betrancourt, M. (2002). Animation: can it facilitate? I*nternational journal of human-computer studies, 57(4*), 247-262.

Vernadakis N., Antoniou P., Zetou E., Kioumourtzoglou E. (2004) Comparison of three different instructional methods on teaching the skill of shooting in basketball. *Journal of Human Movement Studies 46*, 421-440

Vernadakis, N., Avgerinos, A., Zetou, E., Giannousi, M., & Kioumourtzoglou, E. (2006). Comparison of multimedia computer assisted instruction, traditional instruction and combined instruction on learning the skill of long jump. *International Journal of Computer Science in Sport, 5(1)*, 17-32.

Vernadakis, N., Zetou, E., Tsitskari, E., Giannousi, M., & Kioumourtzoglou, E. (2008). Student attitude and learning outcomes of multimedia computer-assisted versus traditional instruction in basketball. *Education and Information Technologies, 13(3)*, 167-183.

Wetton, N. M., & McWhirter, J. (1998). Images and curriculum development in health education. *Image-based research: A sourcebook for qualitative researchers*, 263-283.

Wiksten, D. L., Spanjer, J., & LaMaster, K. (2002). Effective use of multimedia technology in athletic training education. *Journal of athletic training, 37(4)*, 213-219.