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The role of material objects in knowledge construction in intervention: Towards an ecological approach in physical education teaching

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Abstract

This study aims to analyze the affordances of learning environments in the construction of knowledge in physical education (PE) at the middle school level. To achieve this, we used key postulates from Theureau's (2006) theoretical framework for course-of-action analysis. This theory allowed us to interpret the results of this research on the importance of affordances in PE lessons. These results showed that the way PE teachers set up the learning environment does not always allow students to detect appropriate affordances, particularly in hurdles in 8th grade. It is the PE teacher's responsibility to organize their learning environment in a way that enables students to detect appropriate affordances in learning activities.

Keywords: Physical Objects; PE; Ecology; Learning Environment; Affordance

1. Introduction

Affordance refers to the actionable properties of the environment as perceived by an individual according to their abilities (Gibson, 1977). It reflects the capacity, in both humans and animals, to orient their behavior based on the possibilities for action offered by the environment. In physical education and sports (PES), this concept is of particular importance, insofar as learning relies heavily on the construction of a didactic environment mediated by material objects. Numerous studies have highlighted the close links between learning and the environment (Adé & de Saint Georges, 2010; Brown, Collins & Duguid, 1989; Lave, 1988), notably emphasizing the permeability between cognitive processes and the material characteristics of learning situations (Brassac, 2004; Fillietaz, 2008). Long overlooked in research, the role of objects is nevertheless central: they support action, guide attention, facilitate certain cognitive operations, and contribute to knowledge construction, skills development, and the collective organization of activities, particularly in physical education (PE) interventions aimed at learning (Adé, 2016).

In the field of PE, the learning of motor skills has long been explained primarily by the cognitive approach, which defines it as an optimization of information processing and a reduction of motor variability through the reproduction of an ideal movement (Schmidt, 1988; Temprado, 1997). However, the ecological approach offers an alternative conception, according to which learning corresponds to an education of attention that allows the individual to detect the relevant affordances of the environment (Gibson, 1996; Fowler & Turvey, 1978). The student then perceives their environment in terms of possible actions, tailored to their physical and motor characteristics and their level of expertise (Turvey, 1992). From this perspective, what is learned is not a generalized motor program, but a control law linking perceived information to the action produced (Warren, 1988). This approach emphasizes the ability to adapt action to the changing constraints of the environment, the task, and the student. In the context of secondary schools in Porto-Novo, Benin, where physical education teachers construct their lesson spaces daily from available materials, the organization

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of the environment thus appears crucial for the quality of learning. However, an inappropriate design of this environment by the teacher can limit students' ability to detect relevant affordances, justifying the interest and relevance of this investigation.

Study Objective

In general, this research aims to analyze the affordances of learning environments during physical education (PE) lessons at the Zounkpa CEG (General Education College). More specifically, the first part will describe, from an ecological and comparative perspective, how an affordant learning environment can address the difficulties faced by students in hurdles during 8th grade (4ème). The second part will demonstrate that students' ability to detect affordances when faced with difficulties depends on the learning environment provided by the PE teacher.

This article is organized into four sections. In addition to the introductory note, the first section presents the objective and theoretical framework of the study. The second section addresses the research problem and questions. The methodology constitutes the core of the third section. The results of this article are presented in the fourth section. Finally, a concluding note will complete this work.

2. State of the problem, research questions and hypotheses

2.1. State of the problem

Numerous studies in educational sciences and didactics have analyzed the role and status of material objects in the teaching and learning environment (Adé, Sève & Ria, 2006; Gibson & Grinelly, 2001; Doyle, 1977, 1986). This research is largely situated within an ecological approach, according to which cognitive processes are closely linked to the characteristics of the environment, of which material objects constitute an essential component (Brassac, 2004; Fillietaz, 2008). From this perspective, the course-of-action theory (Theureau, 2004, 2006), used in this contribution, proposes a conception of activity based in particular on two central postulates: enaction and pre-reflective consciousness. These postulates allow us to understand human activity as a dynamic inseparable from the interactions between actors and the material elements of their environment. Within this theoretical framework, this article aims to examine the relationships between the material objects that constitute the learning environment and collective activity in physical education (PE) classes, understood as the joint activity of the teacher and students. The analysis focuses more specifically on the teaching of hurdles in the eighth grade. It draws on the contributions of the course-of-action research program (Saury et al., 2013; Theureau, 2004, 2006) to analyze the role played by artifacts of the learning environment in the construction of knowledge in PE. Furthermore, the implementation of effective teaching and learning approaches in PE depends on specific material and infrastructural conditions. Several authors emphasize that the quality of learning depends largely on the resources available and the opportunities offered by the learning environment (Greeno, 1998). This requirement involves not only the teacher's ability to design an affordable learning environment, but also influences how students construct knowledge during learning situations. However, in some secondary schools, physical education (PE) instruction is hampered by a lack, or even a complete absence, of teaching materials and sports facilities. This situation acutely raises the question of the status and role of material objects in teaching and learning. The case of the Zounkpa CEG (General Education College) illustrates this problem: despite a challenging physical environment, sports facilities have been put in place, but their nature, their suitability for the content being taught, and their role in the activities of the participants raise questions. In light of the postulates of the course-of-action theory, which emphasizes the dynamic interaction between the material objects of the didactic environment and the content of knowledge, the following central question arises:

2.2. Research questions

Does the implementation of the learning environment by physical education teachers always allow students to detect adequate affordances during the learning process?

2.3. Central Hypothesis

The implementation of the learning environment by physical education teachers does not always allow students to detect adequate affordances during the learning process.

3. Methodological Approach

3.1. Choice of study framework and survey population

To analyze the affordances of learning environments during physical education and sports (PE) learning, a cross-sectional qualitative case study was conducted. This approach was based on the observation of PE teachers with contrasting levels of professional experience. The observations were made during hurdle racing teaching sessions in fourth grade, at the General Education College (CEG) of Zounkpa, located in the department of Ouémé.

3.2. Sampling and study subjects

Sampling is an essential step in scientific research, as it allows for the collection of relevant data without surveying the entire population (Erard, 2015). This study used purposive non-probability sampling, suitable for exploratory research. This led us to select two certified physical education teachers, both working at the Zounkpa CEG (General Education College) located in the Ouémé department.

Table 1 Summary of teacher status and class of instruction

Physical education teachers	Status	Professional experiences	Classes
E1	Certified Teacher	7 years	Third form [A]
E2	Certified Teacher	5 years	Third form [C]

3.3. Data collection techniques and tools

Two data collection techniques were used: documentary research and instrumented observation.

The documentary research allowed us to conduct a state-of-the-art review on the role of artifacts in knowledge construction in general. The various pieces of information collected on the implementation of SA1 in 8th grade were also effective. Thanks to this technique, the content taught in the hurdles exercise was identified. The instrumented observation included a pre-session interview, the observation itself, and an interview. The pre-session interview, conducted at the beginning of the session, aimed to clarify the teachers' didactic intentions, the tasks to be proposed to the students, the knowledge to be taught, and the learning environment used.

The session observation was carried out using an Android phone to assess whether the teachers' objectives were actually being met. Two sessions were filmed at each teacher's home, for a total of four filmed sessions. A post-session interview was conducted at the end of each filmed session to determine if the objectives were met and what difficulties were encountered with the use of the materials.

3.4. Data collection procedure

This consisted of:

- Collecting teachers' schedules to determine the days and times of their classes;
- Developing and validating interview guides;
- Identifying teachers with a year 9 class;
- Filming two hurdles training sessions and conducting pre- and post-session interviews with each teacher;
- Recording their comments using a voice recorder;

3.5. Data processing

This was carried out in several stages. The first stage was dedicated to writing up the film transcripts to create session synopses. The second stage involved the qualitative analysis of the data collected through interviews and audiovisual recordings. Cross-referencing the interviews with the teaching activities generated during the sessions highlighted the role played by the mediated learning environment and the material objects used in the learning process.

4. Results and Discussion

The results are presented in tables, followed by an analysis of the data from the observation of the learning sessions, according to the following plan:

- Presentation and analysis of the content of the hurdles course in 8th grade;
- Presentation, analysis, and interpretation of the results from the interviews and the observation of the hurdles teaching/learning sessions;
- Comparative analysis of the teaching practices of the two teachers, e1 and e2.

4.1. Presentation and analysis of the content for hurdles in 8th grade

With reference to the documents, program and guide for hurdles in 8th grade, the planned content in terms of knowledge and technique according to the APC (Personalized Learning Approach) is summarized in the table below:

Table 2 Summary of information relating to the hurdles race in 4th grade

Techniques	Knowledge	Learning objective	Learning activities	Equipment planned
Starting position on all fours; attacking the hurdle; clearing with the lead leg; clearing with the lead leg, knee high; clearing with the side leg parallel to the ground, pushing forward; the side leg passes to the side of the body; landing with the leg straight…	Quadrupedal start; finish; running altitude in extension; impulse; hurdle clearance; landing; velocity; hurdle attack; sprint; hurdle race pace and performance…	Clearing hurdles with your free leg straight and your torso forward: while walking; with short strides; and while running faster and faster. Clearing hurdles with your supporting leg bent and apart: while walking; with short strides; and while running fast.	AA1: Run clearing the hurdles AA2: Run consistently between the hurdles AA3: Complete the 60m hurdles in 13 seconds for boys and 16 seconds for girls	Ashes or lime, whistle or clapper, decameter, track prepared for hurdles, signs, board, observation grid, evaluation grid, stopwatch,

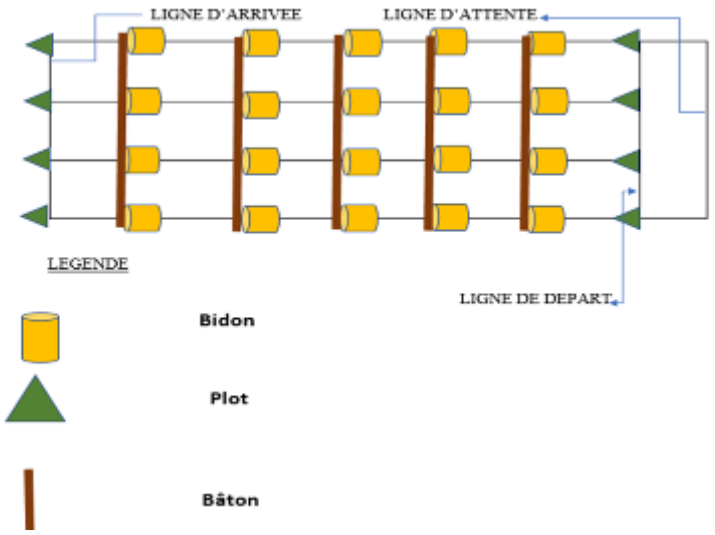
Sources: Guide and Curriculum in effect for 8th grade in Benin (2015)

Analysis of this table shows that the documents in the 8th grade hurdles curriculum, like all other individual disciplines, offer content that progressively guides students towards mastering their bodies and the physical environment through the development of their overall dynamics, agility, and physical expression.

4.2. Didactic Analysis of the First Session by Teachers

Tables 2 and 3 present the characteristics of the first session with the teachers. Analysis of this first session shows that it was dedicated to diagnostic assessment. The teachers' aim was to allow students to express themselves physically through a 60m hurdles race in order to identify their students' level of mastery of the activity, as well as the problems and difficulties they encountered in each phase of the hurdles race. Indeed, during the execution of this task, it was observed that some students, unlike others, started before the starting signal. The majority were unable to clear the hurdles in the inter-hurdle phase; not only did the students jump, but they also stepped on the hurdles. Furthermore, in the finishing phase, there was slowness in crossing the finish line and a failure to respect the lanes. All these observations demonstrate the students' shortcomings in hurdling. Approached at the end of the session through our questions drawn from the interview guide, teacher E1 stated that he was using various teaching methods to address the difficulties his students were experiencing, while teacher E2 said he would decide on the next session. This situation prompted us to focus our attention on the second session.

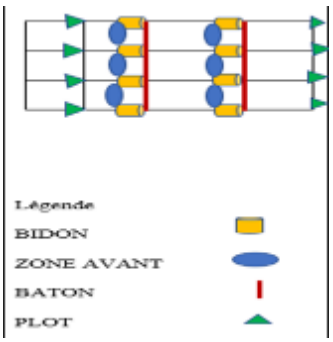
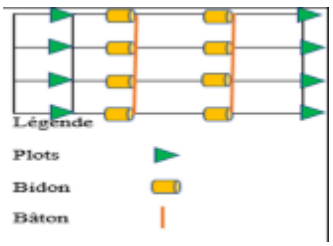
Table 3 Characteristics of the 1st session (Diagnostic assessment) by teachers

Teachers	Physical objects	Evaluation criteria	Educational environment
E1 et E2	Cans; Sticks; Stakes and lime	The student will be able to express physically their prerequisites for hurdles racing in a diagnostic assessment.	

Sources: Field data

4.3. Didactic analysis of the second session for teachers

Table 4 System implemented to correct the runner's reaction at the start and the hurdle clearance for teachers

E	Tasks	Instructions	Goals	Physical and human resources	Success indicators
E1	You are invited to jump over the hurdles as quickly as possible.	Cross the hedge from the marked area.	Prevent the student from jumping the hurdles.		The attack on the hurdle begins with the lead leg from the marked zone. The supporting leg is positioned in front of the marked zone of each hurdle.
E2	You are invited to jump over the hurdles as quickly as possible.	To clear hurdles at low heights by walking, striding and speeding.	Prevent the student from jumping the hurdles.		Ready: Lift your knee off the ground. Try: Gradually straighten up by walking, striding, and running after the sound of the clapper to clear the hurdle.

Sources: Field data

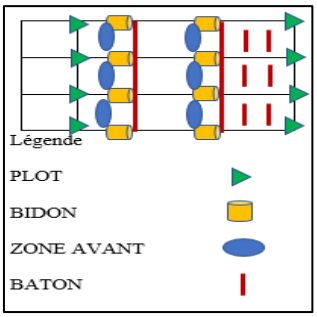
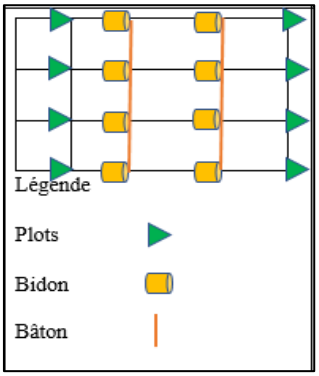
Table 4 presents the system implemented by teachers to correct the runner's reaction at the start and hurdle clearance. Analysis of this system reveals that the teachers felt that the use of green cones and lime marking the starting line helped students understand that placing their hands beyond this line was prohibited. In addition, students began running

before the audible signal of the starting gate, which signifies a false start. Regarding this issue, the students successfully avoided false starts. Thus, the affordance perceived by the students concerning problems related to the runner's reaction at the start was adequate. Regarding difficulties related to hurdle clearance, E1, to prevent students from jumping the hurdles by approaching them too closely, marked a zone before each hurdle using cones. In doing so, his students, during their training sessions, attacked the hurdles from the beginning of the zone, which allowed many students to clear them. However, regarding the difficulties related to clearing the hurdles, many students ultimately failed to clear them in class E2. Indeed, considering the first learning activity, E2 placed the containers horizontally, with sticks placed horizontally on top of them, in order to create a low hurdle. At one point, the students tried to clear the hurdles by walking, then by striding, and at speed. But when he returned the containers to the vertical position, his students were unable to clear the hurdles.

Furthermore, it was observed that some students slowed down after approaching the last hurdle, while others maintained the same speed acquired at the beginning of the run. This could be due to a problem related to running speed and stride length. Following this observation, the teachers implemented another learning activity. The proposed learning activity is as follows:

AAn°3: The student will learn to run as fast as possible after the last hurdle.

Tables 5 System implemented to improve running mechanics after the last hurdle for teachers

E	Tasks	Instructions	Goals	Physical and human resources	Success indicators
E1	You are invited to cross the finish line at full speed.	Run as fast as possible after the last hurdle.	Run as fast as possible after the last hurdle.		The student places their feet as far as possible between the poles, respecting their lane, to cross the finish line.
E2	You are invited to cross the finish line at full speed.	Run as fast as possible after the last hurdle.	Improve the speed and rhythm of stride length during running.		Maintaining the speed acquired to cross the finish line.

Sources: Field data

With the aim of working on acceleration, which is essentially about speed and stride length, teacher E1 believes that, based on his setup and instructions, students can change their movement patterns. Indeed, our observation shows that the horizontally placed poles, spaced 1 meter apart between the lanes, played a fundamental role in the students' behavior during the task. Thanks to these poles, students increased the distance and stride length by placing their feet as far as possible between them. This allowed them to correct both speed and stride length. The students found the solution themselves while performing the task. However, aside from his instructions, teacher E2 did not mention any changes to the environmental context that could lead his students to adopt a different movement pattern conducive to learning; consequently, his students did not improve. We can say that E1 guided students to identify the appropriate affordance for each difficulty through the organization of the proposed learning environment. However, each student

succeeded in the task according to their potential (height, weight, age, level of expertise, etc.). The ecological approach thus takes into account inter-individual variability. Short or tall, skilled or not, each student organizes themselves according to their own resources. We therefore realize that modifying contextual learning variables automatically modifies the behavior of the participants. On the other hand, in E2's case, no environmental constraints were imposed on the students' actions. The design of her learning environment was affordant but was not suited to the learning activity. The instructions alone were not sufficient to modify her students' motor behavior. We can say, as Kernolde & Carlton (1992) suggest, that the instructions generally used focus on how to perform the action. In other words, these so-called prescriptive instructions provide the student with guidance on how to perform a movement. The student imagines a movement without yet being aware of its kinesthetic requirements. By pushing them to focus on information that sometimes does not meet their mechanical needs, these instructions lead to the implementation of costly attentional processes that interfere with motor production (Temprado, Zanone, Monno, & Laurent, 1999).

4.4. Comparative Analysis of the Teaching Practices of Teachers E1 and E2

Considering the first session dedicated to diagnostic assessment, we observe that both teachers grasped the difficulties the students encountered while completing the assigned task. Based on this, both teachers referred to their institutional reports on Physical Activity during the second session to address their students' major problems. Thus, regarding the students' difficulties in initiating action before the auditory signal, we note that the use of cones and chalk lines enabled the students to understand that the starting line is a line not to be crossed before the auditory signal. In this respect, both teachers successfully guided their students to recognize the necessary affordance through the materials they implemented. However, the same cannot be said for solving problems related to hurdle clearance and acceleration, which boils down to speed and stride length after the last hurdle. Indeed, to prevent her students from deliberately avoiding jumping, E1 marked out a zone before each hurdle using cones and lime lines. Her students now approach each hurdle from the beginning of this marked zone, rather than near the hurdles as observed during the diagnostic assessment. Thus, the students, in their course of action, changed their motor skills to a more favorable learning style, and the majority were able to clear the hurdles. We can say that E1 guided her students to identify the appropriate affordance for each difficulty through the organization of the teaching environment she provided.

Furthermore, to address the problems related to acceleration after clearing the last hurdle, our analysis shows that the horizontally placed poles between the lanes played a fundamental role in the students' behavior during the task. Thanks to these poles, the students increased their stride length by placing their feet as far as possible between the spaces defined by the poles. This allowed them to correct both their speed and stride length. The students found the solution themselves through their motor skills and quickly crossed the finish line. By implementing this device, the teacher further guided the students to identify the appropriate affordance for the learning situation. This also demonstrates that the instruction given by E1 was consistent with the proposed teaching environment. However, regarding the same problem related to hurdling, E2, aside from the instruction to "cross the hurdle at a low height by walking, striding, and at speed," did not mark a zone before each hurdle as E1 had done. Consequently, the students did not feel compelled to approach the hurdle from a distance when the hurdles were placed vertically; they approached from very close, leading them to jump, just as they had on the day of the diagnostic assessment. Similarly, regarding the problem of acceleration after the last hurdle, no environmental constraints were imposed on their actions. The design of the learning environment was accessible but not suited to the learning activity. The instruction alone was insufficient to modify the students' motor skills. This is certainly why the objective of E2's session was not achieved. But E1, by modifying his teaching environment, triggered a new motor production in his students, which was conducive to achieving the objective of his lesson. We can clearly see from this that when the physical objects in the physical education lesson space are well organized by the teacher, an affordance emerges that can resolve the difficulties encountered in motor learning. It is in this sense that, far removed from scientific debates, practitioners who strive daily to make their lesson space intelligent by selecting, among other things, physical objects, have unknowingly established themselves as ecologists (Adé, 2016).

5. Conclusion

The investigations on the research topic "Affordances of Material Objects in Knowledge Construction in Physical Education: Towards an Ecological Approach in Physical Education Teaching" were conducted in 8th-grade classes at CEG ZOUNKPA. They highlighted the affordances of teaching environments in the construction of knowledge in physical education, specifically in hurdles. To analyze and interpret our results, we used the course-of-action theory of Theureu (2006). In line with this theoretical framework and the literature review, we employed a methodological approach based on pre-session interviews, direct observation, and post-session interviews. The results allowed us to verify and confirm our hypothesis that the implementation of the teaching environment by physical education teachers does not always allow students to detect adequate affordances during the learning process, particularly in hurdles.

Compliance with ethical standards

Disclosure of conflict of interest

All the authors acknowledge that there is no conflict of interest. They all agree with what is written in this article. In accordance with the requirements of transparency and scientific integrity, we, the authors of this study, declare that we have no conflict of interest, whether financial, commercial or otherwise, that could influence the results or interpretations of our research on initiation rites in Benin, thus guaranteeing the independence and objectivity of our work and ensuring the credibility of our conclusions

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