We can teach more than we can tell: combining Deliberate Practice, Embodied Cognition, and Multimodal Learning.

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Abstract
Acquisition and internalisation of many fundamental skills rely on repeated authentic practice and teachers providing support during practice. Despite this well accepted norms in skills acquisition, much of our assumptions about learning skills, mostly from a cognitive perspective, remain nebulous. Besides splitting hairs to classify skills acquisition into a paradigm, much of findings of related research from educational science and psychology have struggled to transfer into the domain of skills acquisition. Instead, in this paper, we propose to shift our view of skills acquisition from a cognitive approach to an embodied one with the help of multimodal technologies and provide a use-case which combines deliberate practice framework, embodied cognition principles, and multimodal learning.

Keywords
Multimodal learning, Deliberate Practice, Embodied Cognition, Badminton

1. Introduction

The maximum velocity of a badminton shuttle during a game is 493 km/h. The length of a badminton court is only 13.4m. Badminton players have only a fraction of a second to make judgements and react to the opponents' action. Yet, all professional players/experts are able to perform such a daunting task. How are they able to learn these seemingly impossible tasks? More importantly, how does a coach/trainer train such a skill to nurture an expert and how can technology enhanced learning environments be designed to train such a skill? As Aristotle, and perhaps John Dewey too, famously proclaimed, ”for the things we have to learn before we can do them, we learn by doing them”, insinuating that authentic practice is essential for learning a skill. However, without clearly understanding how one learns a skill, the instructional design around such a practice, is convoluted at best. In traditional/classical perspectives on cognition and learning, are often focused on the brain as the principal cognitive resource. However, there is an increasing number of studies that show that cognition is deeply rooted in bodily

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interaction with the environment [1]. As such, performance in complex skills often comprise of many dependencies which cannot be accounted by focusing solely on mental aspects. In the following, we propose a more encompassing view of *embodied cognition* for designing instructions for practice and how it can be integrated into the deliberate practice framework for expertise development.

2. Embodied cognition

Embodied cognition views that cognition is shaped in the process of interaction between the body and the environment [2] as learners are coupled with their environment through multiple recurring *perception action loops* [3]. All learning, regardless whether it concerns sports or mathematics, emerges through action [4]. In this context, an action is not a synonym for movement [5]. Actions are goal oriented and performed to solve a (motor) problem. As such, they can exist as sequences of movements that are related by meaning. An environment holds certain possibilities for action, known as *affordances* [6], that should be understood relative to the *body potentialities*[7] of a learner who is acting in the environment. The actions of an organism are not only determined by what is possible, but also by what is not, as properties of the environment, organism and task put *constraints* on the behaviour that emerges [8]. Following ecological dynamics [9], the constraints of an environment can be leveraged to help students discover new affordances and developing the ability to act accordingly. The design of a learning activity should be carefully tailored to the organismic constraints of the individual learner and provide a problem space that presents students with a need to perform the *to be learned* actions. Adding constraints to the learning activity during practice, and consequently, the accompanying environment, can help to develop new ways of interaction with the environment, which in turn, leads to learning of the skill.

3. Deliberate Practice Framework (DPF)

Deliberate practice framework (DPF) is a meta-framework that continues to inform discourse in skills development and coaching [10]. The term ”Deliberate Practice” was first coined by K. Anders Ericsson in 1993 [11], which he defined as a conscious, repeated, effortful & structured practice with the aim of achieving specific goals. Ericsson [11] argues that the level of expertise is proportional to the amount of deliberate practice in contrast to, simply, the amount of time invested in practice [12]. As a meta-framework, DPF defines key features of deliberate practice, along with responsibilities of the teacher, the student, and the environment in which the practice takes place [13]. In his DPF, Ericsson stresses the importance of a teacher for expertise development. The teacher-student relationship in DPF presumes an explicit form of learning, often by explicit instructions. However, other forms of learning, including implicit learning and learning via manipulation of environmental task constraints, suggests there may be mediating mechanisms that are less explicit [10]. Embodied cognition principles can provide new complementary non-explicit forms of instructions which a teacher can use to enhance deliberate practice within DPF. For example, instead of trying to explicate his/her tacit knowledge via verbal instructions, which is often very complicated if not impossible, the teacher can instead focus on modelling the interactions the student will have with the environment during authentic practice. Doing so can potentially provide the learner opportunities for constructing tacit knowledge via implicit learning, along with the benefits of DPF.

4. Multimodal Immersive Learning Systems(MILeS)

Incorporating embodied cognition principles into DPF requires the teacher and the student to be aware of the students' interaction with the environment. For example, in the context of aforementioned badminton case, one of the many things the teacher needs to be aware of, is the students knee position, i.e. whether the knees are slight bent to propel him/her to the direction of the shuttle. Multimodal immersive learning Systems (MILeS) enable tracking of such interaction between the student and the environment via all the necessary modalities, giving the teacher an authentic representation of the learning process and the context in which the learning occurs.Furthermore, MILeS provides finer control over the students interaction with the environment which allows for focusing on a particular action-perception loop directly associated with the learning objective. This enables the student and the teacher to focus on the important aspects of the task, which increases the likelihood of deliberate practice. Massaro [14] in his book ”Encyclopedia of the Sciences of Learning” defines Multimodal learning, an end result of MILeS, as an embodied learning situation which engages multiple sensory systems and action systems of the learner. As such, we believe, that multimodal learning cannot be isolated from embodied cognition. In the following section, we present our vision of a hypothetical multimodal learning design with deliberate practice and embodied cognition for repetitive practice of skills in the context of badminton.

5. Use cases

One of the fundamental skill to learn as a beginner player in badminton is to learn to do a *low serve*. This is a complex task which requires the player to, among many other things, correctly position the feet, hold the shuttle correctly with the non-dominant hand, co-ordinate the dominant hand holding the racket to make a timely swing at a correct angle and speed, and follow up with a defensive position. With DPF in mind, and assuming that the student is a novice, a teacher would begin training with a simple but fundamental exercise, perhaps holding the shuttle. To make the objective of the exercise clear, the teacher would demonstrate first, followed by a demonstration with explanations. As dictated by DPF, the teacher also provides Just-in-time feedback during and between practice repetitions on the performance. On the other hand, the student would then grip the racket with one hand, hold the shuttle with a another, get positioned, swing the racket with appropriate motion, let go of the shuttle in a timely manner, and hope the shuttle lands in the intend part of the opponents court. Obviously, a novice cannot execute this immediately with required accuracy due to the multitude of aforementioned dependencies. Young et al. [10]'s adaption of DPF as a meta-framework was motivated precisely due to this gap in DPF, i.e. the DPF doesn't define how instructional design in each individual practice task should be designed to help students navigate through the complexity of learning in authentic setting where mastery over multiple dependencies is required at any given time to execute a practice task. our proposal to combine DPF with MILeS & embodied cognition, makes an effort to address this short coming.

One of the ways in which the teacher can incorporate Embodied cognition in practice of *low serve* is to focus a specific *perception action loops.* Such as, the action of varying a shuttle's orientation during low serve to the perception/consequence of the flight path of the shuttle. However, as we stated above, the flight path of the shuttle varies not just on the orientation of the shuttle, but also on the momentum of the racket and its impact force, the angle at which the racket impacts the shuttle, the height at which the player holds the shuttle, the distance from the body/centre of mass from which the player holds the shuttle etc., all affect the flight path of the shuttle. Understandably, this is overwhelming for a student, and perhaps the teacher, to be aware of. This makes the prospect of being in a deliberate practice and integrating embodied cognition in practice, hard to achieve. DPF and embodied cognition can benefit from MILeS, as MILes enables finer control over the multitude of dependencies involved in a low serve. For example, a MILeS system can visualise an expected flight path based on the orientation of the shuttle and the angle of the racket, such that the student and the teacher need only to focus on the momentum of the racket. This feedback forms an *environmental constraint* for the student that steers them into new actions. Repeated practice of this action-perception loop, can help students internalise the relationship of a rackets momentum with the flight path of the shuttle and develop the *body potentiality* to control the momentum.

6. Conclusion

In this paper, we proposed to combine DPF, embodied cognition, and MILeS as complementary package for mastering/training skills. Embodied cognition and DPF, both dominant schools of thoughts in skills acquisitions, share many common facets such as the need to practice repeatedly in an authentic context and focus on successful execution of a skill in a context. MILeS affordances provide finer control over the dependencies of the environment with out violating the integrity of DPF, such as authentic practice, for example. Such finer control provides more possibilities for the teacher to embed embodied cognition into practice and for the student to be more conscious of the objective of practice, consequently, increasing the deliberateness of practice. Therefore, we argue that multimodal learning should evolve from cognitive school of thoughts and focus on embodiment of learning rather than trying to understand how multimodality can contribute to cognitive learning.

References

[1] A. D. Wilson, S. Golonka, Embodied cognition is not what you think it is, Frontiers in Psychology 4 (2013). URL: https://doi.org/10.3389/fpsyg.2013.00058. doi:`10.3389/fpsyg.2013.00058`.

[2] F. Zhao, Applying embodied cognition: Exploring a new college english teaching paradigm of open universities, Higher Education of Social Science 21 (2021) 31–36. URL: http://www.cscanada.net/index.php/hess/article/view/12340. doi:`10.3968/12340`.

[3] M. Turvey, Preliminaries to a theory of action with reference to vision, in: R. Shaw, J. Bransford (Eds.), Perceiving, Acting and Knowing Toward an Ecological Psychology, Wiley & Sons, 1977, pp. 211–265.

[4] D. Abrahamson, R. Lindgren, Embodiment and Embodied Design, Cambridge Handbooks in Psychology, 2 ed., Cambridge University Press, 2014, p. 358–376. doi:10.1017/CBO9781139519526.022.

[5] N. A. Bernstein, Dexterity and its development, volume 1, Psychology Press, 2015.

[6] J. J. Gibson, The ecological approach to visual perception: classic edition, Psychology press, 2014.

[7] A. Shvarts, R. Alberto, A. Bakker, M. Doorman, P. Drijvers, Embodied instrumentation in learning mathematics as the genesis of a body-artifact functional system, Educational Studies in Mathematics 107 (2021) 447–469.

[8] K. M. Newell, Change in movement and skill: Learning, retention, and transfer, Dexterity and its development (1996) 393–429.

[9] D. Abrahamson, R. Sánchez-García, Learning is moving in new ways: The ecological dynamics of mathematics education, Journal of the Learning Sciences 25 (2016) 203–239. doi:10.1080/10508406.2016.1143370.

[10] B. W. Young, D. W. Eccles, A. M. Williams, J. Baker, K. anders ericsson, deliberate practice, and sport: Contributions, collaborations, and controversies, Journal of Expertise 4 (2021) 169–189. URL: https://www.journalofexpertise.org/articles/volume4_issue2/JoE_4_2_Young_etal.html.

[11] K. A. Ericsson, R. T. Krampe, C. Tesch-Römer, The role of deliberate practice in the acquisition of expert performance., Psychological Review 100 (1993) 363–406. doi:10.1037/0033-295x.100.3.363.

[12] K. A. Ericsson, K. W. Harwell, Deliberate practice and proposed limits on the effects of practice on the acquisition of expert performance: Why the original definition matters and recommendations for future research, Frontiers in Psychology 10 (2019). URL: https://www.frontiersin.org/articles/10.3389/fpsyg.2019.02396. doi:10.3389/fpsyg.2019.02396.

[13] K. A. Ericsson, Given that the detailed original criteria for deliberate practice have not changed, could the understanding of this complex concept have improved over time? a response to macnamara and hambrick (2020), Psychological Research 85 (2021) 1114–1120. doi:10.1007/s00426-020-01368-3.

[14] D. W. Massaro, Multimodal learning, in: Encyclopedia of the Sciences of Learning, Springer US, 2012, pp. 2375–2378. doi:10.1007/978-1-4419-1428-6_273.