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eCRONY: hypothesis and experimentation of a new educational tool in motor skills teaching

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Abstract

The eCRONY project hypothesises the development and ongoing experimentation of a digital educational tool aimed at enhancing motor sciences teaching. Traditionally, motor skills education relies on demonstration and imitation, often limited to describing visible movements. This approach does not delve into biomechanical causes or proprioceptive sensations as primary learning tools, aspects typically left to practical internships. However, the growing adoption of digital technologies and distance learning highlights the need for an approach that integrates these elements to better support online students with limited guided practice.

eCRONY, structured in four progressive levels (proprioceptive exploration, biomechanical analysis, comparison of causes and effects, and simulation in the absence of terrestrial forces), aims to serve as a valuable educational supplement. The educational pathway promotes a deep understanding of movements, exploring causal forces and enhancing both sensory learning and autonomous feedback abilities. The proposed experimentation aims to assess the effectiveness of this innovative approach compared to traditional methods, hypothesising improvements in proprioceptive awareness, biomechanical understanding, and critical self-assessment abilities among students. If confirmed, the expected outcomes could position eCRONY as a valuable tool for a more scientific and accessible approach to motor skills teaching.

KEYWORDS: Didactics, Training, Motor Sciences, Proprioception, Biomechanics.

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1. Introduction

The teaching of more practical subjects, such as motor sciences, has traditionally followed an approach based on demonstration, imitation, and repetition, where students observe a movement and replicate it under the guidance of an instructor. Rooted in social learning theories (Bandura, 1977), this method has traditionally focused on visible movement correction. The adoption of digital technologies has broadened this perspective, providing tools that enhance movement analysis while limiting in-person correction (Porter et al., 2010; Dewi et al., 2020). Additionally, these tools have broadened knowledge regarding the visible effects of motor gestures, focusing on the forces acting in overt movement without delving into the internal forces that cause them (Andrews et al., 2016). Despite observing movement execution, students often lack access to the underlying biomechanical and proprioceptive mechanisms (Willis et al., 2021), an issue exacerbated in online learning environments. Currently, no tools directly support this learning, making it dependent on individual proprioceptive practice (Bernardi et al., 2015; Heald et al., 2018; Leite et al., 2019). Proprioception enables the identification, through sensation, of the muscles responsible for motor action. Supporting this concept, numerous studies today confirm the importance

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of a proprioceptive approach in developing movement understanding (Urgesi et al., 2006; Borner et al., 2023; Kurita et al., 2014). In this context, biomechanical studies also help shift students' attention towards the causes of movements (Proske & Gandevia, 2012; Toma & Lacquaniti, 2016). Schmidt and Lee (2019) demonstrated that effective motor learning requires access to information about causal forces. This is because the distribution of muscle contraction forces is not immediately visible; nonetheless, these forces ultimately determine the outcome of an action, thereby holding primary significance for those aiming to teach motor education (Dimitriou, 2016). The understanding of such internal force dynamics is still often limited to medical fields through the use of advanced tools like electromyography, whose data are generally not translated or made accessible within the motor education setting. This limits the integration of such information into university motor learning practices, delegating this step, as analysed, to the abilities of the individual or their instructor and keeping the teaching, particularly in online contexts, focused on effects and imitation (Aoyama & Kohno, 2020; Cho et al., 2022). These limitations highlight the need for a more integrated approach that addresses both proprioceptive awareness and biomechanical analysis, leading to the research question of this study. As Enoka (2015) pointed out, improving the quality of motor teaching might require going beyond imitative didactics and integrating teaching tools that enable students to understand the biomechanics of forces in action. Biomechanics provides students with the tools necessary to develop a deeper understanding of causal motor processes (Cos et al., 2013; Lieberman & Breazeal, 2007; Bogert et al., 2013; Stergiou, 2020). Further studies on optimising motor didactics highlight that biomechanics, where understood, enables the development of a more critical and generalisable approach in teaching (Wulf & Lewthwaite, 2016). With the changes brought about by new tools in this field, a targeted transmission of biomechanical concepts in support of causal learning could be of particular interest (Hebert et al., 1996). In this context, a new didactic methodology, Sincrony, is emerging as an innovative bridge between proprioceptive development and biomechanical analysis, offering an integrated approach that values both bodily perception and scientific exploration of movement. On the one hand, it focuses on the biomechanical study of muscle activation sequences that enable the gesture, as well as their interaction with physical forces such as gravity, mass, or acceleration (De Bernardi, 2008; Fogliata et al., 2022; Latash, 2008). On the other, it emphasises the importance of using proprioception as a fundamental tool for practical motor learning (Tezel et al., 2024). Supporting teaching, particularly online teaching, with a tool that integrates proprioceptive response to movement as a primary source of feedback could provide an interesting perspective to make this type of learning more effective (Johnson et al., 2023). This would represent a shift from a traditional 'know, demonstrate, imitate' approach to a more integrated model based on 'know, perceive through sensation, analyse (causes), demonstrate (effects), imitate' (Zhan et al., 2023). Such an approach, if used in implementing new learning tools, could naturally enable students to observe the full technical execution with an internal focus that is both physical (proprioceptive) and cognitive (causal biomechanics) (Schmidt & Wrisberg, 2008). It could also adapt well to distance learning, thanks to the use of specially created educational videos to help students better understand gestures and the forces at play (Lindberg et al., 2013; Souissi et al., 2021; Mirdamadi & Block, 2020; Batcho et al., 2016; Lin et al., 2022). These aspects were highlighted in the work of Hodges and Franks (2002), who found a direct correlation between increased focus in practical hours and the ability to analyse movement parameters, making them generalisable for teaching purposes. In broader terms, therefore, a didactic integration would be fully aligned with universities' objectives to train critical thinkers capable of analysing and solving complex problems not only as individuals but through repeatable paradigms (Syaputra & Warni, 2023). In light of what has been discussed, teaching motor skills, particularly in online settings, may require introducing new tools for causal learning based on proprioceptive stimulation and expanded biomechanical knowledge. As Knudson (2007) noted, an approach focused solely on the visible effects of movement (trajectories, angles, speed, and acceleration) is insufficient to develop a comprehensive understanding of motor dynamics since this understanding is itself influenced by the ability to relate to the sensation and/or experience of actual movement (Guilhem et al., 2014; Marchal-Crespo et al., 2014; Seidler et al., 2013). A tool that acts as an educational support in this sense could enhance teaching quality, offering greater learning opportunities even to students who do not primarily rely on visual channels (Syaputra & Warni, 2023). These models aim to gradually reduce errors through continuous correction linked to feedback on external feedback (Albert & Shadmehr, 2016; Drews et al., 2021; Tang et al., 2022). However, it is essential to recognise that each individual builds knowledge through a subjective process, often influenced by prior experiences or context; an approach based solely on external feedback may not be sufficient (Piaget, 1972; Vygotsky, 1978). Constructivist theory, in particular, has shown that learning is an active and personalised process, where each student interprets reality based on their own prior knowledge and individual perceptions. This implies that, in motor teaching, the same gesture may be interpreted differently by different individuals, leading to variations in understanding and correction (Bransford et al., 2000). The more educational strategies are varied and objective, the more effective the educational intervention may be in reducing such biases (Chiviacowsky, 2020). Another important factor in this context is selective attention: what a student focuses on determines what they perceive and, consequently, how they learn. Psychology has studied the concept of selective attention in detail, demonstrating how it can influence visual perception and the way we interpret the stimuli around us. Research on selective attention, such as studies on “change blindness,” shows that focused attention can narrow our field of vision, often causing us to miss significant changes in our environment. This suggests that if we rely solely on the visual channel as our approach, it may limit our ability to perceive and learn new elements, even at low speeds. In fields requiring the integration of complex information at high speeds and with multi-structural elements, such as learning motor skills, relying exclusively on selective attention based on a focused visual channel could reduce the breadth of perceived information, hindering comprehensive and dynamic learning (Simons & Chabris, 1999; Simons & Rensink, 2005). When applied to movement, this implies that two students observing the same movement may notice different aspects depending on their visual attentional focus, and, consequently, the feedback they receive may be interpreted differently (Martay et al., 2021). Furthermore, Heisenberg’s uncertainty principle, typically applied to physics, could be extended to motor learning, suggesting that the observation of a movement is influenced by subjective variables, such as the observer’s angle, knowledge, and cognitive biases. This makes it clear that movement correction based solely on external observation is not always sufficient (Lin et al., 2022). This research aims to investigate whether and how an integrated teaching approach, combining the development of proprioception with the analysis of biomechanical forces, can significantly enhance motor skills students’ understanding of movement. The objective is to determine whether this innovative methodology can offset the limitations of online learning, where guided practice and direct correction are reduced. Specifically, the study will explore whether the combination of proprioception and biomechanics can facilitate a deeper and more critical understanding of the causes of movement, compared to traditional teaching methods, which are primarily based on demonstration and imitation. The eCRONY project addresses the growing need to make motor skills education more accessible and flexible, particularly in online learning contexts or where in-person guidance is limited. By integrating proprioceptive feedback and biomechanical analysis, eCRONY supports a new mode of instruction that enables students to develop motor competencies autonomously, in a scientifically informed and replicable way, aligning with modern trends in educational mobility and online training.

2. Materials and Methods

This study follows a Design-Based Research (DBR) approach, in which the development of eCRONY must undergo a process of verification and empirical validation before reaching the pilot phase. Currently, the literature review phase has been completed. Through an analysis of academic programs from the top 20 Sport Science universities ranked in the Shanghai Ranking’s Global Ranking of Sport Science Schools and Departments 2024 (Shanghai Ranking Consultancy, 2024), the absence of similar didactic tools in current curricula has been confirmed. No existing tool combines proprioception, dynamics and kinematics like eCRONY. Additionally, with the support of theoretical physics experts, the scientific foundations of the biomechanical models to be used in the eCRONY system have been validated. The development of educational materials has reached an advanced stage, and eCRONY is now entering its pilot phase. At present, the first instructional videos are being finalized, marking the completion of the material development phase. In the next phase of the research, a pilot study will be conducted on a selected group of students to assess the effectiveness of eCRONY in motor learning, with a particular focus on the development of proprioception and biomechanical understanding. In light of the above, the development of eCRONY would be underway, an innovative educational tool designed to enable students to access content based on guided proprioceptive sensation stimulation, while simultaneously offering an in-depth understanding of movement biomechanics (Vandevoorde et al., 2022). eCRONY would be based on progressively complex levels, utilising supplementary supports such as motor diaries with meta-reflections, as well as a didactic pathway through specialised videos. These videos would integrate various levels of feedback to guide students in understanding lessons related to basic motor movements through practical and sensory comprehension. The videos would be structured around four explanatory levels and would focus on four fundamental movements: vertical jump, lateral shift, push-ups, and walking, common to manysports (Cowin et al., 2022; Bennet et al., 2006).

Structure of eCRONY levels

Each level includes pauses and structured questions to reinforce learning, allowing students to repeat tasks as needed.

Level One: exploration and proprioception

In this initial phase, the student would observe a simulation of one of the listed gestures, without specific indications of the muscles involved in the action. The observation would be designed to stimulate reflection on the causes behind the movement and to encourage proprioceptive stimulation. The level’s structure would thus invite the student to perform the movement, paying particular attention to the body parts engaged during the practice. Subsequently, through questions and specially-designed feedback quizzes, the student would be prompted to imagine which muscles caused the action and in what sequence. Following this, the student would be able to watch the same gesture videos but with coloured indications of the muscles in action and activation sequences. The primary objective would be to improve proprioceptive and kinaesthetic awareness, enhancing the student's ability to perceive and understand their body in action.

Level Two: biomechanical analysis of causes

In the second level, the student would be introduced to a detailed biomechanical description of the selected gestures previously performed in the first level. Through visual simulations, the causal dynamics of the movement would be highlighted. This level would also use vectors and muscle-anatomical explanations related to the gestures, along with questions, quizzes, and even segmented execution of the gesture to perceive and study each unit individually. The aim of this phase would be to guide the student towards an in-depth understanding of the biomechanical mechanisms underlying the gesture.

Level Three: comparison of gesture effects and causes for teaching purposes

In this phase, the student would be invited to compare the movement between its causes and the visible effects of the gesture in question. This process would be supported by two simulations of the same movement analysed from both perspectives. For example, in the walking gesture, one video would show an analysis of the visible effects (e.g., thigh lifting, foot rolling), while a second video would highlight the generating causes (e.g., gluteal contraction, forward torso shift). This level would aim to encourage the student to reason about the differences between causes and effects, and, based on this, form structured hypotheses on how to approach the teaching and correction of the gesture itself. Specific questions and quizzes at this level would evaluate the best teaching strategies based on different levels of difficulty. The student would determine whether it is better to explain by causes or effects. Additionally, the ability to "see" both aspects simultaneously would allow the student to compare their ideal execution with their actual performance.

Level Four: movements in "Vacuum" – Physical forces

The final level would offer the student a unique experience: observing how movement would manifest in a "vacuum" or, more accurately, in the absence of terrestrial forces. This simulation would allow the isolation of acting forces, would enhance the student's awareness of their influences. At this point, the biomechanical understanding acquired in previous levels would be further reinforced. Following this, explanations of the four planes of movement and teaching suggestions for improving the presentation and instruction of movement would be provided. This progressive approach would enable students to develop a profound and practical understanding of movements through a continuous cycle of exploration, analysis, comparison, and advanced application.

PILOT EXPERIMENT

For the pilot experiment, a group of 30-50 students enrolled in motor science courses would be selected, evenly distributed between in-person and online mode. Participants would be randomly divided into: Group 1, Experimental (eCRONY), with at least 15 students per mode (online and in-person), who would use the eCRONY system in their educational pathway; and Group 2, Control (traditional method), with at least 15 students per mode, followed using the conventional demonstration and imitation method. The experiment would unfold over four distinct periods.

Phase 1: Orientation and pre-test

This phase would include an introductory session where Group 1 students would receive a presentation on eCRONY, its objectives, level content, and self-reflection methodology via motor diaries. Group 2 students would attend a presentation but only covering the effect-based video explanations. Both groups would complete a preliminary biomechanics and proprioception knowledge questionnaire to assess the starting level. Their ability to execute key movements (vertical jump, lateral shift, push-ups, walking) would also be assessed with video recording on graded grids to evaluate initial motor control and quality, along with the Borg test. These data would serve as selection criteria and as a baseline for later comparisons.

Phase 2: Intervention

Group 1 students would view the complete course supported by eCRONY, including simulations and detailed explanations of biomechanical dynamics and proprioceptive perception across all four levels. Group 2 (Traditional Method) students would follow only the explanatory videos focusing on the visible effects of movements, with no references to internal dynamics or proprioceptive perception elements. Both groups would have the same allotted time to complete this phase, determined by the experimenters based on learning statistics, thus ensuring a standardised educational process between online and in-person modes.

Phase 3: Re-test and questionnaires

Data would be collected post-intervention for comparison with the baseline results. Additionally, qualitative questionnaires would be administered to assess the overall educational experience.

Phase 4: Control Group access to eCRONY

The control group would subsequently have access to all eCRONY course content, following the same standardised learning timeframes. A final comprehensive evaluation, both qualitative and quantitative, would be conducted at the end of the learning pathway. Since the study is still in the developmental phase, the empirical results will be analyzed in subsequent stages and presented in future research.

3. The Expected Results

In light of the methodological premises and experimental framework, the adoption of eCRONY in physical education teaching is expected to yield a series of positive outcomes. The main expected results are outlined below.

Proprioceptive awareness: students will develop a heightened awareness of their bodily sensations during movement execution, which will facilitate the identification of specific muscle activations.

Biomechanical understanding: through biomechanical analysis, students will gain a deeper understanding of the forces at play during movements, even in the absence of previous quantitative data.

Self-Assessment skills: students will enhance their ability to self-assess and critically reflect on their performance, aided by the visual and proprioceptive feedback provided.

Active learning: using an integrated approach, students will engage in more active and meaningful learning, which will foster their motivation and interest in the subject.

4. Discussion and Conclusions

The anticipated results of the eCRONY project could highlight the added value of using a combination of proprioceptive and visual feedback to enhance motor learning, providing greater benefits compared to the traditional method based solely on imitation. Indeed, several studies have demonstrated that proprioceptive awareness, the ability to "feel" movement, facilitates practical understanding as it encourages a direct, attentive connection between body and mind during the execution of a gesture (Rosenkranz & Rothwell, 2012). In this context, eCRONY would address a specific need, as many students, particularly those learning in online environments or without consistent access to in-person feedback, may require additional tools of this nature. Moreover, biomechanical understanding could further contribute by enabling students to comprehend the causes of movements, fostering a more critical and scientific mastery of movement that could aid in the recognition of potential errors (Sigrist et al., 2013; Le Naour et al., 2019). The analysis of top-ranked academic programs confirmed the absence of similar didactic tools, reinforcing eCRONY's novelty in integrating proprioception and biomechanics into a unified learning system. Unlike existing approaches that primarily focus on visual observation, eCRONY actively engages students in both sensory perception and biomechanical reasoning, making it a pioneering model in digital motor education. Another aspect for the implementation of eCRONY concerns the scalability of the tool across various educational settings. In particular, it will be necessary to assess the platform's accessibility for students with different levels of motor skills and varying familiarity with digital technologies. Additional comparative studies with existing tools could provide useful insights to optimize the process of integration into university curricula. In fact, an understanding of the forces at play, by enhancing error identification skills, could better prepare students with a corrective focus for a teaching role. Therefore, through visual and proprioceptive feedback, eCRONY would support the recognition and self-correction of execution errors, promoting critical reflection and autonomy (Henriques & Cressman, 2012) and reducing the need for external correction. In fact, if eCRONY were to promote active learning through a combination of motor diaries, simulations, and feedback, it could encourage students to engage actively in their learning process, stimulating greater motivation and involvement. Various studies support that an integrated approach of this type not only improves learning effectiveness but also fosters more sustained and critical engagement with the subject matter (Wong et al., 2011). So, the eCRONY project could represent a step forward in the teaching of motor sciences, offering a solution to overcome some of the limitations of the traditional method, which primarily relies on visual imitation and external feedback. With eCRONY, there would be the potential to support the development of proprioceptive awareness, allowing students to perceive and understand their movements more comprehensively. Access to a more in-depth biomechanical understanding of the forces involved in movement could make this process more objective and less dependent, with greater possibilities for self-assessment and self-correction. However, it should be noted that eCRONY would still be in the pilot phase, so its concrete effects on motor learning would remain hypothetical and would require further testing; additionally, the costs associated with its implementation could pose a challenge for widespread adoption. Moreover, it would be interesting to assess its effectiveness based on individual student characteristics, such as motor experience level and predisposition to sensory learning. In summary, if the expected results are confirmed, eCRONY could become a valuable educational tool, capable of making the teaching of motor sciences more accessible and scientifically informed. Nevertheless, further experimentation is essential to fully understand the impact of eCRONY and the most effective methods for integrating it into training programs. Once the pilot study is completed, it would be valuable to apply eCRONY more broadly in motor education, integrating it with the latest innovations in biomechanics derived from the Sincrony methodology. This approach could transform the teaching-learning model by enabling access to and understanding of movement aspects that are not directly visible. While kinematics, widely used for studying motor gestures, is well defined, the dynamic component, such as muscle activation and the forces involved, often remains hidden and is typically studied separately. The use of tools that integrate dynamics and kinematics could therefore allow students to develop a greater ability to analyze movement, facilitating learning and the application of more precise corrective feedback. In this context, proprioception emerges as an essential element in motor learning, as its use would enable students to understand not only the executed action but also the internal processes that drive it. By integrating proprioception as a didactic tool, eCRONY could promote a deeper body awareness, enhancing self-assessment and self-correction abilities. This approach would also serve as a valuable foundation for training future motor science educators, equipping them with innovative tools for a more effective and scientifically grounded motor education.

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