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Article

Investigating AI technology use in English studies for the explanation and analysis of biomechanical studies' results

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Abstract: The use of artificial intelligence (AI) technology in English education has promised new possibilities in the explanation and interpretation of technical biomechanical research analysis. This article investigates how artificial intelligence is filling the gap between factual biomechanical data and relevant, meaningful information needed from an educational perspective, by making it possible for different groups to comprehend it. Instructors, educators, and learners are now able to accomplish much more by utilizing visualizations, language processing (NLP), and adaptive learning. This article investigates the technology-related barriers to interdisciplinary communication, analyzes the efficacy of AI-related tools deployed, and presents a case study on the use of AI instruction and guidance on fundamental biomechanical concepts. The results from this study suggest that AI may provide fresh avenues for making biomechanical research more engaging to English learners, thus improving scientific literacy and fostering interdisciplinary collaboration. The work ends with some comments intended for educators and researchers to look for smarter ways of manipulating AI technology in English teaching and learning in a science-focused world.

Keywords: artificial intelligence; biomechanical research; English education; interdisciplinary communication; natural language processing; data visualization

1. Introduction

The continual growth of the engineering field in artificial intelligence has affected many facets of human life such as education. AI provides advanced new solutions to very complex, and multi-layered issues, but introduces new ones in its wake. In the case of English education, certain linguistic components like communication, language, and interdisciplinary integration stand out. AI can improve not only the explanation, but the interpretation, of results obtained in biomechanical research, thus solving the gap between science and the science learners. Biomechanics is the application of the mechanical principles to living organisms, and as such, includes large and intricate encompassing data that is difficult for non-specialists to grasp. In English studies, educators and students may find it especially challenging due to the prominence of English jargon and coding. This paper seeks to apply artificial intelligence technology as a new pedagogical tool in English teaching and learning that can actively engage students in biomechanical research.

The combination of English teaching and biomechanics is revolutionary, being new to the realms of interdisciplinary studies. With regard to the analysis of movement, posture, and other forms of physical exertion, biomechanics has a lot to offer instructional design. For instance, the biomechanics behind typing and handwriting can aid the production of instructional materials designed to teach students more ergonomically favorable practices, thus lowering the frequency of skeletal muscle injuries. But transmitting information of this kind to audiences lacking a scientific background is improbable because the information is far too specialized [1].

AI, unlike conventional phrase and summary writing programs, has a distinct advantage as it can tie the image-based interdisciplinary focus. This is relevant because many children still going to school in rural settings have no proper teaching materials at all, and AI is part of the solution to these problems. NLP, deep learning, and even image generators can make this reality when complex data sets are needed for learning based on data visualizations [2]. This marks the very beginning of the time when AI aids in comprehension and teaching biomechanics as it relates to schooling (**Figure 1**).

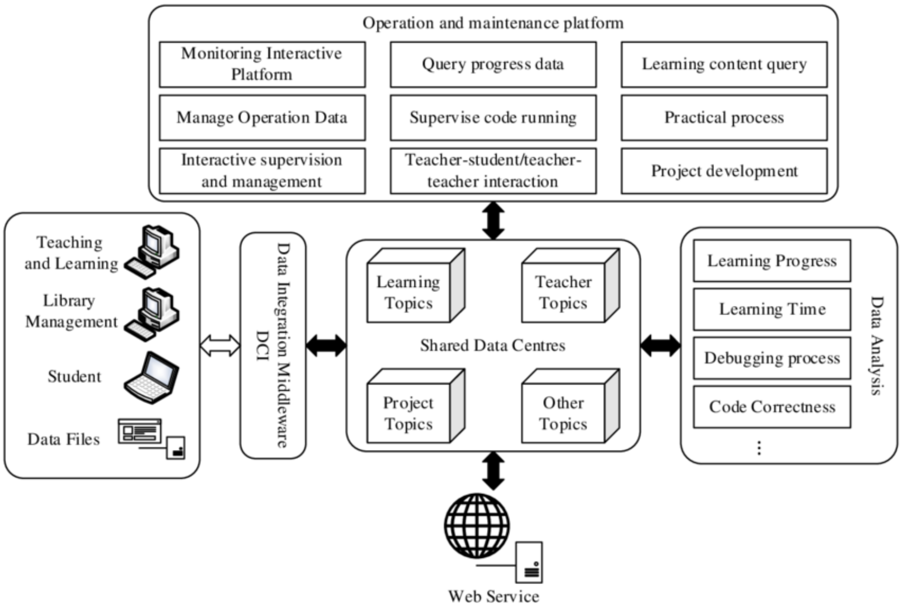

Figure 1. English education interactive platform architecture [3].

The following are the objectives of this study:

1) To understand the underlying challenges involved in the communication of biomechanical research for the English educated non-specialists.
2) To evaluate the capacity of AI technologies such as NLP, data visualization, and adaptive learning technologies to communicate biomechanical research data effectively.
3) To develop pedagogical strategies that incorporate AI technologies for effective interdisciplinary communication and scientific literacy.
4) To conduct a pilot study that demonstrates teaching biomechanical AI concepts using the case study method.

In completing these objectives, this study aims to supply teachers and researchers with AI technology solutions for effective communication of biomechanical research results [4].

It seeks to answer the question, how do AI technologies affect communication in English language teaching and learning using biomechanical research as a base? The incorporation of AI technology in education is a modern approach, which will undoubtedly aid in the interpretation of complex interdisciplinary biomechanical data and make the subject enjoyable for students and teachers.

With the help of this study, English teachers may improve on their teaching strategies, encourage scientific understanding, and develop collaborative and cross-discipline teaching environments. For other scholars, it stresses how they need to communicate their results in such a way that people from different backgrounds can see and understand them, thus expanding the boundaries of biomechanical research. In addition, applying AI tools in instruction facilitates the ongoing digitalization of different industries and prepares students for the technologically advanced global market [5].

This study, like many others, tries to prove that AI technology can be effectively used in English teaching and learning as a break from the traditional mechanistic paradigms, especially when dealing with biomechanical research issues. The use of AI tools along with educational techniques increases the efficiency of the learning process by making it more inclusive and attractive, helping to close the gap of Science and Language Education. This paper is an attempt to improve the state of interdisciplinary relations and serves as a starting point for the development of new approaches in teaching and learning.

The role of biomechanical research in English education

English education can benefit largely from biomechanical research, which concentrates on the use of engineering principles on the studied systems of living organs, like movement, postures, and even their performance. One might think that biomechanics and learning a language cannot be affiliated with each other, but in this modern era of globalization, it should also be noted that there is a shift towards multi-disciplinary education, which truly makes it necessary to apply science to a broad spectrum of academic disciplines. An English teacher, because of trained procedures used in the field, is competent to assist the students in understanding and interpreting dense analytical relationships of biomechanical data. For instance, in the research on children’s handwriting, instruction on general pedagogy should focus on the efficient ways of teaching writing [6]. In addition, pedagogy on the type of practicing digital literacy should include the composition of essays in an efficient manner. Additionally, applying these findings to teaching strategies would strengthen practical approaches to education as well as teaching and learning efficacy.

Still, there are limitations to utilizing biomechanical research for English teaching, especially in the context of the traditional methods of teaching. A primary obstacle poses itself through the technicality of biomechanical data which often contains words like “kinematics”, “ground reaction forces”, or “electromyography”. Such words may make someone without a scientific training background feel excluded and might impede accurate and clear communication of concepts. The traditional methods of teaching, such as lectures or textbooks, are not helpful in solving this problem and may make things worse for everyone. There is also the second problem associated with comprehension of biomechanical data [7]. Use of static diagrams and charts, which are dominant in the earlier means of teaching, may not clearly depict the changes in mechanistic features of human activities, such as the walking style of a person or the prevalent forces during a sport activity. Because rarely are moving images given to explain, it leads to surface-level knowledge.

English education has as well suffered immense problems that we still cannot very easily solve. One of the major gaps is incorporating biomechanical research into teaching. There is a possibility that educators will have to put more work into adapting their work to fit correctly into practical educational scenarios and environments. Let us take the example of explaining how students can use the biomechanics of handwriting in a classroom setting. It is not enough to state the concepts in simpler terms, they also need practical examples and applications on how to use them. Students are often left confused about why they need to learn about the research that goes behind biomechanics, in the first place.

However, there is space for improvement. The gaps inherent in traditional approaches encourage the hope that with a combination of technology and multidisciplinary approaches, we will be able to achieve more. For instance, teachers can approach biomechanics and work together to create learning materials that are useful for both the teachers and the students. Furthermore, videos and other interactive simulations can ease the student’s struggle with difficult anatomical terms [8]. These resources can present the viewers with visuals of biomechanical ideas that are hard to grasp, making them easier and more interesting for the students.

In the context of English learning, biomechanical research poses potential advantages and disadvantages. Traditional methodologies usually never tackle the contextual and technical intricacies of biomechanical information, but new developments like Interdisciplinary partnerships and multimedia use can help overcome such hurdles. With a bit of creativity, the reason for making students learn Biomechanics can be turned into a source for fostering scientific understanding and interdisciplinary thinking in students. This prepares them for the modern age challenges of multi-disciplinarity [9]. This issue indicates the gap between science and language education and requires more research on effective teaching strategies for this topic.

2. Strengthening the description of biomechanical research results using artificial intelligence

With artificial intelligence, it is possible to describe in a much more precise way the results of biomechanical research in a context of learning the English language due to the problems that arise due to the complexity and sensitivity of technical terms. The use of artificial intelligence facilitates one of the most complex problems within technology, extraction for natural language. NLP algorithms can understand dense biomechanical texts and are able to transform complex technical language into easy, plain, understandable words. For instance, an AI program can transform a student’s “Ground reaction forces” (GRF) explanation from advanced to “When you walk or run, your feet push against the ground, and the ground pushes back with equal force (**Figure 2)**. This force helps you move forward.” This makes it easier for the audience without losing the main point [10].

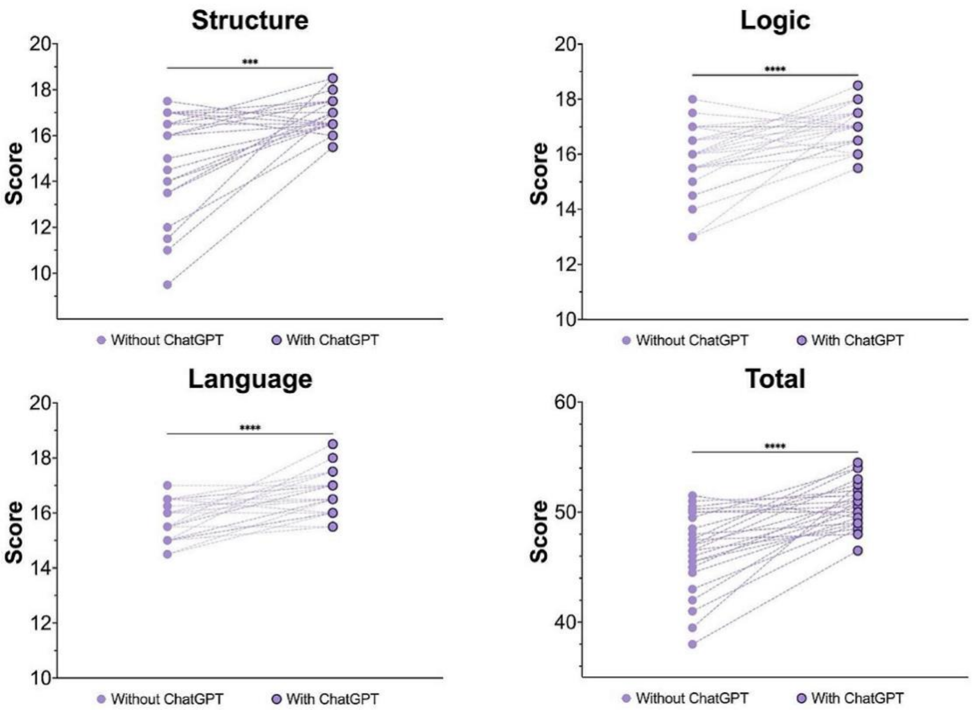

Figure 2. ChatGPT improved the quality of students' academic papers [11].

Aside from translating languages, AI has the best tools for displaying biomechanical data visually. New algorithms can work on multi-layered datasets and produce performant visualizations like three-dimensional animations of joint movement and muscle activation heatmaps. For example, AI could utilize motion capture data to illustrate a walking figure, which highlights certain biomechanical concepts like joint angles and muscle forces. Such visual elements can enhance comprehension and at the same time motivate students through interactive learning. In this case, it could be a case of an AI learning platform where students can adjust the virtual model of the human body, change the stride length or the posture and see the biomechanical results.

AI's prowess in personalizing the learning processes greatly assists in the extra contextualization of biomechanical data. The intelligent tutorial systems (ITS) harness machine learning techniques to monitor students' engagement and modify the subject matter to suit their individual appraisals. For instance, if a learner has difficulty understanding torque in biomechanics, the machine can use specific explanations and ask for example, where torque is calculated when a bicep curl is done:

$$\tau = r \times F \times sin(\theta),$$

where τ is torque, r is the distance from pivot point (joint) to the place where force is applied, F is the applied force, and θ is the angle between the force vector and the lever arm. This formula can be further related to other situations such as opening a door or lifting the textbook. The system strives to ensure that biomechanical research is conducted in the context of students' interests and prior knowledge.

Proofreading this document goes far beyond simply correcting typographical errors. For example, in trying to explain how people run, AI tools can produce images of particular parameters like vertical ground reaction force (vGRF), which can be determined from the following estimation:

$$\text{vGRF} = m \times a,$$

where m is the mass of the runner and a is the vertical acceleration during foot strike. If we combine this equation with aligned graphs, depicting vGRF as a function of time and a graph displaying how vGRF changes during the running cycle, students get a much better grasp of how force, motion, and the prevention of injury are related.

AI tools provide great assistance when it comes to contextualizing biomechanical research findings by linking the research to some real-life applications, thus making it easier for the students to understand the research. For instance [12], an AI system could analyze a study on posture while typing and make customized recommendations for improvement. AI systems ensure that biomechanical research is not learned in isolation by tying the findings to the students' activities of typing on laptops, writing essays, or texting on a smartphone. For instance, the system could have considered problems such as overextension of the wrist and ineffective grasping of fingers, providing recommendations such as elevating the chair, angling the keyboard, or applying a wrist support, which are even more suitable in place of the previous suggestions [13]. These recommendations are grounded in biomechanical principles but are presented in a way that resonates with students' everyday experiences, thus bridging the gap between theory and practice.

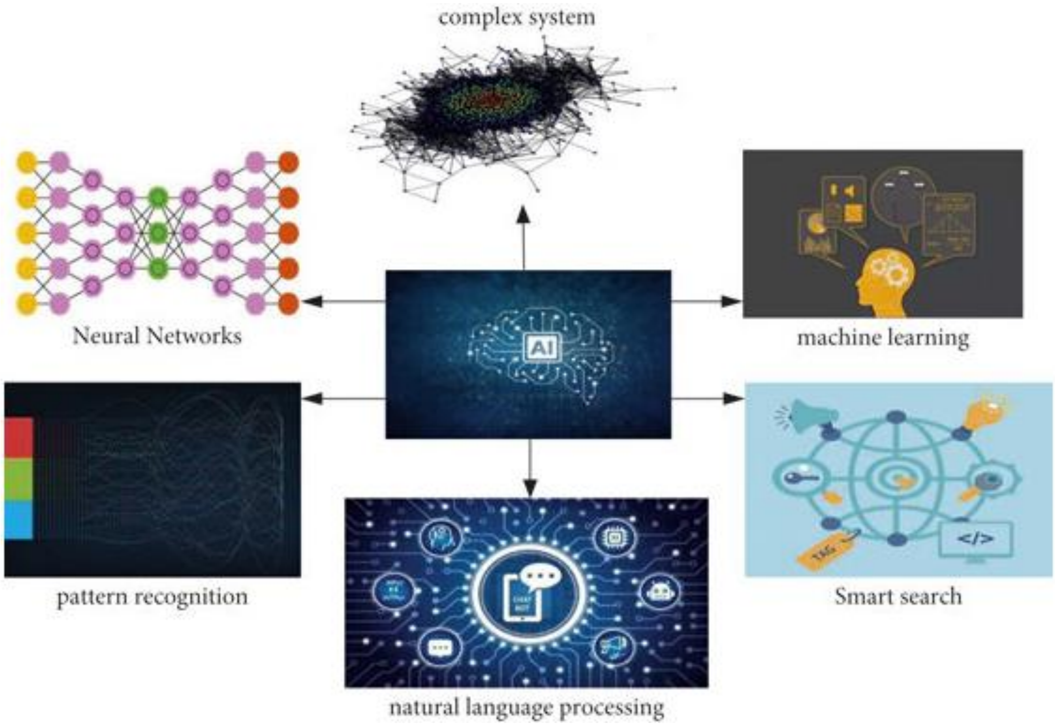

Figure 3. AI application areas [14].

AI-enhanced technologies can improve biomechanical communication by offering solutions such as simplifying technical language, improving data representation, and tailoring learning techniques. Students looking for simplified explanations can use NLP tools that convert complicated terminology to simpler terms. Rather than saying 'ground reaction forces' as it is, the AI system provides a better rephrased explanation: Ground reaction forces refer to the pushing that takes place when one walks or runs. When feet push against the ground, the ground pushes back with equal force. This force aids one in moving forward.' This particular use case of biomechanical terms greatly helps those who are not fluent in English as it brings efficiency and clarity to communication (**Figure 3**).

AI aids understanding by offering more effective ways of learning, such as vivid and multi-dimensional data visualizations, as well as overly complicated languages. An AI-powered platform can automatically create simultaneous 3D animations whenever joint motion or muscle activity patterns are altered so that students can use it and see the results in real time. This form of visualization helps students learn how changes in one's posture or movements can alter joint angles, muscle forces, posture, and overall body efficiency. Students who have an engagement in AI interactive simulation techniques vastly report changing passive lectures into real-world problem-based learning scenarios.

Electricity is unique and personal for everyone. For instance, adaptive learning technologies examine students' data as it is being collected to provide feedback and suggestions based on specific situations. In a situation, a student may be weak in correlating muscle activation to joint motion. In this case, the system may provide interactive exercises where students can see how fingertip force changes during typing. With the help of AI, while students are provided with activity-based education, they are guaranteed to incorporate the knowledge derived from theoretical concepts into practical situations. This approach aids all students in understanding biomechanical research in a wider range of learning styles and opportunities.

AI helps in overcoming the divide between the rigorous technical research and the realities of education while incorporating practical learning. For instance, an AI platform may examine the distribution of forces being applied by a student's fingers on the keyboard while he is typing and even provide advice on how to distribute the load, which if improperly done, may lead to excessive strain. These practical approaches encourage students to appreciate the value of biomechanical research and pose the educational challenge of bridging the divide between theory and practice. AI communication significantly changes the way biomechanical research is disseminated. It becomes more purposeful, engaging, and effective for students studying English and those in English education [15].

3. Interpretation and communication strategies enhanced by AI

AI has transformed the strategies and tools utilized in interpreting and communicating biomechanical research results, making them simpler to understand and more interesting. The use of AI-driven metaphors and analogies is among the most effective techniques to explain the nuances of biomechanics by relating them to different systems. For instance, AI technology can optimize extensive language data sets to create meaningful analogies, like describing the human body as a complex system of levers and pulleys. This specific example helps learners' picture how bones serve as levers, joints serve as pivots, and muscles serve as the force in a mechanical system. To give another example, the mechanical advantage of a lever system with bones can also be expressed in the following manner:

$$\text{Mechanical Advantage} = \frac{\text{Load Arm}}{\text{Effort Arm}},$$

where the load arm is the distance from the joint to the point of resistance, and the effort arm is the distance from the joint to the muscle insertion point [16]. Comparing and relating this concept to everyday scenarios, such as lifting a heavy object with a crowbar makes the students understand the theoretical application of mechanics in biological systems.

In the latest, more advanced AI products, like VR and AR, students can learn interactively and make use of their imagination to construct learning experiences. These students can trigger biomechanical phenomena, such as joint kinematics or even gait analysis, and observe them in real time with virtual simulations. For example, a powerful module in virtual reality can make students "walk" in a constructed environment and while walking [17], they can view the muscle activation patterns, joint angles, and GRF (ground reaction forces) in real time. The joint angle (θ) is adjusted when a person moves and can be captured through specific marker position during motion capture. The movement can also be calculated in a trigonometric way:

$$\theta = \arccos\left(\frac{\boldsymbol{a} \times \boldsymbol{b}}{|\boldsymbol{a}| \times |\boldsymbol{b}|}\right),$$

where a and b are vectors representing the positions of adjacent body segments. By using the VR environment, students could visualize what the effects of automation or movement speed have on joint mechanics [18], thus expanding their understanding of biomechanical principles.

Once again, pedagogic approaches can be taken a step further with AI powered adaptive learning systems as these systems personalize the learning experience. These systems automatically assess student performance and, in the process, could mark down the regions where the learner has had issues problematically related to biomechanical concepts. As an example, the learner may have issues understanding how muscles are activated to move a joint. This concept can be addressed with specific feedback and interactive problems such as for example, a calculation of the power a muscle generates during a joint movement can be performed with the equation:

$$P = F \times v,$$

where P is power, F is the force exerted by the muscle, and v is the velocity of the joint or limb. Such calculations are suitable for adaptive learning modules so that AI does not only help students learn conceptual facets but also help them implement the concept into realistic situations.

AI stands out once more in facilitating the interpretation of EMG signals, which record muscle engagement. AI-based systems are able to analyze EMG signals to calculate the onset and strength of muscle contractions and measure how well these contractions translate into movement and coordination. Consider, for instance, the root mean square (RMS) value of an EMG signal, where muscle contractions are aimed at, and the intensity of muscle activation is expected to be the highest. The value can be derived from the equation:

$$\text{RMS} = \sqrt{\frac{1}{N}\sum_{i=1}^{N} x_i^2},$$

where *xi* represents the EMG signal amplitude at each time point, and *N* is the total number of data points [19]. Students can see how EMG data changes in comparison to joint kinematics with the help of advanced AR systems and will be able to study the more complex question of what muscle activation is needed to lift things or to squat.

The incorporation of AI and these novel strategies aims to build better learning environments that can serve diverse learning needs. By metaphors, virtual reality simulations, and tailored responses, AI interprets biomechanical research and its applications in a way that makes it more understandable. This multi-dimensional approach deepens student engagement and understanding of biomechanics, thus equipping learners with the knowledge needed to use these principles in real-life scenarios across academia and the workplace. The use of AI in the teaching of biomechanical principles marks a monumental shift in the ease at which students understand complex scientific material and interact with it.

4. Case study: AI in action

AI technology has transformed the connection between biomechanics research and English instruction by aiding the understanding of highly technical areas of science. In one of the recent English lessons, AI technology was applied in the student's research on typing ergonomics. The research entails the question of how typing on keyboards of different designs affects the efficiency and strain of musculoskeletal tissues, which is an attempt to analyze the productivity versus injury balance from a scientific standpoint. Students were provided with a platform that gave AI-sourced aid in the form of summaries of research, interactive cartoons showing proper typing positions, and even constructive comments about their typing activities [20].

The AI system produces 3D visualizations of optimal hand placement and areas of potential strain, such as wrist extension and finger extension. Biomechanical parameters such as joint angles, muscle activity, and force application are the basis of these animations. For instance, the platform may determine the wrist flexion angle (θ) by computing:

$$\theta = \arccos\left(\frac{\boldsymbol{a}\times\boldsymbol{b}}{|\boldsymbol{a}|\times|\boldsymbol{b}|}\right),$$

where a and b refer to the forearm and hand positions depicted as vectors. Students can use these angles over time to see the increases in muscle strain that occur due to assuming and then deviating from the ideal posture, in this case, the shoulder muscles [21].

In adjusting parameters like desk height, the angle of the keyboard, and the position of the monitor, students can monitor how shifts in posture produce a variety of biomechanical outcomes. For example, the platform is able to measure the normal force (F_N) that is applied on the fingertips, which is a function of keyboard angle (α) and the force of gravity acting on the fingers (F_g):

$$F_N = F_g \times \cos(\alpha),$$

where $Fg = m \times g$ (mass of the hand multiplied by gravitational acceleration). These calculations will allow students to determine how ergonomic adjustments negatively affect the hand; for instance, the increase on the desk or angling the keyboard may lessen strain in the fingers and wrists [22].

The AI platform can give suggestions to the students in real time. The platform can provide these suggestions due to the invariances of an individual's movements. For instance, if a student uses a lot of force to type, the system's advice would be to press the key with less force so that the muscles can strain less [23]. Per this, the system would demonstrate F_m, the muscle force needed to type a specific key whereas Hooke's law is used to determine how the keyboard works:

$$F_m = k \times x,$$

From these parameters, if a strong connection is formed between performance and muscle force when creating [24], pupils would be able to learn how to type in a more muscle-efficient way. Moreover, the platform could also assess the amount of mechanical work (W) done on the fingers while typing, an indicator of energy output:

$$W = F \times d \times \cos(\phi),$$

where F is the force applied by the finger, dd is the distance the key travels, and ϕ is the angle between the force and displacement vectors. This formula is beneficial in providing students with a clear representation of how improper typing is, such as high key displacement or high elbow strain typing. All leads to fatigue due to improper typing techniques [25].

To increase engagement even more, the AI system could model the center of pressure (CoP) on the fingertips during typing, which measures the distribution of force.

$$\text{CoP} = \frac{\sum_{i=1}^{n} F_i \times r_i}{\sum_{i=1}^{n} F_i},$$

where Fi is the force applied at each fingertip and ri is the position vector of the force application point. This allows students to assess their typing technique and learn how to shift their styles for improved force balance [26].

This case study illustrates how AI changes the manner in which biomechanical research is communicated for English purposes, making it more interesting to students. The use of these tools not only deepens understanding but also motivates students to attempt to learn and teach biomechanics themselves. With the help of interactive visuals, feedback, reports, and personalized learning activities, AI closes the distance from intricate scientific investigations to education, making students understand the importance of biomechanics in everyday life.

5. Conclusion

The implementation of AI technology in English education has profoundly influenced the explanation and analysis of biomechanical study results. Using AI tools such as NLP, dynamic data visualization, and adaptive learning systems, we have made scientific concepts accessible to learners. These technologies allow students to master complex terms, participate in interactively taught lessons, and obtain real-time feedback, making the study of biomechanics more comprehensive.

These results prove that AI integration improves literary communication and provides students with competencies needed in the multidisciplinary world. Knowledge of the English language becomes a tool for solving various intricate problems, rather than just a subject to study. Students' exploration, understanding, and interpretation of scientific data become easier, thus nurturing curiosity, collaboration, and innovation.

In the future, it would be critical to assess how the AI-powered communication systems effectively supported students' conceptual retention, critical thinking, and active participation in interdisciplinary learning over a prolonged time. There is an opportunity to examine the effectiveness of specific AI tools, for example, virtual reality (VR) simulations, intelligent tutoring systems, or automatic summarization tools, in various educational contexts, such as K-12 schools, colleges, and even vocational training and courses. In addition, the application of AI in other interdisciplinary fields, such as environmental data incorporated into language arts or sound physics taught through music pedagogies using AI, could also enrich interdisciplinary education.

The impact of artificial intelligence on modern reality is indisputable, and its role in the future of education is remarkable. New technologies, including augmented reality (AR) and generative AI, can help accomplish elaborate research by providing environments that facilitate the instant exchange of ideas. For example, AR enables students to place information, such as biomechanical data, within the context of real-world objects and thereby understand the various scientific aspects tangibly. Generative AI provides students with the type of learning materials that are best suited to their personal needs, making education more effective and ensuring mastery of multiple subjects.

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Conflict of interest: The author declares no conflict of interest.

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