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Mind Mapping as an Innovative Tool to Enhance Project-Based Learning Utilizing Technology Tools

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Project-based learning (PBL) is a method to promote engaged learning that enables students to employ their creative and critical thinking abilities, often resulting in meaningful learning experiences (Wurdinger, 2018). A PBL assignment was created for a sport-focused technology and innovation class in which the students created their own augmented reality (AR) activation. AR can be a powerful tool for PBL assignments, allowing students to create interactive and immersive experiences that bring their ideas to life (Jailungka, 2020). This assignment utilized Meta Spark Studio, a free platform for creating AR effects, that provides an accessible and user-friendly way for students to experiment with AR technology and develop their technical skills. However, the implementation of PBL can present challenges for both educators and students, particularly when it comes to technology and innovation (Freshwater, 2009). Many students may struggle with the technical skills needed to complete a technology-focused PBL assignment, or they may face barriers to accessing the necessary technology. To address these challenges, educators can utilize mind-mapping techniques to help students break down complex tasks, visualize progress, and identify their goals (Hollland et al., 2003). Mind mapping can also help students recognize areas where they may need additional support or resources prior to undertaking the tasks involved. Engaged learning through PBL and AR can be an effective way to help students develop real-world skills and apply their knowledge. Mind mapping and PBL can lead to increased student motivation, increased innovation, and increased knowledge retention.

Keywords: project-based learning, mind mapping, technology, innovation, augmented reality

Introduction

Aristotle is credited as saying, "Anything that we have to learn to do we learn by the actual doing of it" (Smith, 2020, para. 8). This quote and many other similar quotes throughout history underscore the importance of hands-on

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learning in education. This academic commentary focuses on the use of project-based learning (PBL) in the specific context of a college-level technology and innovation in sport class. Specifically, what follows will address both challenges and opportunities presented by the implementation of PBL via the utilization of emerging technological innovations and mind mapping in an attempt to develop critical thinking abilities and create immersive learning experiences.

This commentary will focus on mind mapping as a tool to address challenges associated with PBL and innovative technologies. Mind mapping uses pictorial representations and visual connections to depict the relationships that exist between similar ideas, concepts, and information (Zahedi & Heaton, 2016). To prepare students for careers after the classroom in an ever-changing and always innovating sport industry, academic programs should evolve and incorporate innovative experiential learning practices in their courses (Braunstein-Minkove & DeLuca, 2015). Researchers have found that educators can utilize mind-mapping techniques to help students break down complex tasks, visualize progress, and identify their goals (Holland et al., 2004). Mind mapping can also help students recognize areas where they may need additional support or resources before undertaking the tasks involved.

As sport management is very much an applied field that requires innovation in teaching format to adapt to meet the needs of the industry (DeLuca & Braunstein-Minkove, 2016), this article is designed to add to previous commentary and instructional technique papers in sport management that have focused on the adoption of teaching practices including online teaching (Steir & Schneider, 2009), design thinking (Pierce et al., 2019), social media (Lopez-Carril et al., 2020), journaling (Clevenger & DeLuca, 2023), podcasts (Johnston et al., 2021), mobile technologies (Manning et al., 2017), and gamification (Duguay et al., 2022). This technology and innovation class provides a model context in which to incorporate mind mapping into a PBL experience that encourages students to think creatively and innovatively to solve real-world challenges. This article identifies mind mapping as an instructional tool to facilitate PBL that utilizes emerging innovations and technology in the classroom. Furthermore, this article expounds on the academic and practical importance of introducing students to new technologies to prepare them for the industry and the future of work.

Project-Based Learning

PBL is an approach to education that directly engages students in educational projects meant to provide practical experience in solving real-world problems or creating products or plans to address a specific challenge (Kokotsaki et al., 2016). PBL allows students to more successfully solve highly complex problems and identify solutions (Loyens et al., 2023). Additionally, because the PBL assignments within a course are specifically focused on the content of the course and the application to the industry that the course is situated in, the knowledge and skills a student develops through PBL are often applicable to the professional future of the student (Loyens et al., 2023).

There have been a number of studies on the use of PBL in education and the benefits of using that form of learning. Walker and Leary (2009) found that the use of PBL not only increased the motivation of students but also led to students being more active participants in the educational process. Another area in which PBL has shown a great deal of promise for use in academia is in its ability to increase an individual's long-term retention of knowledge. Karacalli and Korur (2014) found that students who completed PBL assignments demonstrated significantly higher levels of knowledge retention when compared to those who received standard classroom instruction.

Furthermore, studies have shown that PBL also helps to increase student engagement in their learning. Baron and Corbin (2012) noted that when students work on projects that are meaningful and relevant to the topic they are learning, they are more likely to feel and act engaged throughout the process. Similarly, PBL has been shown to be effective at helping students develop critical thinking skills that industry values (Torff, 2011). Loyens et al., (2023) also found that PBL had a positive impact on both higher-order thinking and critical thinking skills. PBL has also been shown to increase the self-efficacy of students and their belief that they can succeed in a task and even succeed in accomplishing a task that might be new to them. In fact, students who completed PBL learning were more likely to indicate higher self-efficacy scores and belief that they can competently complete tasks than their peers who received traditional classroom teaching (Mahasneh & Alwan, 2018). Krajcik and Blumenfeld (2006) state that the positive outcomes associated with PBL are the result of the scientific investigation, collaboration, and deeper conceptual understanding that a well-formulated PBL assignment provides.

Project-Based Learning in Innovation Education

However, the implementation of PBL can present challenges for both educators and students, particularly when it comes to technology and innovation (Freshwater, 2009). Many students may struggle with the technical skills needed to complete a technology-focused PBL assignment, or they may face barriers to accessing the necessary technology. Many of these challenges can be addressed through mind-mapping techniques. The concept of mind mapping and how it can be used to address challenges is addressed later in this article.

Patton (2012) found that PBL projects that used digital-based technologies strongly enhanced learning outcomes for students, as they were able to have a learning experience that was able to be shared digitally with peers and instructors. The implementation of technology into PBL was found to improve content knowledge in not only high-performing students but also in lower-performing students as well (Erstad, 2002). Cevik (2018) showed that PBL had an impact on technology education by providing students with hands-on experience in fields that are technically focused on science, technology, engineering, and math (STEM). Cevik argued that by incorporating PBL activities into these technology-focused fields, instructors can help create students who are equipped with what they refer to as "21st-century skills." Uden (2006) also emphasizes the effectiveness of the partnership of PBL and technology for student learning and found that students displayed positive results in their increase of technology knowledge when coupled with the use of PBL.

A large proportion of successful PBL practices in the classroom hinge on the ability of the instructor to provide structure to the PBL assignment that can support and direct the student throughout the PBL process (Hmelo-Silver et al., 2007). To that end, mind mapping has been shown to be an instructional technique that can be incredibly effective at both supporting and directing students through their learning journey (Mamontova et al., 2016).

Augmented Reality

Augmented reality) is an innovative medium that adds digitally created elements to the real world (Berryman, 2012; Craig, 2013). In simpler terms, AR enhances your surroundings by incorporating virtual text or images into what you see. While virtual reality (VR) takes the user into an entirely computer-generated environment, AR brings computer-generated elements into the real-world environment. Within the wide range of fields exploring AR, marketing has emerged as a particularly notable area. The ability of AR to elevate products and services makes it highly relevant to consumers who can engage, share, and discuss AR content (Hilken et al., 2018). In the realm of sports broadcast rights, AR has demonstrated its ability to profoundly impact viewer engagement and foster positive consumer behavior (Goebert et al., 2022; Hilken et al., 2019).

Numerous marketing studies have provided evidence of AR's effectiveness in multiple scenarios. It has proven valuable in advertising (Hopp & Gangadharbatla, 2016), sport settings (Goebert & Greenhalgh, 2020), influencing purchase intention (Hilken et al., 2017), and creating immersive experiential marketing campaigns (Beck & Crie, 2018; Huang & Hsu Liu, 2014). Sport marketers have been especially bullish on the use of AR in sport-related areas (Goebert, 2020). All of these findings inform the reasons why AR was chosen as the delivery product for this PBL assessment.

While AR use specifically in sport management curriculums and education has not been studied, multiple other disciplines have investigated the use of AR in their academic disciplines. Their findings on the use of AR have included a substantial number of benefits including enhanced creativity, enhanced accessibility, increased collaboration, greater memory retention, greater sensory engagement, increased autonomy, a better understanding of abstract concepts, increased motivation, and increased learning gains (Garzon et al., 2019). An AR prototype was the PBL product for this specific course; however, any technological product that requires investigation and learning on the part of the students in the course could be utilized. AR fit the context of the course discussed and provided a PBL outcome that could be strategized for via mind mapping.

Mind Mapping

Mind mapping is a visual representation of individual ideas, concepts, and their related components (Davies, 2011). These mind maps are created by making a connected network of ideas surrounding a central item of focus. Mind mapping is often not highly structured and involves stream-of-consciousness thinking that is more freeform, allowing for innovative or creative ideas and solutions to problems (Dong et al., 2021). One of the main intentions for the use of mind mapping is the mass generation of ideas to address complex problems. Mind mapping encourages creative thinking and brainstorming and has been shown to have significantly positive results in both industry and academic settings (Davies, 2011).

Although freeform in nature, there are generally considered to be four main parts that a mind map must contain. These components are (1) a central image representative of an idea or product, (2) main themes that branch out from that central image, (3) those branches then have keywords, images, or concepts included, (4) and all of those branches form a connected structure (Stankovic et al., 2011). Mind mapping allows an individual to visualize various components of a complex task all at once in a graphical layout.

Constructivist Theory emphasizes the role of the learner when placed in a specific context (Burrell & Morgan, 1979). This theory states that impactful learning occurs when an individual interacts directly with the content they are tasked with learning. Stankovic et al. (2011) found that mind mapping as a graphical or visual tool is an excellent fit for study via constructivist theory. A tenet of cognitive loading theory is that we have a limited capacity in our active working memory but a larger capacity to hold information in our long-term memory. By interacting with a topic and creating visual cues, learners can more easily convert their learning to long-term memory. Mind mapping facilitates this by providing the students with experience as well as visual cues for memory. Fogliasso, et al.

(2007) stated that mind mapping via rich pictures can help many different types of learners utilize their long-term memory. There is a dearth of research focused on using mind mapping as a PBL tool in sport management. However, multiple other disciplines have incorporated mind mapping into their educational practices including finance, mathematics, engineering, executive education, education, computer programming, medicine, economics, and marketing, among others (Davies, 2011; Liu et al., 2014; Liu et al., 2018).

The Case for Mind Mapping in Sport Innovation or Technology

Debbag et al. (2021) investigated the use of mind mapping in technology-focused education and found that students learned more via this route of instruction than a traditional route due to the reinforcement of performing a task and experiencing ideation. Shao (2020) also found that mind mapping was an ideal fit as an instructional technique in technology-focused classes or assignments. Shao (2020) incorporated mind mapping into a computer technology course and found that mind mapping significantly increased scores on complex technology assessments as compared to a brainstorming method that did not incorporate mind mapping. Stankovic et al. (2011), in their technology-focused E-business class, found that students who were assigned mind mapping PBL were both more interested and more motivated to complete their assignments than their peers who had consumed the same material in a traditional classroom setting. Gul et al. (2023) incorporated mind mapping and three other instructional techniques to attempt to teach advanced computer programming languages. The authors found that mind mapping was the most effective instructional technique when it came to teaching the most modern and technologically advanced computer programming concepts.

Backed by the previously cited academic research (Debbag et al., 2021; Shao, 2020; Stankovic et al., 2011), mind mapping has the potential to be a powerful tool through which to strengthen and solidify student learning. Due to the complexities of the sport industry, the proclivity for innovation, and the ever-changing sport business landscape, mind mapping and the creative problem solving that it encourages seem like a natural fit for PBL assignments within sport management courses, especially those with an innovation or technology component.

Incorporating Mind Mapping and AR into a Course

A PBL assignment was created for a sport-focused technology and innovation class in which the students created their own augmented reality (AR) activation.

AR can be a powerful tool for PBL assignments, allowing students to create interactive and immersive experiences that bring their ideas to life (Jailungka et al., 2020). For this assignment, students develop an AR activation intended to enhance marketing or engagement for the sport team or athlete of their choice. Students experience the entire process of product creation including conceptualization, prototyping, testing, and implementation.

Mind Mapping Process

Prior to utilizing the Meta Spark Studio software or designing their AR interaction, students were introduced to mind mapping as a concept, and demonstrations of mind mapping in action were presented to the class. The students then participated in a mind mapping activity in order to give them supervised experience with mind mapping and to allow them to gain a more in-depth understanding of the process.

Once students were introduced to and practiced with mind mapping, they were provided with an interactive and fillable PDF version of a mind map custom created prompts for the express purpose of sparking ideas for the creation of the AR product and meeting the criteria put forth in the assignment rubric. Students worked in collaborative groups as they brainstormed ideas for the project by utilizing their mind maps. After this collaborative stage, students began to work on mind mapping individually. There are many ways to mind map but for this project to meet the specifications of the PBL assignment and rubric, the included prompts that they received consisted of previous uses, design elements, sport or team of focus, design concept, how it works, what it does, and what should it evoke (see Figure 1).

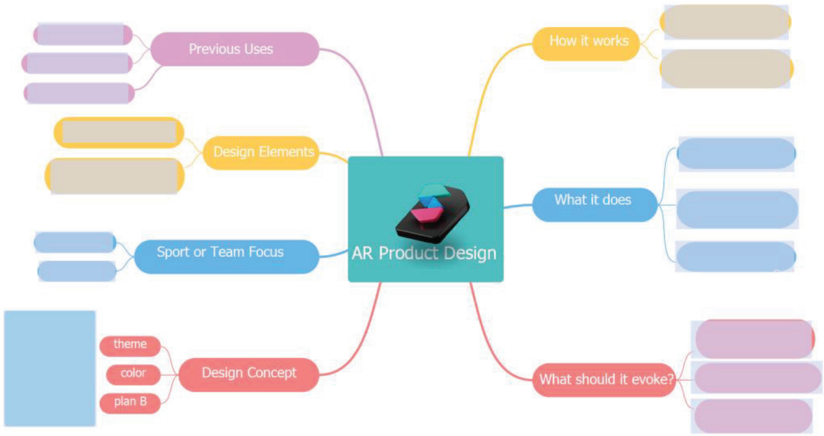

Figure 1. Custom and fillable mind map PDF.

Mind Map for AP Protoype

Name:

Attributes	Inadequate	Below Average	Average	Above Average
Depth of Information (Knowledge)	The mind map is not complete No ideas evident	Basic level of only key ideas Extends only a few ideas	Solid grasp of content Exhibits extensions of most key ideas	Solid grasp of all content Key ideas show deep understanding of the content
Ideas Have Key Images or Terms (Communication)	No key images or terms are present to illustrate ideas	Images and key terms are too few Images and key terms are inprecise	Images and key terms show clear understanding of the content	Images and key terms are clear and dynamic and show a mastery of content
Links or Branches Showing Connection Between Ideas (Thinking)	No links or branches connecting ideas to each other	Attempts made to connect or link branches to the main idea but too inconsistent	Clearly connects or links some branches or ideas to the main idea	Effectively and meaningfully connects branches and ideas to the main idea of the project
Ideas Build from Central Idea and Become More Specific or Complex (Application)	Ideas do not build, do not become more specific, or do not become more complex	Ideas build from the center Still not clear that ideas are becoming more complex or specific	Ideas clearly build from the central idea Generally becoming more specific or complex	Ideas clearly connect to the central idea Ideas consistent and meaningfully become more specific or more complex

Total______________________________

Figure 2. Rubric for mind mapping

A detailed rubric (see Figure 2) was developed for the mind map portion of the assignment based on a mind mapping rubric created by Swestyani et al. (2018). The rubric was built on work from Zein (2015), who determined that effective mind mapping should incorporate the four aspects of (1) knowledge, (2) communication, (3) thinking, and (4) application. Each of these aspects is reflected in the rubric for the mind mapping portion of the PBL assignment.

Augmented Reality Product Creation

Once the students had completed the mind mapping portion of the PBL assignment, it was time for them to utilize their completed mind maps to create the product that results from the PBL. For this project, the students use Meta Spark Studio. Facebook/Meta launched their Reality Labs in 2018. Meta Spark

Studio (see Figure 3) was chosen for several reasons. First, it is free so there is no burden of expense on the students or the university. Second, Meta has invested very heavily in AR technology with the result being a deep repository of information and tutorials for how to use the software. Finally, Meta Spark Studio was found to be one of the simplest, most user-friendly AR creation software available (Afshar, 2023). Users can easily create unique AR interactions without requiring knowledge of coding or programming languages (Afshar, 2023).

Earlier in the semester the instructor held a special class period known as "Download Day." During this class period, the instructor guided students through the process of accessing and downloading necessary software for the completion of assignments and activities for the class. A portion of this class period was dedicated to teaching students how to access and use Meta Spark Studio. Scheduling this "Download Day" is an important step in equipping the students for success in this project and helping to guide their creation of the project.

Once the software was downloaded, several training exercises with Meta Spark Studio were conducted in which students, in collaboration with the instructor, practiced scenarios of different ways in which to utilize the technology. Once familiar with the software and how to access templates to assist their creation of the AR PBL, students then began to work on their project. Throughout the semester, the instructor provided office consultation opportunities and in-class training to equip the students with the necessary tools to have a successful PBL

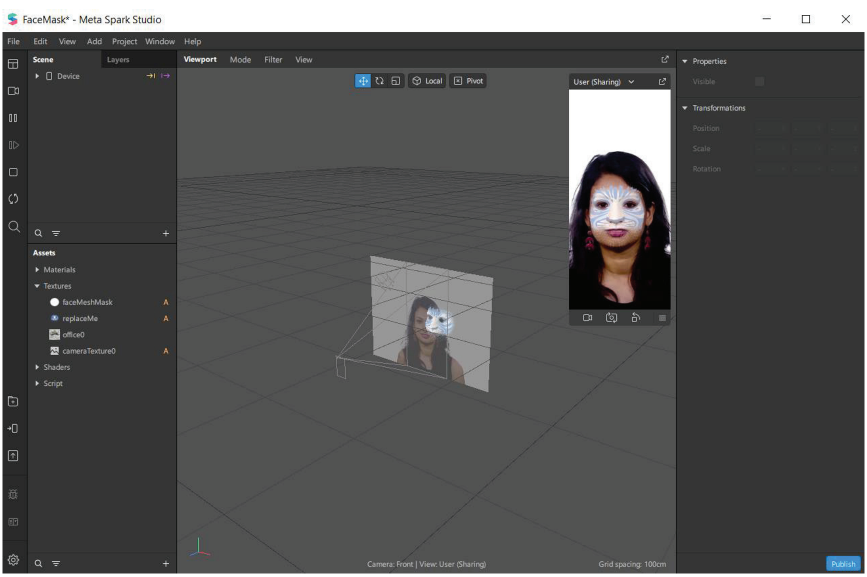

Figure 3. Meta Spark Studio interface

experience. Once the students had completed their AR interaction and submitted it, the instructor utilized a project-specific rubric (see Figure 4) to provide feedback and evaluation for the AR product.

Meta Spark Studio Prototype

Name:

Attributes		**Inadequate**	**Below Average**	**Average**	**Above Average**
Functionality	The prototype is not functional. 0	The prototype does not function well or has a difficult user experience. 10	Prototype is lacking in detail. Functions at the basic level. 15	Clear and understandable use of the prototype. Prototype was intuitive. 20	The prototype is easy to use and is immersive. 25
Purpose of Use\Fit	Purpose of use of the prototype and fit to the context was not clear. 0	Weak or very little fit and purposeful design of the prototype 10	Did not do a good job of designing a specific use or fit for the prototype. 15	Good fit and usefulness of the prototype for the context it was designed for. 20	Fit and usefulness were excellent and a product of thoughtful consideration and design. Not a basic interaction. 25
Aesthetics	No visuals to accompany prototype. 0	Weak visuals that were extremely unclear to user 10	Visuals did not do a good job of presenting what was the intended use of the prototype 15	Good visuals accompanying the prototype. 20	Presented strong visuals that made the prototype stand out. 25
Creativity\Interactivity	No creativity demonstrated 0	Weak creativity. Prototype as boring 10	Visualization and proposal was mediocre. Not a lot of creativity or interaction as part of the prototype 15	Creative layout and presentation of the prototype. It was interactive 20	The prototype was novel and creative, it was exciting\entertaining to use 25

Total ____________________

A sample image (see Figure 5) of a completed PBL AR interaction created with Meta Spark Studio is included for reference.

Figure 4. Rubric for Meta Spark Studio AR prototype.

Figure 5. AR interaction created with Meta Spark Studio

Partnering with Industry
Pierce et al. (2019) advocate for working with an industry partner when implementing learning strategies in a sport-focused classroom. They also suggest providing ample preparation time for both the industry partner and instructor to prepare the assignment to be as impactful as possible for the student and the industry partner. Emerging technologies such as AR are often utilized by sport organizations in their social media and marketing efforts. When partnering with a sport organization for this PBL, it is important to know what matters to that organization and how they currently utilize AR or foresee their organization utilizing AR in the future. This tactic has resulted in student-created PBL products being used by sport organizations, thereby gaining the student exposure to the demands of the industry and also valuable experience that can be included as part of their résumé. Industry partners can also provide valuable feedback to both the instructor and the students as to what the industry values and is moving toward in terms of the technology utilized for the PBL product.

Conclusion

Engaged learning through PBL and AR facilitated by mind mapping can be an effective way to help students develop real-world skills and apply their classroom knowledge to a real-world challenge. However, educators must be prepared to address the challenges that arise, such as technology and innovation barriers, using mind mapping and other strategies. There are several good resources for those interested in learning more about PBL, mind mapping, and AR. Kokotsaki et al. (2016) provide a thorough overview of PBL and conclude their paper with six key recommendations for the use of PBL in the classroom. Buzan (2018) and Edwards and Cooper (2010) provide background information about mind mapping and practical ideas on how to successfully implement it in your endeavors. Finally, Goebert (2020) explains how AR has been and will be used in sport and Craig (2013) defines AR and the concepts associated with it.

As with any implementation of novel pedagogical practices, there are bound to be some challenges that arise. Most notably, it can be a challenge when it seems as though an instructor and a group of students are learning about a concept (PBL, mind mapping, or AR) at the same time. To attempt to mitigate many of the issues that might arise in this instance, it is strongly recommended that instructors familiarize themselves with these concepts and practice them on their own prior to classroom implementation. The resources listed in the preceding paragraph will help to offset the learning curve associated with these concepts. A simple and free place to start experimenting with mind maps is Canva's whiteboard mind mapping tools (https://www.canva.com/graphs/mind-maps/).

Further challenges could arise in the evaluation of the mind maps and AR activations. It is with this challenge in mind that rubrics were provided in this document. These rubrics can be used and edited to the specific context in which you implement these practices. Another challenge is allocating the correct amount of classroom time to training with these technologies. In subsequent assignments to better equip students, more classroom time will be made available to the learning of these technologies to help ensure that students have the proper comfort level to leverage these technologies into a strong PBL submission.

The case introduced in this commentary resulted in several learnings for the instructor. First, students were quick to pick up on the concepts introduced, especially those with technological components. Anecdotally, it seemed as if the use of advanced technological concepts engaged the students more in the classroom content. Perhaps this is due to students being what Dingli and Seychell (2015) refer to as "digital natives," which is a term for young individuals who do not find complex digital technologies or technological updates confusing or problematic but instead find them appealing. Second, it is important to structure classroom time in which multiple new technologies are not introduced at the same time. Although the students did well with the new technologies, it seemed to be easier for them if one day was dedicated to mind mapping and another to the Meta Spark Studio. This separation allowed students to focus solely on one new technology at a time and reduced the temptation for them to jump from program to program before gaining a sufficient understanding of one before accessing the other. Finally, it is important to understand that just as students come to your classroom with a wide range of academic abilities, students will also come to your classroom with a wide range of technological competence (Katz, 2005). Some students will excel beyond even what the instructor might expect and some will provide the minimum product for the PBL assignment. With that in mind, it is important to let the rubric guide the grading and not have your grading anchored to the highest or lowest achievers as technological competence no doubt plays a role.

Innovation provides a way for sport organizations to compete and try to gain an advantage over their competition. With that in mind, sport organizations are seeking to hire individuals who are able to ideate and innovate (Ratten, 2021). Ratten (2020) emphasizes that the sport industry not only utilizes technology and innovation but needs it to survive and remain competitive. The innovative nature of the sport industry leads to the increased demand for workers who possess problem-solving and innovative skills. Frevel et al. (2022) found that sport managers of the future will need to possess new types of skill sets that are more and more dependent on technological and innovative thinking. Mind mapping could be one way that educators can prepare the sport managers of tomorrow to address the unique challenges of the always-innovating sport industry.

Mind mapping is an innovative and impactful teaching practice that can lead to increased motivation, knowledge retention, and creative problem-solving skills for students. Innovation in the sport industry is continually evolving and the discipline should strive to seek out innovative tools to attempt to equip students for the industry in which they will be working. Mind mapping is one such tool that when partnered with a PBL assignment can introduce students to creative opportunities that exist through the utilization of emerging technologies.

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