21st Century Skills and Mobile-Technology-Supported Inquiry-Based Learning

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The development of 21st-century skills is paramount. Among these skills, which encompass collaboration, communication, critical thinking, and creativity, Mobile-Technology-Supported Inquiry-Based Learning (mIBL) in Science Education emerges as a potent method for their enhancement.

Keywords: inquiry-based learning ; mobile learning ; MBL ; sensors ; mIBL ; 21st century skills

1. The 21st Century Skills

There are several perspectives on the precise substance and meaning of 21st century skills, which all highlight what students can accomplish with information and how they use what they learn in actual circumstances [1][2]. Society for Technology in Education (ISTE) acknowledged that in a world that is becoming more digital, students require abilities in the following areas: (1) collaboration and communication; (2) critical thinking, problem solving, and decision making; (3) creativity and innovation; (4) research and information fluency; (5) digital citizenship; and (6) operations and concepts of technology. The Framework for 21st Century Learning [3] was created by the P21 Framework, a collaborative organisation that generated a cohesive, common vision for learning [4]. The P21 Framework outlines three types of competencies: (1) learning skills (collaboration and communication, critical thinking, problem solving, creativity and innovation); (2) literacy skills (information literacy, media literacy, and ICT literacy); and (3) life skills (flexibility and adaptability, initiative and self-direction, social and intercultural skills, productivity and accountability, and leadership and responsibility) [4]. Researchers' study focuses on learning skills as described by the P21 framework.

Collaborative learning is a kind of learner-to-learner contact that involves learning, sharing of authority and acceptance of responsibility, and respect for the skills and contributions of each group member. Along with assertiveness, responsibility, and empathy, collaboration is often seen as a social skill. Individual efforts must give way to teamwork, and autonomy must give space to community, if crucial concerns are to be effectively addressed [2][5][6]. Collaboration skills are necessary for students to engage and compete in the 21st century because they enable them to communicate with their peers and share their thoughts and ideas for accomplishing learning objectives and promote the community. Based on the above, the students' views on acknowledging group members' abilities through teamwork, accomplishing the learning objectives, promoting community, sharing of authority and developing assertiveness will be examined.

Communication is the ability to express thoughts and ideas effectively using oral, written, and nonverbal abilities in various formats and circumstances. Communication is motivated and directed by the desire to attain certain goals and is supported by perceptual, cognitive, emotional, and behavioural activities [7][8]. Effective communication skills encompass characteristics such as empathy, understanding, and active listening, respect for a person's dignity, integrity, and autonomy as well as the capacity to explore and share ideas and thoughts in a warm, non-judgmental, and pleasant manner. Therefore, the students' views on participating in dialogue for expressing thoughts and ideas, encouraging peers' effort, communicating to attain certain goals, developing empathy or respect for peers' personality, and developing abilities of active listening will be examined.

Critical thinking as a skill refers to the capacity to evaluate the credibility of a claim or piece of information and reach a judgement regarding what to believe or do. It is also a cognitive tool that students employ to evaluate their methods and beliefs in a reflective manner [2][7]. Students who can monitor and analyse their own cognitive processes are more likely to display high-quality thinking as a result of metacognition (or thinking about thinking). When students think critically, they evaluate the outputs of their thought processes, such as the quality of a choice or the efficacy of a problem solution. Several other essential student learning outcomes, such as metacognition, motivation, collaboration, and creativity, are related to critical thinking abilities [9][10]. Problem solving refers to the ability to detect problems, acquire and assess relevant information, propose viable solutions, and select the most effective technique for addressing the problem [7]. The

OECD defines problem solving in the context of education as follows: ‘The capacity of students to understand problems situated in novel and cross-curricular settings, to identify relevant information or constraints, to represent possible alternatives or solution paths, to develop solution strategies, and to solve problems and communicate the solutions’ [11] (p. 3). Ideally, such problems should be authentic and founded in everyday situations [2]. Based on the above, the students’ views on reflecting/monitoring, evaluating processes of thought, proposing alternative and viable solutions, and detecting and understanding the problem will be examined.

Although there is no consensus among scholars about the definition of creativity, the majority think that it is a path that students enjoy [12][13], and involves the production of anything regarded as innovative or beneficial in a specific social context. The researchers concur that the final result of creativity might be a physical object, or an idea generated by developing, refining, analysing, and assessing external stimuli and data [2][7]. An intriguing definition of creativity is provided by Walia [14] (p. 242): “Creativity is an act that arises from a perception of the environment that acknowledges a certain disequilibrium, resulting in productive activity that challenges patterned thought processes and norms, and gives rise to something new in the form of a physical object or even a mental or emotional construct”. Therefore, the students’ views on producing innovation (tangible or intangible), producing something beneficial in a social context, and gaining pleasure from producing innovation will be examined.

2. Mobile-Technology-Supported Inquiry-Based Learning (mIBL) in Science Education and 21st Century Skills

Inquiry-based learning (IBL) is a learning approach in which students assume the role of scientists, as they develop questions, formulate appropriate hypotheses and design activities and experiments to test them, they analyse, understand, and explain the results of their experiments, they draw conclusions, and communicate their findings. Therefore, they undertake investigations to generate new knowledge based on the gathered data [15][16][17]. The inquiry process includes references to communication skills, planning, and evidence selection, all of which enhance thinking and problem solving [18]. Numerous studies recommend IBL as a crucial element in Science Pedagogy because it improves students’ conceptual comprehension, critical thinking, problem solving and collaboration skills. IBL has the potential to engage students in a real scientific discovery process by giving them a sense of classroom learning achievement and making learning more enjoyable [15][19][20].

Mobile learning refers to the use of mobile devices to aid learning, such as smartphones, laptops, tablets, and wireless sensors. Numerous concepts are associated with m-learning, including learning in multiple contexts and through social interactions; ubiquitous learning (learning anywhere and at any time); context-aware ubiquitous learning, which emphasises the support of learning across contexts; authentic learning, which focuses on real-world problems to create an attractive learning environment; customization of access to information in order to develop new skills; and student-centred learning [16][19][21][22][23][24]. Science is built on the exploration of the physical world, and digital mobile technology is deemed suitable for supporting this research because it provides the means to make it more accessible and pervasive [25][26]. Many researchers have also reported that adopting effective learning methods in mobile learning activities might be an empowering strategy for fostering students’ 21st century skills [7].

Many researchers mention the contribution of Science Education to the development of 4Cs skills. Authors concur that during science learning, students must build their collaboration abilities since they must be able to work with teammates to solve problems [5][7][27]. Moreover, Communication is also considered a vital component of education as it has a significant impact on students’ cognitive perception [28][29]. There are no disagreements on the significance and prevalence of Critical thinking and problem solving in Science Education across various educational systems. Problem solving or locating suitable solutions to challenges is one manner in which Critical thinking and Science are related [30]. The link between Critical thinking and Science Education includes practices, skills, and processes such as problem-finding/identification and obtaining information. Several countries have attempted to include Critical thinking in Science Education, realising that living in a diverse society requires citizenship ability [30][31].

Therefore, the literature suggests that the 4Cs skills (Collaboration, Communication, Critical thinking and problem solving, and Creativity) are essential components of Science Education and can be enhanced by inquiry-based learning (IBL) as well as by using portable digital devices (m-learning). Mobile-technology-supported inquiry-based learning (mIBL) intends to use mobile technologies to support the inquiry process and drive students to create and share their knowledge, and mIBL enhances IBL in terms of mobility and feedback speed and has a beneficial effect on student–teacher interaction [32][33]. According to relevant research, inquiry-based learning strengthens students’ reasoning and thinking skills through inquiry activities, and mobile learning activities might improve critical thinking by encouraging collaborative learning [34][35].

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