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EDITORIAL

Editorial

The second issue of Science Education International for 2021 brings together 11 papers from Turkey, Mexico, The United States, the Philippines, Thailand, and Greece. In the first article, Emre Yildiz investigated the effect of the educational game method on the learning achievements of 120 seventh-grade Turkish students with different learning styles. In the second also from Turkey, Filiz Bezci and Semra Sungur examined 269 eight-grade Turkish school students' scientific reasoning ability in relation to gender and learning environment perceptions. The third article from Mexico's David Salgado-Chavarría and Joaquín Palacios-Alquisira used problem-based learning (PBL) approach to review the Green Chemistry Principles when applied to a polycondensation reaction. The fourth article by Daniella Molle and Weiqiong Huang highlights the issues around multilingual students in the United States having limited access to rigorous science instruction noting that they are underrepresented in science, technology, engineering, and mathematics (STEM) fields in both tertiary study and the workforce. Pongprapan Pongsophon and Artitaya Jituafua aimed to develop a learning progression (LP) for botanical literacy and assess the impact of a garden-based education course on 49 Thai pre-service science teachers in the fifth article. Jeah May O. Badeo and Bee Ching U. Ong Kian Koc investigated the effect of using a comic-based learning module in Physics as a learning tool on 12–14-year-old Philippine students' conceptual understanding and motivation in the sixth article. The seventh article by Gonca Kececi, Pelin Yildirim, and Fikriye Kirbag Zengin reports on the effects of science education using mobile augmented reality (MAR) application on 143 sixth-grade students Turkish students' attitudes toward science, technology, and their academic achievement. Similarly, Küçükaydın sought to investigate the relation between scientific attitudes and intellectual risk-taking behaviors of 184 fourth-grade Turkish students in the eight article. The ninth article by Shem Unger and Mark Rollins evaluated whether 90 American university students exposed to an apparently credible website were able to distinguish whether a species existed as part of two short online activities. The tenth article from Nikolaos Zarkadis, Dimitrios Stamovlasis, and George Papageorgiou investigated the association of 421 eight, tenth, and twelfth grade Greek students' fundamental ideas and misconceptions about ontological features of atom identity and behavior with the formation of their portrayed representations of the atomic structure. The eleventh and final article is from Turkey's Devrim Akgunduz and Canan Mesutoglu who investigated technical and vocational education (TVET) teachers' progress in their knowledge, perceptions, and competencies related to Industry 4.0 components and STEM within the context of a professional development program.

In the first article, Emre Yildiz investigated the effect of the educational game method on the learning achievements of 120 seventh-grade Turkish students with different learning styles. Yildiz's study is founded in experiential learning theory. In this theory, knowledge is formed through the transformation of experiences. Yildiz's study noted that the Kolb inventory classifies students into two dimensions: A preferred perception mode (concrete or abstract) and a preferred processing mode (active experiment or reflective observation). In this study, unlike the general studies in the literature, students at secondary school level were studied to examine the effect of educational games developed in accordance with the learning nature of different learning styles on learning achievement. Yildiz highlights how games enable students to learn through their own experience as a natural learning tool. Specifically, learning is more effective when the learning environment is fun and is also suitable for students with different learning styles, as it includes central elements such as curiosity, adventure, imagination, strategy, role playing, sports, challenge, visualization, problem solving, discovery, experiment, and creativity. After the educational game application, it was determined that there was a significant increase in the learning achievement of the students for all learning styles. Yildiz concludes with potential further areas of research to build on this study.

In the second also from Turkey, Filiz Bezci and Semra Sungur examined 269 eight-grade Turkish school students' scientific reasoning ability in relation to gender and learning environment perceptions. Students' experiences in specific learning environments are very important. Bezci and Sungur note how educational research has highlighted the relationship between learning environment and student outcome. For this study, gender differences in science education outcomes have attracted the attention of science education researchers. Girls and women are commonly reported as exposed to inequalities in science education. In research, it has been reported that teaching science with inquiry-oriented teaching approaches promotes students' scientific reasoning ability. However, large-scaled social responsibility projects and campaigns that have been carried out against the gender inequality in education until recently in Turkey may have played a role in the current finding that boys and girls are similar concerning their scientific reasoning abilities. In this study, the mean scores were quite low for both genders. Thus, this study's findings suggest that necessary action should be taken to improve the scientific reasoning ability of both genders. Bezci and Sungur acknowledged that their findings are limited to the Turkish context but then note further research is needed in other populations.

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The third article from Mexico's David Salgado-Chavarría and Joaquín Palacios-Alquisira used PBL approach to review the Green Chemistry Principles when applied to a polycondensation reaction. Salgado-Chavarría and Palacios-Alquisira sought to improve five Mexican chemistry student's learning experience for a better comprehension of the importance of Green Chemistry. The intention of this project was that students could see the importance of considering greener alternatives during the design and synthesis of new materials. In this study, PBL methodology was used as: It is a student-centered approach that relates the learning process to real-world problems; students work in teams to find and develop a solution; and the teachers/instructors act as facilitators. In this study, while students were assigned different dicarboxylic acids this did not prevent them from working as a team. The students who participated in this project were able to develop important skills and capabilities, such as teamwork; collaboration; analysis, organization, and summarization of the information; critical thinking; problem-solving, and improvement of their oral and written communication skills, along with considering the importance of using green chemistry when designing a process or a product. Salgado-Chavarría and Palacios-Alquisira concluded with recommendations based on this study.

The fourth article by Daniella Molle and Weiqiong Huang highlights the issues around multilingual students in the United States having limited access to rigorous science instruction noting that they are underrepresented in STEM fields in both tertiary study and the workforce. Their paper discusses, the Design Principles for Engaging Multilingual Learners in Three-Dimensional Science a resource published by the Making Science Multilingual (MSM) program. Molle and Huang examined the interorganizational and interdisciplinary collaboration that gave rise to the MSM design principles. Interdisciplinary collaboration is a process that involves professionals from different disciplines and aims to foster the integration of perspectives, concepts, theories, methods, and so on from these disciplines to promote more innovative and holistic solutions to complex problems. Their exploration of interdisciplinary and interorganizational collaboration was based on Bronstein's conceptual framework. The study sheds light on the range of processes that contribute to the success and sustainability of this kind of collaboration. Molle and Huang's study illustrates the interconnections between processes at the organizational, program, and interpersonal levels. However, their analysis contributes to the knowledge base of what makes interdisciplinary collaboration effective. Molle and Huang hope that their study can inform the efforts of scholars and educators who are particularly interested in supporting the academic success of multilingual youth.

Pongprapan Pongsophon and Artitaya Jituafua aimed to develop a LP for botanical literacy and assess the impact of a garden-based education course on 49 Thai pre-service science teachers in the fifth article. The scope of this study was an attempt to validate the botanical literacy construct and examine the effect of the garden-based education course on the botanical literacy of participants. LP represents a promising framework for developing organized curricula and meaningful assessments in science. Well-grounded LPs allow for coherence between science curriculum standards, classroom instruction, and assessments. Pongsophon and Jituafua's study adopted the structural level of scientific literacy as a framework for botanical literacy. At the structural level, students have a conceptual understanding of big ideas and possess procedural knowledge and skills in science; therefore, Pongsophon and Jituafua chose matching and multiple-choice tests in consideration of the content coverage and objectivity. Their study's results are consistent with the previous studies in that the major concepts in botany progress increasingly by complexity: Plant diversity, plant morphology, and plant ecophysiology. Pongsophon and Jituafua concluded with recommendations for future research because of this study.

Jeah May O. Badeo and Bee Ching U. Ong Kian Koc investigated the effect of using a comic-based learning module in Physics as a learning tool on 12–14-year-old Philippine students' conceptual understanding and motivation in the sixth article. Badeo and Koc highlighted that students often find it difficult to understand Physics concepts. Comics is generally underrated as an educational tool as it is frequently seen as nothing more than as a pastime, yet studies in different fields have shown that it can be more than just a mere pastime. Badeo and Koc reported that there are growing number of studies on the use of comics as a tool in the fields of medicine, communication, art, business, and education. Their study used a mixed method approach consisting of a quasi-experimental pretest-posttest design. After the implementation of the comic-based learning module for 4 weeks, a significant increase in students' conceptual understanding in Physics was revealed. Even though pedagogical content knowledge of teachers in teaching Physics plays a significant role in ensuring students' learning, the comics-based learning module should be considered as a factor to teach Physics. Specifically, Badeo and Koc highlighted how inclusion of comics helped motivated these students to learn.

The seventh article by Gonca Kececi, Pelin Yildirim, and Fikriye Kirbag Zengin reports on the effects of science education using MAR application on 143 sixth-grade students Turkish students' attitudes toward science, technology, and their academic achievement. MAR is notable as it can create a flexible teaching process and environment for students by enabling them to control their own teaching processes and provide an effective teaching environment to diversify and enrich education. The mixed method model was used in this study. The research was carried out for a total of 8 weeks for the systems unit in our body, one of the units of the 6th grade science curriculum, was divided into pre-test and post-test applications. During the process, Anatomy 4D application, a MAR application, was used in the experimental group, support and movement system, respiratory system, and circulatory system. It was concluded that even though the mean values of the students in the experimental group in

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which MAR applications were used in classes regarding their attitudes toward science and technology were higher than the mean values of the students in the control group in which standard course books were still applied in classes regarding their attitudes toward science and technology, there was no statistically significant difference between the attitudes of the students in the experimental group toward science and technology and the attitudes of the students in the control group toward science and technology. Kececi, Yildirim, and Zengin concluded with recommendations based on this research.

Similarly, Küçükaydın sought to investigate the relation between scientific attitudes and intellectual risk-taking behaviors of 184 fourth-grade Turkish students in the eight article. Küçükaydın noted that previous research identified scientific attitudes as having four categories, attitudes toward school science, science careers, science itself, and specific issues in science. Küçükaydın goes on to note that more than 1 variable is effective on scientific attitude with intellectual risk-taking behaviors as a category worth examining. This research employed a correlational survey model. This study determined that gender was not a determinant factor for scientific attitude, but for the "exhibiting scientific behavior" dimension of the survey scale, there was a meaningful differentiation in favor of male students. These findings demonstrate how there is not a consensus in the literature on the issue of gender as a determinant factor on scientific attitude. However, the present study revealed that risk-taking behaviors were more prevalent in male students than female students. Küçükaydın suggests potential areas of further research needed in this area.

The ninth article by Shem Unger and Mark Rollins evaluated whether 90 American university students exposed to an apparently credible website were able to distinguish whether a species existed as part of two short online activities. Unger and Rollins noted that over 70% of college graduates are considered scientifically illiterate on some level, meaning they lack the ability to understand basic scientific facts or knowledge related to scientific. They go on to note how students often accept science information at face value or literately without question of veracity since scientific literacy is often not taught in schools. Unger and Rollins' study was a two-part activity investigated whether students were willing to question the veracity of a website describing a false species over a 2-week period. Their study found that many these university students failed to determine the species used in the study were false. Unger and Rollins make recommendations for further study based on their results.

The tenth article from Nikolaos Zarkadis, Dimitrios Stamovlasis, and George Papageorgiou investigated the association of 421 eight, tenth, and twelfth grade Greek students' fundamental ideas and misconceptions about ontological features of atom identity and behavior with the formation of their portrayed representations of the atomic structure. Zarkadis, Stamovlasis, and Papageorgiou reported that students' ideas for the atom characteristics related to its identity and behavior seem to affect their portrayed representations of the atomic structure. Zarkadis, Stamovlasis, and Papageorgiou noted that while there are five categories of student models for the atomic structure described, they are not necessarily stable. Accessing these students' portrayed representations for the atomic structure was achieved through a questionnaire to assess both students' ideas for the ontological features of atom as identity and behavior and their portrayed representations of the atomic structure. Remarkable are the results concerning the effect of students' ideas and misconceptions for the atom characteristics as identity and behavior on their portrayed representations of the atomic structure. These results indicate that the understanding of ontological features of atoms is crucial. The findings of the present study highlight that students' portrayed representations of the atomic structure are quite coherent, presenting a remarkable resistance to change in different contexts, but the effect of the students' knowledge of the atom ontological characteristic as identity and behavior and the cohort characteristics (i.e., the curriculum and the age) seem to affect these representations. Zarkadis, Stamovlasis, and Papageorgiou concluded with recommendations based on this study.

The eleventh and final article is from Turkey's Devrim Akgunduz and Canan Mesutoglu who investigated 39 TVET teachers' progress in their knowledge, perceptions, and competencies related to Industry 4.0 components and STEM within the context of a professional development program. The emergence of Industry 4.0 is leading to more interdisciplinary work in teaching and development of educational knowledge and practices. This underlines the critical importance of STEM education with its focus on an interdisciplinary approach and using new technologies in educational practices. TVET presents a promising context toward a shared STEM education vision with the naturally occurring collaborations with the industry. This study used a qualitative research design to investigate the impact of this 1-year long professional development study on teachers. Findings indicated that the teachers perceived improvement in their Industry 4.0 competencies for all the components, mostly for 3D design and cloud computing. Akgunduz and Mesutoglu concluded with recommendations.

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