

# Approaches and Methods of Science Teaching and Sustainable Development

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Unfortunately, science teaching at the university level has largely consisted of lectures in which the students' position is usually to gather information by listening and taking notes from the instructors [1–3]. However, in science, technology, engineering, and mathematics education (STEM) studies along with science education, new approaches and methods have established increasing devotion in recent years to stipulate appropriate preparations of students' abilities [4,5]. STEM education offers the integration of various scientific disciplines as a solid object, the teaching and learning of which are combined and organized so it can be utilized for problem-solving in daily circumstances [6]. Here, Wiswall et al. proposed that students participating in the courses and undertakings concentrated on STEM subjects attained better results in STEM topics than not participating students [7]. In these situations, to support the satisfaction, association, and motivation of students, various active methodologies could be integrated into the current classroom [8–10]. Despite the STEM methodology's implementation, which encourages students' scientific literacy, however, their disinterest was one of the main origins for negative scientific attitudes [11]. Additionally, an interdisciplinary method could be achieved through this active method in STEM courses. It considers the way to foster a realistic atmosphere with the better student experience as an objective [12,13]. Particularly, the decade of education for sustainability development (DESD) of the United Nations (UN) has designated the current situations of STEM education, which could stimulate the understanding of communal values and spread life-long preparation together with active instruction methods [14–17].

The educational sustainability development (ESD) has chased a life-long awareness and quality for individuals who are in varied educational sectors [1–3]. The DESD of the United Nations Educational, Scientific and Cultural Organization (UNESCO) and the UNESCO 2015–2030 Agenda incorporated the philosophies, objectives, beliefs, and exercises of sustainable education [16–18]. In the higher education context, it must be a part of a universal arrangement proposing sustainability education [19,20]. It can also shape its objective to individuals together with knowledge that will redirect the effects of their performance [19–22]. Specifically, it was elevated to a better comprehension of the notion of sustainability, was reoriented to the educational curricula, and was indicated toward the attainment of information, skills, value, and knowledge [23–25]. Here, sustainable education mentioned by Sterling [26] was conducting into transformative learning that was a modification of educational culture for the potential realization and economic, social, and ecological interdependency of people. Thus, in the same context of transformative learning, Mezirow [27] designated instructors the responsibility of helping students to accomplish more independent and reliable objectives. Finally, teaching resolutions in the context of an instructional culture are considered in approving teacher trainees along with communications, standards, abilities, and thinking methods, which could serve as transition delegates for sustainable development [28–30].

STEM education for sustainable development was associated with knowledge-acting and containing the values of sustainability education [31]. However, a distinct research area



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could have its own dimensions, approaches and aptitudes, and scientific skills, which are not connected with its value [31–33]. Likewise, it was an emergent part within educational science, which had a robust connection to science education for sustainable development [34–36]. Equally, sustainability STEM in higher education was a beginning stage as ever, although they had performed different portions to transform societies/cultures by instructing key persons that were leaders, academics, and entrepreneurs [37]. Accordingly, it was essential to reflect on universities' characteristics that were altering at a comparatively slow pace [37,38]. In the aforementioned challenging situations, the life-long sustainability STEM education can generate a pedagogical probability for filling the niche of the current education system [1,39]. In higher education, the approaches and methods of science teaching for sustainable development are still in an early chapter, without a proper tool, while they could have some possibilities for teaching and learning. With higher confrontations and demands, this proposal can be connected with various active applications and research domains of STEM education in these circumstances [4,40].

With this Special Issue “Approaches and Methods of Science Teaching and Sustainable Development”, we aimed to contribute a solid research corpus for concentrating the challenges required to deliver an adequate Science and Sustainable Development Education to different educational scholars. In many educational institutions, sustainability formed a part of their curricula. Efforts were stipulated for guaranteeing a correct implementation/development of sustainability topics looking for the sustainable development goals (SDGs) in the universities, as well as fresh viewpoints on ongoing challenges.

As a science teaching approach, in the first paper in this Special Issue, Lucian-Ionel Cioca and Raluca Andreea Nerisanu discussed a quasi-experimental and nonequivalent group design, for which the procedure involves the use of visual mnemonic devices. In the potential and boundaries of leading fields of creativity literature, there was always an area for the extension of methods, and novel conceptualizations were always involved. This paper, therefore, presents a concise organization of the methods utilized to improve originality and reflects whether visual mnemonic devices could grow creativity. In the teaching procedure, the devices were employed to relieve the memorizing process by making a graphic demonstration. The results indicated that the abstracting degree was amplified after exploiting visual mnemonic devices, together with fluency and other creativity extents. Accordingly, the paper presented that the creativity was also amplified based on a national percentile scheme once exploiting the visual mnemonics devices, thus representing an example for incorporating visual mnemonic devices amongst the methods to promote originality and creativity (Table A1 Contribution 1).

As an ESD in a problem-based university learnings, Alain Ulazia and Gabriel Ibarra-Berastegi indicated various goals for sustainability connected to not only clean energy and climate change but also in educational terms associated with co-operative learning, motivation, and reflective thinking in the new faculty of Engineering in Renewable Energies at the University of the Basque Country in Eibar. In this sense, the laboratory-windpump challenge situation was paradigmatic since it established effective problem-based learning for the students in the context of the activation of heuristic tools (analogies/diagrams); analytical discussions conjoining complicated thoughts about aerodynamics, mechanics, and hydraulics; and a suitable cluster atmosphere. Here, the conclusions of this paper were reinforced by qualitative and quantitative results inside of a theoretical background on the basis of the discovery logic and its related constructive-learning approach rather than on the justification logic within an aprioristic assumption that is well-known and given (Table A1 Contribution 2).

Thus, in the same context, Muhammad Waqar Ashraf and Faisal Alanezi reiterated that current university curricula utilization was to integrate sustainability components into engineering education. Here, the concepts of sustainability were presented into the courses designated by employing a micro-curriculum method. Higher education institutions (HEIs) are progressively hunting SDGs in engineering and technology education. The concepts correlated with production, operations, and consumption sustained to increase

the significance for students in an engineering major. Therefore, it was required to advance an engineering education program together with the technical contents that also fostered a critical logic regarding the social and environmental fields. The existing sustainability education status in engineering programs suggested in Saudi universities was not very favorable. Furthermore, a standalone course was initiated. It could also be perceived that this attitude had been fruitful in incorporating sustainability into the engineering curriculum. Finally, it was indorsed that such an advance could be employed to grow sustainability consciousness in engineering education/programs (Table A1 Contribution 3).

In addition, in engineering education, Huang et al. offered and exemplified a design-based learning (DBL) method for nurturing individual competency for sustainability. Here, two studies were performed with engineering students in typical activities of educational areas. For the first study, it assisted students in performing a topic-specific design task for the practicum item of a sensor technology course, which paralleled the DBL performance approach and the conventional and passive learning method. For the second study, it directed students to improve innovative projects for contributing in the “Internet Plus” Innovation and Entrepreneurship Competition (IPIEC). The results illustrated that the DBL approach was worthwhile for teaching in sustainability competency in the context of teaching procedures and learning demand. In the DBL group, the students contributed more distinction in individual competencies such as system-thinking, multidisciplinary applications, and collaboration. Therefore, these discoveries proposed that applying the DBL approach to work sustainability competency into engineering education was advantageous for encouraging students’ capabilities to deal with challenges concerning sustainability exercises (Table A1 Contribution 4).

In the STEM areas, it was necessary to progress a comprehensive education and to advance learning competences and student perceptions of these courses. Here, Matos-Núñez et al. examined the teaching efficiency in the view of a cognitive and emotional term of a STEM workshop versus an academic-expositional methodology in the primary science education classroom. With a quasi-experimental design, the research was conducted along with a control and experimental group and a pre- and two post-tests. According to the two teaching methodologies proposed, cognitive, emotional, attitudinal, and gender variables were assessed: the control group with expository academic methodology and the experimental group with active methodology on the basis of a practical STEM workshop development. The results disclosed that both methodologies proposed were correspondingly effectual in short-term education but statistically substantial differences were found in long-term education in favor of STEM workshops. Equally, the STEM workshops principally created positive emotions/attitudes for the students parallel to those the transmission/reception methodology generated in the control group (Table A1 Contribution 5).

In the SDGs’ achievements, Gutiérrez-García et al. described the design, implementation, and assessment of the obtained didactic proposal knowledge for non-formal education that supported controlled education based on botanical content. Firstly, a workshop was held where young individuals contributed directly to emerging fieldwork with a real scientific procedure with the active methodologies’ use based on experiences. Then, a student’s group was selected for an interview to attain the overall concept of the learning gotten. Here, the students’ motivation was somewhat positive, which allowed us to acquire voluntary contribution in the fieldwork and also offered the students as a participative attitude through the workshops’ advance. Concerning the didactic application to its immediate setting, it was shown to upsurge interest in the students’ own learning and value contexts. This educational experience’s results had been highly positive such as the knowledge that was learnt, and the preservation of interest in the environment and the occupation of an investigator was encouraged (Table A1 Contribution 6).

In the cognitive and affective domain study in science education, Ortega-Torres et al. discussed various aspects. Firstly, the motivation and self-perception of Spanish secondary school students were presented by using approaches when acquiring science. Then, the nature of the association between learning strategies’ motivation and observed usage was

examined. Finally, the effect of dissimilar motivational, cognitive, metacognitive, and management approaches on students' science attainment was assessed. Here, the relation between motivation and the usage of learning approaches was an emphasis of study to increase the learning of students. The obtained results from the Pearson's product-moment correlations, the variables, and stepwise regression examination were proposed. Firstly, motivation, cognitive and metacognitive, and resource management approaches had a substantial effect on the science achievement of students. Then, the motivation of students became an enabling feature for the knowledgeable exertion that was measured by the self-perceived usage of science learning approaches. Finally, motivational modules had a greater influence on students' science performance than cognitive and metacognitive approaches with self-efficacy variable as the strongest impact (Table A1 Contribution 7).

In addition, along with the Contribution 5, Nguyen et al. provided a review for pedagogical methods in STEM education, which could be positioned to educate the sustainability concepts. Generally, young persons are society's future for social alteration, and so it was essential to offer proper education that not only prepared them with skills and knowledge but also altered their behavior and attitudes towards ESD. In addition, it indicated how teachers of middle and high school education observed STEM education and how they pertained STEM disciplines integrated in planning projects to adopt development matters in Vietnam. Here, 77 teachers who thought of STEM projects throughout the country were examined. In addition, interviews were conducted with 635 teachers who contributed to the STEM agenda. Participating teachers appreciated STEM education and were willing to employ constructivist pedagogical approaches, which could help to resolve real-world glitches. It was expected that an incorporated STEM method could alter general education into an innovative/inclusive education for social equity and SD (Table A1 Contribution 8).

Through the context of Contribution 6, María-Pilar Molin-Torres and Raimundo Ortiz-Urbano assessed new teachers' training in terms of the particular skills desirable to progress active-learning methods associated with the teaching of heritage sustainability. Within the SD framework, the cultural heritage thought was interrelated with the heritage consciousness of a specific and spatial setting and to the maintenance of collective memory. The study, for this reason, took numerous scientific influences as the background for pondering ESD as a primary tool to recapture and preserve heritage assets both from an informative and an educational view. The results indicated that several opinions were associated with attaining and expediting the implementation of innovative methodologies because of an initial university training shortage. Therefore, this paper generally offered a chance for students to evaluate a sequence of prejudices concerning their working approaches and to overcome extreme theorization in their university educations (Table A1 Contribution 9).

To examine the game performance effects inside of an educational socio-constructivist viewpoint and a supportive learning model, Khalifa et al. firstly manifested a social tool for both teachers and students to gather and accomplish their thought procedures and then a tool to motivate contemplation and critical deliberation on implementation to produce transformation during game-action plans. In this study, with three tests, skill competence was measured. Here, the Loughborough Soccer Passing Test (LSPT), along with a shooting correctness examination, was performed as a 15 m ball dribbling assessment. With the Game Performance Assessment Instrument (GPAI), the performance of the game was evaluated, and the consequence variables measured encompassed decision making, skill execution, support, game performance, and game involvement. However, there were no such enhancements discovered in the dribbling and shooting tests, while both groups indicated noteworthy improvements in their short-passing capability. On the contrary, significant improvements were found only in the verbal interaction group formed in general game performance. Accordingly, verbal interaction might be an operational tool to improving tactical comprehension throughout cooperative learning (Table A1 Contribution 10).

In transdisciplinary ESD, Kubisch et al., looked first at transdisciplinary research and then discussed the potentials of translating this notion into a new education type, which could be called Transdisciplinary Education (TE). Ensuing the adoption of the



SDGs by the community of states, there had been augmented recognition of international education as being a key SD driver. The Science Education for Action and Engagement Towards Sustainability (SEAS) project proposed to target investigations into different corporations between schools and out-of-school institutes in European countries. By the comparison of the collaborative formats and delivering a notion and technique pool for instructors, SEAS aimed to facilitate the integration of TE in the future of formal schooling. This paper gave the insights into the Austrian research education teamwork k.i.d.Z.21. Representing k.i.d.Z.21 experiences and taking up transdisciplinary characteristics research, chances, and experiments of integrating TE in formal schooling were deliberated (Table A1 Contribution 11).

González-Peña et al. exposed learning outside the classroom (LOtC) activities that were part of pedagogical practices, which were presently applied in the students' skill development. The objective of this paper was to regulate faculty and undergraduate students' perceptions regarding industrial visits and to outline these activities' advantages and disadvantages. Here, to examine and compare participants' perceptions on industrial visits such as LOtC activities, descriptive statistics were employed. For constructing industrial visits, the results designated a positive perception, which produced more attention to the class material and assisted students in acquiring knowledge. Despite this examined positive perception, it was found out that lecturers were unlikely to establish industrial visits often because of the work necessary to design, perform, and appraise these activities. It is suggested that about 40% of the students might misplace the advantages of LOtC activities that could be proposed. Here, lecturers should be encouraged and reinforced by administrators to include industrial visits in their courses as a teaching approach to offer an advantageous practice to the students' majority registered in chemistry and sustainability undergraduate programs in the University (Table A1 Contributions 12 and 13).

With the gamification in STEM and sustainability, Yllana, Jeong, and González-Gómez specified that the usage of active and flipped methodologies has amplified in recent years. Escape Room games specially employed as educational tools have teaching-learning potential. Thus, they could be advantageous because of the improvement in students' motivation/emotions towards learning. While the cognitive factor and multidimensional fields were thoroughly associated, this was predominantly valuable in the STEM subjects. With science and sustainability matters, this paper offered an online-based Edu-Escape Room as an educative STEM course tool. It was investigated how this instrument predisposed the multidimensional domain such as attitudes, self-efficacy, and emotions of pre-service teachers (PSTs) with the intervention proposed. Based on attitude and self-efficacy analysis, it was perceived that most of the elements evaluated showed an upsurge in self-efficacy and more positive attitudes afterward toward the proposed intervention. Therefore, there were multiple advantages in the PSTs' multidimensional domain of devouring the proposed online-based Edu-Escape Room (Table A1 Contribution 14).

Along with the Contribution 11, Roberto Araya and Pedro Collanqui mentioned that education was critical for refining energy efficiency and diminishing CO<sub>2</sub> concentration, but teamwork between countries is also critical. Accordingly, the research question of this study was whether synergistic cross-border science lessons with energy experimentations were practicable and could increase energy efficiency consciousness amongst middle-school students. An interactive cross-border session between Chilean and Peruvian eighth-grade classes was planned and confirmed. With the energy efficiency of APEC databases, this was the part of a STEM education project on Asian-Pacific Economic Cooperation (APEC). Here, we found high levels of student engagement. Students deliberated not only the energy cross-cutting characteristics but also its relationship to socioeconomic progress and CO<sub>2</sub> emissions. The interactive cross-border science classes, in conclusion, were a possible educational alternative with probability as a scalable community policy plan for refining energy efficiency awareness amongst the population (Table A1 Contribution 15).

Finally, after COVID-19, the Special Issue was connected to the online and virtual learning. Abouhashem et al. proposed that unprecedented change in educational ped-

agogies because of the COVID-19 pandemic had appreciably disturbed to the students' learning procedure. During the closure of schools in the COVID-19 epidemic, this research explained the development of a STEM-based online course that could solve the limitations of virtual science classrooms, which could assure an active STEM instruction atmosphere. Here, as instructional tools, numerous resources based on digital learning were employed to attain the content objectives. Particularly, a methodology of feedback mechanisms was performed so as to increase online instructional distribution and the role of project learners as a student-oriented approach. Therefore, it could aid the qualitative assessment of course contents. In conclusion, the course assessment, student feedback, and SWOT analysis indicated the need to evaluate the efficiency of the course proposed (Table A1 Contribution 16).

With this Special Issue, we therefore published articles on innovative approaches and developments in education, which could encourage theoretical, methodological, and empirical research works on teaching and learning, competencies and assessment, policy, program development and implementation, instructor preparation, community- and project-based learning, institutional collaborations and partnerships, and other relevant subjects. Particularly, especial emphasis put on innovative teaching approaches and methodologies that had been proved to be relevant on the STEM education, not only considering the cognitive domain of the learning process but also the affective domain, such as flipped-classrooms, blended-learning, gamification, service-learning, etc.

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## Appendix A

**Table A1.** List of Contributions.

No.	Contributions List
Contribution 1	Cioca, L.-I.; Nerişanu, R.A. Enhancing Creativity: Using Visual Mnemonic Devices in the Teaching Process in Order to Develop Creativity in Students.
Contribution 2	Ulazia, A.; Ibarra-Berastegi, G. Problem-Based Learning in University Studies on Renewable Energies: Case of a Laboratory Windpump.
Contribution 3	Waqar Ashraf, M.; Faisal Alanezi, F. Incorporation of Sustainability Concepts into the Engineering Core Program by Adopting a Micro Curriculum Approach: A Case Study in Saudi Arabia.
Contribution 4	Huang, Z.; Peng, A.; Yang, T.; Deng, S.; He, Y. A Design-Based Learning Approach for Fostering Sustainability Competency in Engineering Education.
Contribution 5	Mateos-Núñez, M.; Martínez-Borreguero, G.; Naranjo-Correa, F.L. Learning Science in Primary Education with STEM Workshops: Analysis of Teaching Effectiveness from a Cognitive and Emotional Perspective.
Contribution 6	Gutiérrez-García, L.; Blanco-Salas, J.; Sánchez-Martín, J.; Ruiz-Téllez, T. Cultural Sustainability in Ethnobotanical Research with Students Up to K-12.
Contribution 7	Ortega-Torres, E.; Solaz-Portoles, J.J.; Sanjosé-López, V. Inter-Relations among Motivation, Self-Perceived Use of Strategies and Academic Achievement in Science: A Study with Spanish Secondary School Students.

Table A1. Cont.

Contribution 8	Nguyen, L.T.P.; Huy Nguyen, T.; Khiet Tran, T. STEM Education in Secondary Schools: Teachers' Perspective towards Sustainable Development.
Contribution 9	Molina-Torres, M.P.; Ortiz-Urbano, R. Active Learning Methodologies in Teacher Training for Cultural Sustainability.
Contribution 10	Khalifa, W.B.; Zouaoui, W.; Zghibi, M.; Azaiez, F. Effects of Verbal Interactions between Students on Skill Development, Game Performance and Game Involvement in Soccer Learning.
Contribution 11	Kubisch, S.; Parth, S.; Deisenrieder, V.; Oberauer, K.; Stötter, J.; Keller, L. From Transdisciplinary Research to Transdisciplinary Education—The Role of Schools in Contributing to Community Well-Being and Sustainable Development.
Contribution 12	González-Peña, O.I.; Peña-Ortiz, M.O.; Morán-Soto, G. Is It a Good Idea for Chemistry and Sustainability Classes to Include Industry Visits as Learning Outside the Classroom? An Initial Perspective.
Contribution 13	González-Peña, O.I.; Morán-Soto, G.; Rodríguez-Masegosa, R.; Rodríguez-Lara, B.M. Effects of a Thermal Inversion Experiment on STEM Students Learning and Application of Damped Harmonic Motion.
Contribution 14	Yllana-Prieto, F.; Jeong, J.S.; González-Gómez, D. An Online-Based Edu-Escape Room: A Comparison Study of a Multidimensional Domain of PSTs with Flipped Sustainability-STEM Contents.
Contribution 15	Araya, R.; Collanqui, P. Are Cross-Border Classes Feasible for Students to Collaborate in the Analysis of Energy Efficiency Strategies for Socioeconomic Development While Keeping CO2 Concentration Controlled?
Contribution 16	Abouhashem, A.; Abdou, R.; Bhadra, J.; Siby, N.; Ahmad, Z.; Al-Thani, N.J. COVID-19 Inspired a STEM-Based Virtual Learning Model for Middle Schools—A Case Study of Qatar.

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