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Teachers' Perceptions of STEAM Education

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To cite this article:

Breda, A., Garcia, V., & Santos N. (2023). Teachers' perceptions of STEAM education. *International Journal of Technology in Education (IJTE), 6*(4), 700-719. https://doi.org/10.46328/ijte.563

IJTE
International Journal of Technology in Education
2023, Vol. 6, No. 4, 700-719 https://doi.org/10.46328/ijte.563

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Article Info

Article History

Received:
03 March 2023
Accepted:
21 September 2023

Keywords

STE(A)M education
Instructional approaches
Teacher's perceptions
Teacher's practices

Abstract

The support of academics, professionals, and researchers from the most diverse scientific areas to STEAM education is due to the strong impact it has on preparing citizens for a world of continuous scientific and technological development. Among its benefits, we highlight the improvement of critical, innovative, and creative thinking; the development of problem-solving, collaborative, cooperative, and communication skills; the gain of self-confidence, self-motivation, empathy, and resilience. However, the pace of implementation is not the same in all world regions. Developing and less developed countries have limitations of assorted nature in almost all areas of scientific-technological knowledge. With a consensus on the impact of STEAM Education on the progress of any society, its implementation in developing countries becomes fundamental and urgent. The study described here focuses on Cape Verdean teachers' perception of STEAM education and its integration into their pedagogical practices. It includes the analysis of data collected via a questionnaire adapted from one developed by the community for science education in Europe, SCIENTIX, and reported information on official documents. The findings reflect not only teachers' ideas and beliefs about STEAM education, but also their pedagogical approaches, the resources they (do not) use, and the obstacles they face.

Introduction

The identification of key areas for economic development in the US, namely Science, Technology, Engineering, and Mathematics, triggered the STEM movement that spread throughout the world with significant repercussions in various fields, namely in the field of education. The STEM acronym was introduced in 2001 by the Division of Education and Humanities of the National Science Foundation (NSF) director, the biologist Judith A. Ramaley (Hallinen, 2023). The acronym STEAM was formed as an extension of STEM, to incorporate Arts (A), a wider category of creative and cultural activities that span a wide range of social and practical science disciplines. The emergence of the STEAM concept can be traced back to the numerous research articles in education providing evidence of the arts' potential in enhancing various aspects of student development, including creativity, critical thinking, innovation, collaboration, and interpersonal communication. Recent reports have supported these findings that highlight the arts' positive impact on cognitive skills like spatial reasoning, abstract thinking, divergent thinking, creative self-efficacy, openness to experience, and curiosity (Perignat & Katz-Buonincontro, 2019). Key factors about the importance of STEAM education lie in the development of students' knowledge and skills to understand and use technology appropriately and efficiently and in the opportunities to make them creative and critical problem solvers with transversal knowledge in several areas, promoting transdisciplinary knowledge and skills capable of facing the challenges of the 21st century, preparing them for a range of careers promoting economic growth and competitiveness. Having relevance for all countries, it has particular significance for developing countries. By fostering innovation, pioneering spirit, and technological advancement, STEAM education positions itself as an essential instrument in establishing ideal conditions for the design and implementation of projects attracting an increasingly large number of investments, making sustainable economic growth flourish. It allows the creation of new jobs that respond to the challenges of a globalizing, competitive society in continuous scientific and technological development, enabling developing countries to build up a skilled workforce capable of competing on the international stage. It promotes the knowledge and problem-solving skills needed to address identified challenges, in these countries, namely in healthcare, agriculture, education, and tourism. It also fosters inclusion by providing equal opportunities for all and helps to narrow the gender gap in STEM fields promoting a more equitable society. Unfortunately, the speed of STEAM education dissemination is very different from country to country, being very slow or almost non-existent in countries of the sub-Saharan Africa region. Numerous factors contribute to this variability, including limited access to reliable electricity and inadequate network infrastructure, making communication and dissemination of information highly deficient. Additionally, high levels of poverty and limited financial resources, make it difficult to invest and use new technologies. Unequal access to quality education and low digital literacy rates intensify the situation. Political instability delays the viability of investing in innovative educational policies and scientific and technological advancements. The wide variety of local languages is also an obstacle, making effective communication and dissemination of information difficult. In addition, insufficient investment in research and development negatively affects technological and scientific development.

Cape Verde is one of the African developing countries with a high rate of development. It is a small archipelago of ten islands, of which only nine are inhabited, with an area close to 4000 km2. The educational system is predominantly public and comprises preschool, school, and extra-school education subsystems. The school education subsystem follows the Portuguese model and comprises three levels, basic education, secondary education, and higher education, and also special teaching modalities. Extracurricular education encompasses literacy, post-literacy, and professional training activities. The eight-year Basic Education is mandatory and is organized in 3 sequential cycles, the 1st cycle of 4 years and the 2nd and 3rd cycles, of two years each. Secondary education extends over a duration of 4 years, structured into two consecutive cycles, each lasting for 2 years. The initial cycle serves as a period for reinforcing fundamental education and providing guidance in both academic and vocational pursuits. In the subsequent cycle, there are two distinct teaching paths: one focused on general education and the other on technical education. As reported in the document “Strategic Plan for Education” of the Ministry of Education of Cape Verde (Ministério da Educação, 2017), there is a great imbalance between the frequency of students in the general (50,665 students) and technical (1,629 students) courses, with values close to gender parity, with a slight increase in female students (52%). The vast majority of secondary school teachers have adequate qualifications, needful, however, training in specific areas, particularly in the areas of Science and Technology. The abovementioned report points to a strong decrease in access to the 7th Grade, registering additionally, a gradual increase in the number of dropouts and failures from the 7th Grade onwards. Less than half of the students who enter the 7th grade complete secondary education. In Cape Verde, there are 2 public and 8 private higher education institutions. It is worth mentioning the significant increase in the number of students attending higher education. From 1,810 students in 2001, it increased to 13,700 in 2013, stabilizing since then. In just 12 years, the number of students attending higher education has increased more than sevenfold.

Cape Verde is a country with an enormous potential for the implementation of STEAM teaching and learning contexts, with several factors contributing to this purpose. The literacy rate of ninety-eight percent, of Cape Verdean youths. aged 15 to 24, is astonishing. This becomes even more extraordinary when considering that in 2017, over half of the women in the fifty to fifty-four age group were illiterate, (Ministério da Educação, 2017, p. 22). This high rate of literate young population creates conditions for the emergence of a grounded scientific curiosity, innovation, and creativity, and also for proficiency in the use of technology. Regarding the enrollment indicators in secondary and higher education, those are also higher than the ones provided by countries with comparable economic levels. In addition to the growth in access rates to the different levels of education, the political stability that Cape Verde has been experiencing for some time now allows for the continuity of educational action plans that require medium or even long-term deadlines for their implementation. Close collaboration with Portugal, both at the level of teaching institutions and research centers, facilitates the creation of international partnerships, allowing Cape Verde to realize its potential in these areas. However, despite the significant potential for implementing STEAM education in Cape Verde, there are still several challenges to overcome, which include the need to invest in technological resources, which are limited; in the construction of adequate and modern infrastructures, and in building up developmental professional courses that respond to the demands of the labor market and teachers' qualifications. For a comprehensive understanding of the current state of STEAM education in Cape Verde, we carried out an exploratory research study, involving 62 teachers, focused on the following research questions:

RQ1: What do Cape Verdean teachers think about STEAM education?

By exploring their perceptions, we hope to get an understanding of their attitudes, beliefs, awareness, and understanding of STEAM education and how it can benefit Cape Verdean students.

RQ2: To what extent do Cape Verdean teachers integrate STEAM approaches into their practices?

By investigating Cape Verdean teachers' practices, we expect to get a grounded picture of how STEAM education is being implemented in the country.

RQ3: What are the constraints faced by Cape Verdean teachers in implementing STEAM contexts?

By addressing the specific needs of Cape Verdean teachers and students, we can suggest actions that lead to real equitable and inclusive STEAM education practices.

In our study, we invited Cape Verdean teachers to provide their insights and contributions regarding the utilization and scope of 12 specifically identified instructional approaches in their teaching practices. The following section presents a concise overview of these approaches. Next, we describe the methodology used to carry out the study, followed by the presentation of the results and respective discussion derived from the statistical analysis of the collected data. Finally, the conclusions derived from this exploratory research study are presented.

Instructional Approaches

In the context of STEAM education, there is a strong emphasis on active learning methodologies such as Project-Based Learning (PBL), Inquiry-Based Science Education (IBSE), and Flipped Classroom (FC), which places students at the center of the learning experience and encourages them to solve problems by modeling real-world situations or tackling complex contextualized problems. In a PBL context, students are encouraged to work collaboratively and cooperatively and to think critically about the project/problem they have to tackle. Competencies related to problem-solving and creativity are two of the skills, among many others, that necessarily come into play. Students, immersed in this approach, experience the development of teamwork triggered by a problem or project with real meaning. For the beginners of this type of approach, will be the emergence of new and challenging skills, and for others the development of those same skills. Hawari and Noor (2020) describe a teaching experience in arts education emphasizing the potential benefits of integrating project-based learning (PBL) in a STEAM context. In the conclusions they present, they refer to the positive impact of its use on the development of students' personalities and knowledge, among others.

Usually, the constraints pointed out in the implementation of STEAM contexts are low connection with the real world, significant dependence on the methodology to be used considering the teachers' profile, and the guarantee of transdisciplinary between the different disciplines (Montés et al., 2023). As stated by Capraro et al in Lu et al. (2021, p. 2555), "STEM education is not just about consolidating different disciplines, teachers should pay more attention to the interaction between subjects as well as the correlation between subject knowledge and pedagogical content knowledge". Implementing a STEAM teaching and learning approach poses a significant challenge for teachers. Moving away from traditional instructional models that prioritize mono-disciplinary instruction to an approach that emphasizes transdisciplinary integration and collaboration represents a major change. This paradigm shift requires very motivated and highly qualified teachers, who must master not only their scientific teaching areas but also possess advanced technological, scientific, and pedagogical skills. To achieve this transformation, it is imperative to develop coordinated efforts to align the curricula of the different disciplines and guarantee the necessary resources for its implementation. As noted by Nadelson and Seifert (2017), it is clear that this change is a medium-to-long-term process requiring substantial resources and a comprehensive curricular restructuring. There are studies reported in the literature where curricula and STEAM projects are strongly connected. Jia et al. (2021) present a framework for developing an integrated STEAM-Maker (learning by making) curriculum, which is explained in detail. The implementation of a new elementary school course based on interdisciplinary principles of STEAM-Maker integration revealed positive changes in students' learning motivation and self-efficacy.

Despite several studies indicating the potential of STEAM-PBL instruction, few studies are focused on mathematics learning. To analyze the classroom implementation of PBL approaches in a STEAM context, from the point of view of mathematics learning, Diego-Mantecón et al. (2021) examined 41 classroom experiences (projects) of 11 Spanish secondary school teachers, who participated in a pluriannual (more than 4 years) STEAM training program. Out of these, only 25 incorporated some kind of mathematical content, with 15 of them requiring medium-high mathematics knowledge and promoting positive attitudes toward this scientific area. One of the conclusions of this research study was that, given the necessary time and monitoring, teachers can move from implementing monodisciplinary to interdisciplinary and even transdisciplinary projects.

Next, we will make a summary of the twelve teaching approaches indicated in one of the sections of a questionnaire distributed to Cape Verdean teachers, where they were asked to indicate the frequency they used each one of them. in their teaching practices. A 4-category Likert scale (never, occasionally, sometimes, and often) was used for this purpose. The instructional approaches in consideration are the following: Traditional Direct Instruction (TDI), Teaching with Experiments (TWE), Project-/Problem-Based Learning approach (PBL), Inquiry-Based Science Education (IBSE), Collaborative Learning (COL), Peer teaching (PT), Flipped Classroom (FC), Personalized Learning (PL), Integrated learning (IL), Differentiated Instruction (DI), Summative Assessment (SA), and Formative Assessment, including self-assessment (FA).

Traditional Direct Instruction – TDI

By traditional direct instruction, we mean a structured teacher-centered approach, with the teacher providing information/knowledge to students and guiding them in their learning process. The teacher focuses his classes on the delivery of curriculum content, hoping that students will take the necessary/appropriate notes, clarify their doubts and, based on the knowledge passed on, complete the proposed tasks. It is a teaching approach where teachers have a high level of control, mastering content knowledge, and skills. Traditional direct instruction often focuses on memorizing facts and routines and tends to prioritize content learning, uniquely to apply it to a predetermined set of instructions, leaving little room for innovation or thinking outside the box. Traditional direct instruction has received much criticism being identified as limiting students' creativity and critical thinking, including a lack of student engagement which can result in boredom and disinterest, hindering the learning process, (Santyasa et al., 2020; Baran et al., 2018; Samsudin et al., 2018; Kirschner et al., 2006; Sweller, 2003), but its effectiveness in promoting knowledge and certain skills are also mentioned. According to Mayer (2004),

A basic premise in constructivism is that meaningful learning occurs when the learner strives to make sense of the presented material by selecting relevant incoming information, organizing it into a coherent structure, and integrating it with other organized knowledge. It follows that instructional methods that foster these processes will be more successful in promoting meaningful learning than instructional methods that do not (p. 17). Also, Gersten et al. (1986) refer that "low-performing students repeatedly show higher academic achievement when their teachers follow a consistent practice of demonstration, guided practice, and feedback". With this approach, students can practice and develop basic routine skills, teachers can cover a wide range of curricular topics in a relatively short time, and teacher-student interaction allows clarification of doubts and misunderstandings, promoting a deeper understanding of the material under consideration.

Teaching With Experiments – TWE

Teaching with experiments involves activities in which students work, usually in groups, on carefully designed inquiry questions. Observing, doing, and reflecting constitute a basic trilogy of knowledge construction. In working with experiments students use resources such as simulation tools and lab materials to collect data resulting in discovery-based learning experiences (Pedagogy in Action, 2023). TWE allows the discussion of issues that may not even have been anticipated at the outset and creates opportunities for mediation between peers and teacher-student(s) promoting retention and a deeper understanding of the concepts inherent to the experiments (Emerson, 2014). It is a rewarding approach for both students and teachers as, on the one hand, it awakens students' intellectual curiosity, but also provides an enjoyable interaction between them and their teacher, raising the instructor's satisfaction (Li & Wong, 2018). However, preparing and performing experiments is usually time-consuming and may require expensive or dangerous materials that need to be continuously monitored. But we must be aware that sometimes the collected data lead to inconclusive results, resulting in demotivation, and lack of interest in the subject under study.

Project/Problem-Based Learning – PBL

The Project/Problem-Based Learning (PBL) approach is designed to be student-centered, meaning that students must take an active role in their learning. Engaging students in PBL learning contexts make them responsible for both the content they learn and the methods they use to learn it. It helps them in improving their confidence and autonomy. Collaborative work to solve an open-ended or complex is one of the central components of this approach, giving rise to moments for the development of collaboration and communication skills. Furthermore, PBL is deeply rooted in applying knowledge to real-world situations, allowing students to develop problem-solving skills and create links between theoretical concepts and practical techniques. However, the process of designing, preparing, and implementing a PBL instructional intervention is incredibly time-consuming, resulting in less time left to meet curriculum requirements. Effective guidance from highly qualified and pedagogically committed teachers is essential for successful PBL implementation. In addition to the difficulties in managing group dynamics, assessing student learning in PBL contexts is extremely complex. The number of parameters and the respective weights to be taken into consideration are demanding challenges that teachers face.

Inquiry-Based Science Education - IBSE

Scientific inquiry in science education is focused on problems allowing the development of scientific knowledge of the world around us. Bybee, (Strat and Jegstad, 2022, p. 3), identifies three main objectives for incorporating research into education. The first objective is to help students in understanding research processes, focusing on their conceptual knowledge (acquiring knowledge about scientific phenomena and understanding how science is developed) and procedural knowledge (focused on teaching students to carry out investigations as a process). The second objective highlights how students can develop specific cognitive skills while engaging in inquiry. These skills are among the so-called 21st-century skills (OECD, 2018), including, problem-solving, critical thinking, creativity, and collaboration skills. The third goal lies in considering inquiry as a pedagogical strategy, giving learners space and structure for observation, experimentation, and construction of knowledge.

The IBSE approach is particularly adequate to promote the development of research skills (Edelson et al., 1999), including, see Figure 1, "identification and refinement of research questions; formulating hypotheses and/or making predictions; planning, managing and carrying out investigations … data analysis and evaluation; interpretation of results; developing explanations; construction and use of models" (Constantinou et al., 2018, p. 5). However, inquiry-based science learning is often seen as an impractical approach to teaching science in secondary education (Fitzgerald et al., 2017). This skepticism is shared by many other researchers and educators. It is worth mentioning that empirical studies corroborate the widely held view among researchers that faithful IBSL is rarely implemented in real classrooms, (Danaia et al., 2013; Capps & Crawford, 2013), which makes the discussion around it very complex, not to say useless.

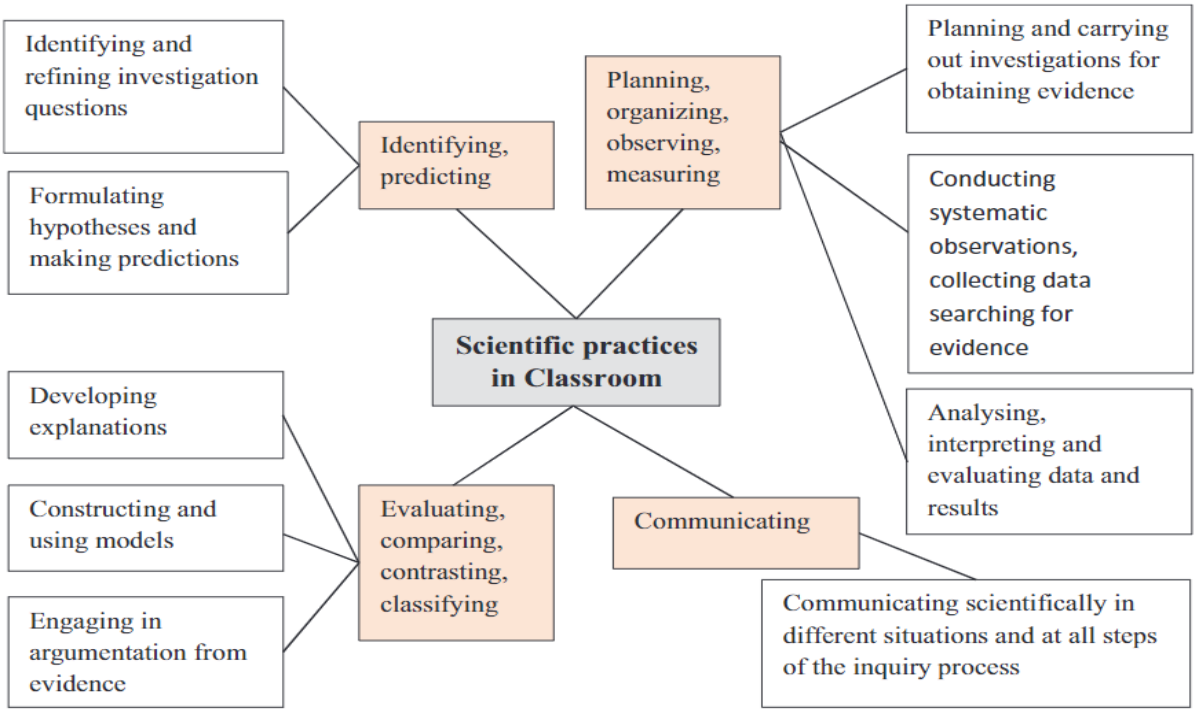

Figure 1. Scientific Practices Fostering Classroom Inquiry in Science Education (NRC, 2000)

Collaborative Learning – COL

Collaborative learning (COL) refers to a set of instructional approaches and techniques that foster student collaboration within small groups, aiming to improve individual and collective learning outcomes. Through collaborative learning, students improve their academic knowledge and develop essential interpersonal, communication, and teamwork skills. Research in education places it as one of the most used and successful approaches to learning and teaching in every subject area, crossing all levels of education, Basic, Secondary, and Higher (Williams & Svensson, 2020; Johnson & Johnson, 2009).

Peer Teaching – PT

Peer teaching is an instructional approach where students assume the role of teachers to assist and guide their fellow peers in learning. In this method, the student playing the teacher's role shares knowledge with his colleagues, using a simplified language that both parties, he and his peers, can understand, deepening his understanding and helping his peers to build new knowledge, (Topping, 1996).

Flipped Classroom – FC

In the flipped classroom pedagogical model, students prepare in advance, and outside the classroom, for the face-to-face class, they will have soon. To deal with new topics that will be discussed and worked on in the classroom, in an active learning dynamic, they can make use of videos, texts, and any other pedagogical resource, some of them previously delivered by their teachers, (Bergmann & Sams, 2012). As mentioned in several studies (Hidayah & Mustadi, 2021; Latorre-Cosculluela et al., 2021; Akçayır & Akçayır, 2018), the FC model brings several benefits to students. Of these, we highlight motivation (learning in an unexpected situation did not affect their interest in the FC model, on the contrary, students were willing to participate and collaborate to do better), its flexibility to different learning styles, the real-time feedback, and assessment data (teachers have more time during class to observe and interact with students). Among the challenges and constraints associated with the FC model are the preparation and responsibility that falls on the students (the flipped classroom only works if the students get involved with the materials made available for their autonomous exploration) and the time teachers need to prepare the materials for their students.

Integrative/Integrated Learning – IL

Integrating/Integrated Learning involves the integration of distinct knowledge areas, creating opportunities for students to develop multiple skills and providing deeper learning experiences for students. The focus is on incorporating multiple perspectives, from distinct fields, and employing them creatively and innovatively to develop a more inclusive understanding of the subject. As mentioned by Haapaniemi et al. (2019), an essential competence of the 21st century is to make sense of the complex and enormous flow of information that reaches each one of us, making it clear how important it is for students to be able to link dispersed information.

However, as stated by Milanković Jovanov et al. (2022) integrative learning is much more than linking dispersed information, "integration means the unification of certain parts into one whole and the interconnection of autonomous elements" (p. 4). For a comprehensive overview of principles and practices for learning focused on student empowerment and self-development based on intentionally integrated learning opportunities and experiences, see Ferren and Paris (2022). IL is also a quite time-consuming instructional approach requiring highly qualified teachers.

Personalized Learning – PL

Personalized learning is an instructing strategy that tailors the learning speed and strategies to the specific needs of each student. In other words, it aims to customize learning to each student's strengths, needs, skills, and interests (US Department of Education, 2017). Personalized learning has become increasingly prevailing since the beginning of the 21st century. It can be implemented by making use of different means and resources such as intelligent learning systems; intelligent tutoring systems; flexible curricula; learning management systems; mobile learning; and diversified learning materials (Li & Wong, 2020). Although evidence reported in the literature suggests that PL projects generally promote the learning outcomes for which they were designed there is still no robust empirical basis to validate them. The reported investigations do not produce clear evidence of the effects that personalization design choices have on student outcomes, limiting both the development of a cohesive theory of personalized learning and confidence in the design to follow for a PL implementation, (Bernacki et al., 2021).

Differentiated Instruction – DI

Differentiated instruction is a commonly used term to describe a variety of teaching strategies, including curriculum planning, assessment and monitoring, instruction, and classroom organization, meeting the individual needs of each student (Tomlinson, 2014). The teachers' role in a DI context is to provide students with alternative ways to learn as deeply and as quickly as possible without assuming that one student's learning path is identical to everyone else's. Guiding principles include, among others, planning lessons, establishing, at a minimum, the learning objectives to be met; continuously collecting data from each student, to be able to quickly plan the consequent adaptations; working with flexible groups of students (full class, small groups, and individually); integrating formative and summative assessment assignments, appropriate for all students, and adjusted as needed (Tomlinson, 2014; Gibbs, 2023). This is an instructional approach that teachers find difficult to understand, and how it should be implemented in their classroom. Some studies point to differentiated instruction practices in primary education as having the potential to improve student outcomes, when well implemented. Unfortunately, there are no indications that these results may be generalized to other levels of education (Smale-Jacobse et al., 2019).

Summative Assessment – SA

Summative assessment is a widely used instructional approach to assessing student learning at the end of a course or learning unit by measuring, against a standard or benchmark, the knowledge, and skills described in the curriculum or learning objectives that a student acquired during the instructional period. This approach has a dual role in terms of feedback. By evaluating their students, the teacher perceives what was less or more apprehended by a student or by a group of students, and can reflect on the reasons that led to this. On the other hand, the feedback each student receive is an opportunity to clarify his misconceptions and mistakes. But summative assessment covers only a small part of the curriculum content, and therefore the teacher's knowledge of each student's progress is very incomplete.

Formative Assessment – FA

Formative assessment also known as assessment for learning is an instructional approach whose purpose is to guide students' learning processes and improve students' learning outcomes. Its effectiveness is directly related to gathering evidence about student learning and using them to guide student learning. Meaningful feedback is a central procedure in any FA instruction context (Lui & Andrade, 2022; Morris et al., 2021).

Method

In this study, our main objective is to obtain a comprehensive understanding of the current state of STEAM education in Cape Verde, considering the research questions, previously stated: (RQ1) What do Cape Verdean teachers think about STEAM education? (RQ2) To what extent do Cape Verdean teachers integrate STEAM approaches into their practices? (RQ3) What are the constraints faced by Cape Verdean teachers in implementing STEAM contexts?

We employed a descriptive and interpretive mixed-method approach. The data required for our study were gathered from official documents provided by the Cape Verdean Ministry of Education and other relevant entities, and from a questionnaire adapted from the SCIENTIX community for science education in Europe survey instrument, aiming to collect information about European teaching practices in STEM education. This questionnaire has been carefully modified to suit the specific context of Cape Verde. It contains multiple-choice and open-ended questions, allowing teachers to provide information about their teaching practices and their experience with STEAM education. The adapted questionnaire was applied online, and collaboration with the University of Cape Verde entities was essential for its dissemination among teachers, ensuring the questionnaire's visibility within the educational community. Ethical considerations were carefully pondered. The confidentiality and anonymity of the participants' responses were rigorously preserved during the data collection and analysis processes. Limitations to have into consideration when interpreting the data are the sample size, possible biases, and the scarcity of available official documents, which may prevent the generalization of the results.

Participant Characterization

The questionnaire was answered by 62 Cape Verdean Basic and Secondary Education teachers. Knowing the age distribution of teachers is an important factor to be considered, as age is intrinsically related to factors such as experience and skills, motivation, job availability, and greater or lesser ease in using technology. As reported by Joye & Wilson (2015) and Passey (2021), younger teachers may have more up-to-date training and proficiency with digital technologies, which can be useful in subjects that require the use of technological resources. On the other hand, experienced teachers, due to many years of teaching practice, are much more prepared to deal with unexpected and tense situations that may arise in the classroom, and above all to guide their students considering their profiles and educational needs.

The distribution according to the age of the respondent and considering the five age groups - (1) less than thirty years old, (2) thirty to thirty-five years old, (3) thirty-six to forty-five years old, (4) forty-six to fifty-five years old, and (5) over fifty-six years old - is shown in the bar chart illustrated in Figure 2. We thus observe that most of the participants in the study are in the age group between 36 and 45 years old (35.5%), being worth mentioning that teachers under 36 years old represent 50% of the sample, indicating that there was a time when a high number of graduates opted for a teaching career and that this influx is continuous and constant. In addition, a predominantly young teaching staff enhances the use of new perspectives and technologically supported innovative teaching approaches.

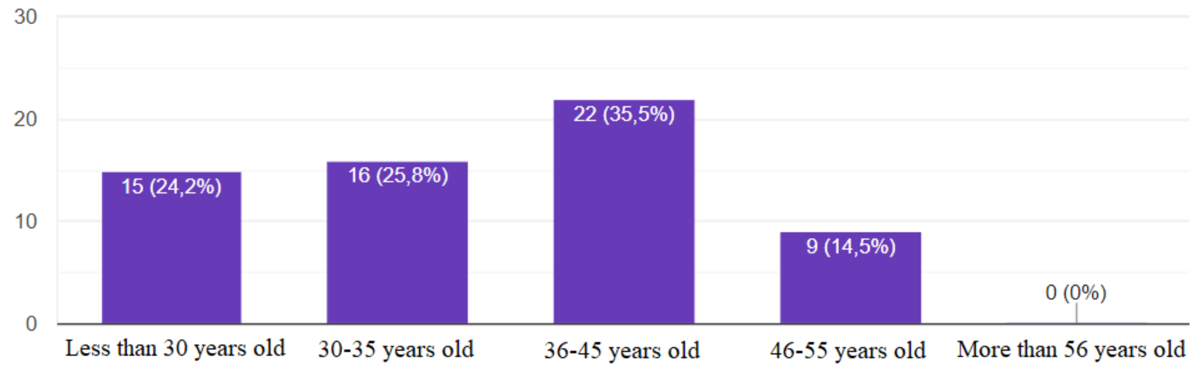

Figure 2. Distribution of Teachers according to their Age

The distribution of the participant teachers based on their years of teaching experience and considering six categories (less than four years, four to ten years, eleven to twenty years, twenty-one to thirty years, thirty-one to forty years, and over forty years) is represented by the bar chart shown in Figure 3.

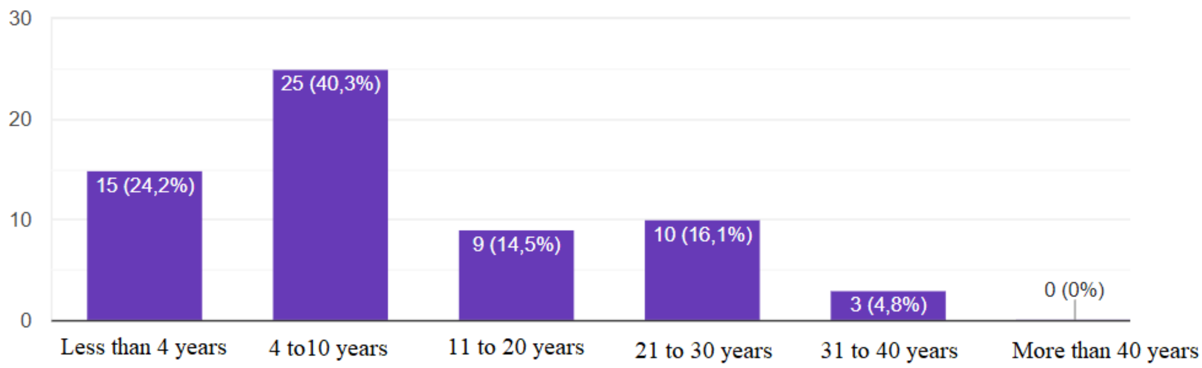

Figure 3. Distribution of Teachers based on Teaching Years

Data reveal that the vast majority of teachers (64.5%) have been teaching for ten years or less, with 40.3% of participants teaching between four and ten years, reinforcing both the continuous entry of new teachers into the Cape Verdean educational system and the existence of a period in which the entries, in the teaching career, were truly admirable. The sample is in line with what is written in the strategic plan of the Cape Verdean Ministry of Education, where it is stated that the student-teacher ratio decreased from 28.7 in 2000 to 21.7 in 2014, a fact which is even more pronounced in higher education, where the ratio stands at 12 (Ministério da Educação, 2017, p. 41). The percentage of professors with more than twenty years of experience is also high (30.9%), bringing added value from the pedagogical point of view. The landscape of the teachers' years of experience of teachers reveals a strong potential for effectively integrating STEAM education in Cape Verde.

Out of the 62 teachers who answered the questionnaire, 57 provided information about the island where they teach. The demographic distribution of the 57 teachers is represented by the bar chart in Figure 4. The sample includes teachers who teach on seven of the nine inhabited islands of Cape Verde, with the majority of respondents, 49%, teaching on the island of Santiago, the most populous island in Cape Verde, followed by São Nicolau, 23%, Santo Antão, 12%, and São Vicente, 9%. The remaining three islands represent the remaining 8% of respondents.

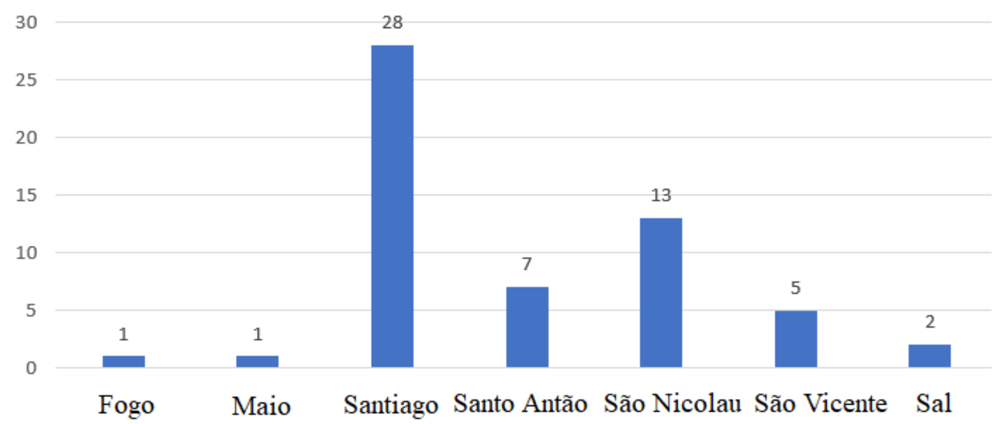

Figure 4. Teachers' Distribution across the Islands

Data Analysis

The collected data, supported by the questionnaire delivered online, and by the information obtained from official documents, were analyzed employing both descriptive and interpretative methods. The descriptive analysis consisted of searching for patterns of responses, frequencies, and distributions that would allow us to understand how Cape Verdean teachers perceive and incorporate STEAM approaches into their practices. The interpretative analysis, which was derived from both the quantitative and qualitative data, revealed teachers' perspectives and interpretations about the twelve instructional approaches, in focus on the research study, also identifying the challenges they face in their daily pedagogical practices.

Results and Discussion

Let us begin by describing, analyzing, and interpreting, in detail, the data gathered through the questionnaire answers. In response to the first questionnaire query:

Are you familiar with STEAM Education? If yes, where did you first come across it?

Among the respondents, 49 teachers (79%) indicated they were unfamiliar with STEAM Education, while only 13 (21%) replied to have heard about it. Out of these thirteen teachers, seven mentioned hearing about STEAM Education when attending a teacher training course, with 3 of them specifically referring to GeoGebra training courses, while four teachers reported discovering STEAM education through online searches (Google). The other two teachers mentioned that they learned about STEAM education through conversations with colleagues. The reduced number of positive responses indicates a significant lack of awareness or familiarity with STEAM education among the sampled population, suggesting that STEAM contexts are not yet widely implemented or discussed within the teaching practices of the respondents or in the programs for their professional development.

Concerning the second query,

What instructional approaches do you use in your classes?

Participants were asked to specify the frequency with which they employed various instructional approaches in their classes. These approaches were categorized as follows: Traditional Direct Instruction (TDI), Teaching with Experiments (TWE), Project-/Problem-Based Learning approach (PBL), Inquiry-Based Science Education (IBSE), Collaborative Learning (COL), Peer teaching(PT), Flipped Classroom (FC), Personalized Learning (PL), Integrated learning (IL), Differentiated Instruction (DI), Summative Assessment (SA), and Formative Assessment, including self-assessment (FA).

To gather the corresponding information, a Likert scale was utilized, ranging from "1-Never" to "4-Often." Additionally, a brief explanation was provided for each instructional approach to ensure clarity, see Table 1.

Table 1. Instructional Approaches (IA)

IA	**(1)**	**(2)**	**(3)**	**(4)**
Traditional Direct Instruction (TDI)	6	7	36	13
(lessons focused on the delivery of content by the teacher and the acquisition of content knowledge by the students).	9.7%	11.3%	58.1%	21%
Teaching with Experiments (TWE)	3	6	27	26
(experiments are used in the classroom to explain the subject matter).	4.8%	9.7%	43.6%	41.9%
Project/Problem-Based Learning (PBL)	3	5	23	31
(students are engaged in learning through the investigation of real-world challenges, problems/projects).	4.8%	8.1%	37.1%	50%
Inquiry-Based Science Education (IBSE)	3	20	28	11
(students design and conduct their own scientific investigations).	4.8%	32.3%	45.2%	17.7%
Collaborative Learning (COL)	0	4	33	25
(students are involved in joint intellectual efforts with their peers or with their teachers and peers).	0%	6.5%	53.2%	40.3%
Peer Teaching (PT)	0	3	16	43
(students are provided with opportunities to teach other students).	0%	4.8%	25.8%	69.4%
Flipped Classroom (FC)	11	17	26	8
(students gain the first exposure to new material outside class, and then use classroom time to discuss, challenge and apply ideas or knowledge)	17.8%	27.4%	41.9%	12.9%
Personalized Learning (PL)	4	4	22	32
(teaching and learning are tailored to meet student’s interests and aspirations as well as their learning needs).	6.5%	6.5%	35.4%	51.6%
Integrated Learning (IL)	1	7	30	24
(learning brings together content and skills from more than one subject area).	1.6%	11.3%	48.4%	38.7%
Differentiated Instruction (DI)	1	7	27	27
(classroom activities are designed to address a range of learning styles, abilities and readiness).	1.6%	11.3%	43.5%	43.5%
Summative Assessment (SA)	5	6	16	35

IA	(1)	(2)	(3)	(4)
(student learning is evaluated at the end of an instructional unit and compared against a benchmark or standard)	8%	9.7%	25.8%	56.5%
Formative Assessment, including Self-assessment (FA)	0	8	18	36
(student learning is constantly monitored and ongoing feedback is given; students are provided with opportunities to reflect on their own learning).	0%	12.9%	29%	58.1%

(1) - Never; (2) - Sporadically; (3) - Sometimes; (4) - Often

The corresponding grouped bar chart, shown in Figure 5, makes it readily apparent that active and collaborative learning approaches are highly favored among participating teachers. Peer teaching (PT), collaborative learning (COL), and formative assessment (FA) emerge as particularly popular teaching methods, often employed by most teachers.

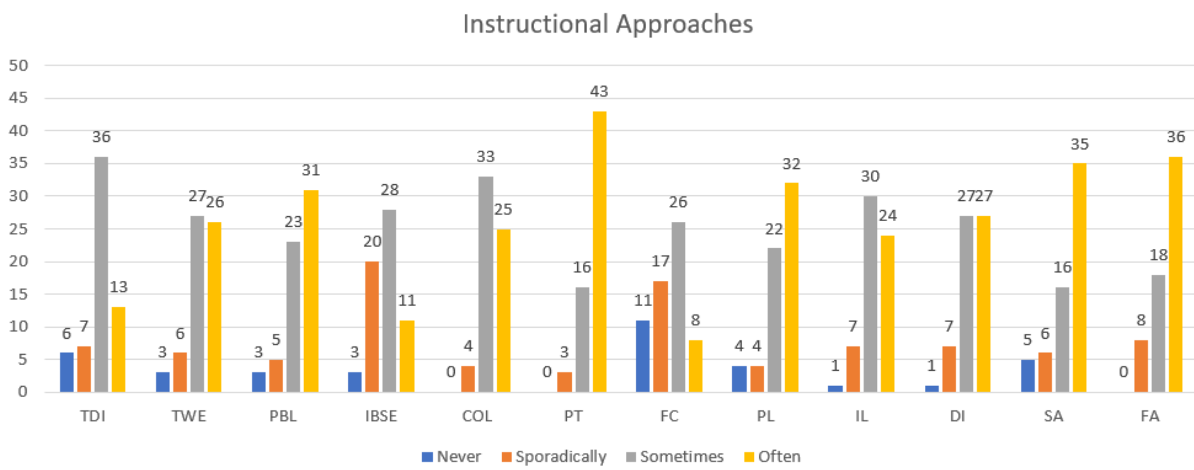

Figure 5. The Use and Extent of the Twelve Instructional Approaches

The popularity of peer teaching (PT) and collaborative learning (COL) suggests a strong emphasis on student engagement and recognition of the benefits of cooperative learning experiences. In addition, the frequent use of formative assessment (FA) highlights the importance given by teachers on continuous monitoring, and on the feedback provided to students, in assessing student progress and promoting learning. This suggests that teachers prioritize assessing student understanding and providing guidance for improvement. We can also observe that the response pattern for each instructional approach varies widely.

It is worth mentioning that a substantial number of teachers consistently employ personalized learning (PL), differentiated instruction (DI), and project/problem-based learning (PBL) approaches, which means that teachers recognize the importance of adapting instruction to meet individual needs, interests, and abilities of students, and value real-world connections and hands-on experiences in the learning process. Traditional direct instruction (TDI) continues to be widely employed. A significant majority of teachers incorporate TDI, regularly, into their teaching practices, suggesting that TDI remains one of the most prevalent teaching approaches. It can also be observed that the adoption of the flipped classroom (FC) and inquiry-based science education (IBSE) approaches is relatively lower. The lower usage of these approaches may indicate teachers' unfamiliarity with these approaches, perceived challenges in their implementation, or greater confidence in more traditional instructional methods.

While the findings reveal that Cape Verdean teachers are generally unfamiliar with STEAM education, respondents reported the use of active learning and innovative approaches, sounding us as an apparent contradiction. This may be explained by considering either their teaching experiences or their preconceived ideas about the purpose and intention of the questionnaire, or even both. It may happen that teachers have discovered, through their experience. that active learning and innovative approaches enhance student engagement, participation, and learning outcomes, even without explicit knowledge of STEAM approaches, but it may also happen that teachers' preconceived ideas about the purpose and intention of the questionnaire viewing it, for instance, as an instrument for assessing their professional performance emphasize active learning and innovative approaches in their responses.

In response to the third questionnaire query,

> *Describe what you consider to be the biggest obstacles to your teaching practices to employ a STEAM instructional approach (that is, an approach using science, technology, engineering, arts, and mathematics as access points to guide students' research, dialogue, and critical thinking),*

Respondents identified several constraints. Among them, we highlight the followings: a shortage of equipment (overhead projectors, graphing calculators, and computers); highly inadequate school infrastructure (inefficient electricity supply and inefficient internet access, among others); high deficiency in scientific, pedagogical, and, above all, technological professional development programs for teachers; and increasing number of disinterested and unmotivated students in STEAM core areas, principally in mathematics.

The scarcity of electronic equipment and poor internet access restricts the use of STEAM contexts in schools, limiting student participation in activities requiring the use of technology. The official entities are well aware of the obstacles identified by teachers. The Strategic Plan for Education (Ministério da Educação, 2017) emphasizes the importance of adapting and renovating school infrastructure to align with the curriculum's requirements and the new pedagogical management paradigm (p. 43). Furthermore, it recognizes the significance of the pedagogical aspect in the development of compulsory education and acknowledges the value of teachers and researchers. To this end, there is a recommendation to increase the number of teachers with Ph.D. qualifications (p. 44). Training and qualification of teachers are also a concern of the official entities, who identified as priorities, among others, the reinforcement of teacher training and developmental professional programs at all levels and modalities of education, the need for pedagogical support for teachers, in the new curriculum contents and in the recommended approaches for its implementation (p. 44).

In summary, considering research question RQ1 (*What do Cape Verdean teachers think about STEAM education?*), the study findings indicate that Cape Verdean teachers have limited awareness or familiarity with STEAM contexts, which are not usually implemented or discussed in their teaching practices or professional development programs. Only a small percentage (21%) of teachers had heard about STEAM education, primarily through teacher training courses, online searches, or informal conversations with colleagues. Concerning research question RQ2 (*To what extent do Cape Verdean teachers integrate STEAM approaches into their practices?*), the instructional approaches used by Cape Verdean teachers suggest a preference for active and collaborative learning, but it is not clear to what extent they integrate STEAM-specific approaches into their practices. Finally, regarding research question RQ3 (*What are the constraints faced by Cape Verdean teachers in implementing STEAM contexts?*), Cape Verdean teachers identified several constraints including, lack of student interest, lack of teachers' technological competencies, inadequate infrastructures, and deficiency in training and professional development programs. In conclusion, the provided data suggests that Cape Verdean teachers are using a mix of traditional and modern instructional approaches, with an emphasis on collaborative, personalized, and real-world learning. However, the Flipped Classroom approach remains less popular, which may justify further investigation into the reasons behind its limited adoption.

Conclusion

The data collected from the questionnaire and analyzed through descriptive and interpretative methods revealed that STEAM education is not widely implemented or discussed within the teaching practices or professional development programs of Cape Verdean teachers due to their limited awareness or familiarity with it. While the teachers' unfamiliarity with STEAM education might suggest a contradiction, their reported use of active learning and innovative approaches can be attributed to factors such as their own teaching experiences, professional development, and preconceived ideas about the purpose and intention of the questionnaire. These factors may have led them to employ these approaches, even without explicit knowledge of STEAM education.

Through analysis of the teaching approaches used by Cape Verdean teachers, it is clear that active and collaborative learning methods are the preferred ones. Peer teaching, collaborative learning, and formative assessment are some of the most used approaches mentioned by study participants. These methods promote student engagement, create cooperative learning experiences, and require continuous monitoring and feedback. In addition, personalized learning, differentiated instruction, and project/problem-based learning approaches are also used by a substantial number of teachers, highlighting the importance given by them to adapting teaching to individual student needs and to the integration of real context problems.

Traditional direct instruction remains a common approach among teachers, while inquiry-based science education and flipped classrooms have low adoption rates. This happens, perhaps due to the lack of familiarity of teachers with these instructional approaches or the need for more research on their implementation and effectiveness. Further exploration and analysis of the reasons behind the lower utilization of IBSE and FC approaches can provide valuable insights into teachers' preferences and priorities.

Regarding the constraints faced by Cape Verdean teachers in implementing STEAM contexts, the respondents identified several challenges: a scarcity of computer resources, lack of student interest and motivation in STEAM core areas, low teachers' technological competencies, scarcity of educational resources and materials, insufficient infrastructure, and shortage of training and professional development programs. We can then derive the following conclusions. There is a clear and urgent need for training and professional development programs. These programs should focus on providing teachers with the necessary pedagogical, scientific, and technological knowledge and skills to efficiently integrate STEAM into their teaching practices, (Costa et al., 2022; Conradty & Bogner, 2020; Gardner et al., 2019).

Acknowledgments

This work was supported by The Center for Research and Development in Mathematics and Applications (CIDMA) through the Portuguese Foundation for Science and Technology, references UIDB/04106/2020 and UIDP/04106/2020.

References

Akçayır, G., & Akçayır, M. (2018). The flipped classroom: A review of its advantages and challenges. *Computers & Education*, *126*, 334–345. https://doi.org/10.1016/j.compedu.2018.07.021

Baran, M., Maskan, A., & Yaşar, Ş. (2018). Learning Physics through Project-Based Learning Game Techniques. *International Journal of Instruction, 11*(2), 221–234.

Bergmann, J. & Sams, A. (2012). *Flip your classroom: reach every student in every class every d*ay. Washington: International Society for Technology İn Education.

Bernacki, M. L., Greene, M. J., & Lobczowski, N. G. (2021). A Systematic Review of Research on Personalized Learning: Personalized by Whom, to What, How, and for What Purpose(s)? *Educational Psychology Review, 33*(4), 1675–1715. https://doi.org/10.1007/s10648-021-09615-8

Capps, D. K., & Crawford, B. A. (2013). Inquiry-Based Instruction and Teaching About Nature of Science: Are They Happening? *Journal of Science Teacher Education, 24*(3), 497–526.

Conradty, C., & Bogner, F. X. (2020). STEAM teaching professional development works: effects on students' creativity and motivation. *Smart Learning Environments, 7*(1).

Costa, M., Domingos, A., Teodoro, V. D., & Vinhas, É. M. R. G. (2022). Teacher Professional Development in STEM Education: An Integrated Approach with Real-World Scenarios in Portugal. *Mathematics*, 10(21), 3944. https://doi.org/10.3390/math10213944

Constantinou, C., Tsivitanidou, O. E., & Rybska, E. (2018). What Is Inquiry-Based Science Teaching and Learning? In *Contributions from science education research* (pp. 1–23). Springer International Publishing. https://doi.org/10.1007/978-3-319-91406-0_1

Danaia, L., Fitzgerald, M., & McKinnon, D. H. (2013). Students' Perceptions of High School Science: What Has Changed Over the Last Decade? *Research in Science Education, 43*(4), 1501–1515.

Diego-Mantecón, J. M., Prodromou, T., Lavicza, Z., Blanco, T. P., & Ortiz-Laso, Z. (2021). An attempt to evaluate STEAM project-based instruction from a school mathematics perspective. *Zdm – Mathematics Education, 53*(5), 1137–1148. https://doi.org/10.1007/s11858-021-01303-9

Edelson, D. C., Gordin, D. N., & Pea, R. (1999). Addressing the Challenges of Inquiry-Based Learning Through Technology and Curriculum Design. *The Journal of the Learning Sciences, 8*(3–4), 391–450. https://doi.org/10.1080/10508406.1999.9672075

Emerson, T. L. N. (2014). Anyone? Anyone? A guide to submissions on classroom experiments. *Journal of Economic Education, 45*(2), 174–179. https://doi.org/10.1080/00220485.2014.889970

Ferren A., Paris, D. (2021). *Faculty Leadership for Integrative Liberal Learning*, Association of American Colleges and Universities, AAC&U. https://www.aacu.org/publication/faculty-leadership-for-integrative-liberal-learning

Fitzgerald, M., Danaia, L., & McKinnon, D. H. (2017). Barriers Inhibiting Inquiry-Based Science Teaching and Potential Solutions: Perceptions of Positively Inclined Early Adopters. *Research in Science Education, 49*(2), 543–566. https://doi.org/10.1007/s11165-017-9623-5

Gardner, K., Glassmeyer, D., & Worthy, R. W. (2019). Impacts of STEM Professional Development on Teachers' Knowledge, Self-Efficacy, and Practice. *Frontiers in Education*, 4:16. https://doi.org/10.3389/feduc.2019.00026

Gersten, R., Woodward, J. R., & Darch, C. (1986). Direct Instruction: A Research-Based Approach to Curriculum Design and Teaching. *Exceptional Children, 53*(1), 17–31.

Gibbs, K. (2023). Differentiation in practice: an exploratory investigation in an Australian mainstream secondary school. *Teaching Education*, 1–19. https://doi.org/10.1080/10476210.2022.2161508

Haapaniemi, J., Venäläinen, S. H., Malin, A., & Palojoki, P. (2019). Home economics education: exploring integrative learning. *Educational Research, 61*(1), 87–104.

Hallinen, J. (2023, May 26). *STEM*. Encyclopedia Britannica. https://www.britannica.com/topic/STEM-education

Hawari, A. D. M., & Noor, A. I. M. (2020). Project-Based Learning Pedagogical Design in STEAM Art Education. *Asian Journal of University Education*, *16*(3), 102.

Hidayah, L. N., & Mustadi, A. (2021). The Implementation of The Flipped Classroom for Early Grade Students in Elementary School. *International Journal of Elementary Education, 5*(1), 98.

Jia, Y., Zhou, B., & Zheng, X. (2021). A curriculum integrating STEAM and maker education promotes pupils' learning motivation, Self-Efficacy, and interdisciplinary knowledge acquisition. *Frontiers in Psychology*, *12*. https://doi.org/10.3389/fpsyg.2021.725525

Johnson, D. W., & Johnson, R. T. (2009). An Educational Psychology Success Story: Social Interdependence Theory and Cooperative Learning. *Educational Researcher, 38*(5), 365–379.

Joye, S. W., & Wilson, J. H. (2015). Professor Age and Gender Affect Student Perceptions and Grades. *Journal of the Scholarship of Teaching and Learning*, *15*(4), 126–138.

Kirschner, P. A., Sweller, J., & Clark, R. F. (2006). Why Minimal Guidance During Instruction Does Not Work: An Analysis of the Failure of Constructivist, Discovery, Problem-Based, Experiential, and Inquiry-Based Teaching. *Educational Psychologist, 41*(2), 75–86. https://doi.org/10.1207/s15326985ep4102_1

Latorre-Cosculluela, C., Suárez, C., Quiroga, S., Sobradiel-Sierra, N., Lozano-Blasco, R., & Rodríguez-Martínez, A. (2021), Flipped Classroom model before and during COVID-19: using technology to develop 21st-century skills, *Interactive Technology and Smart Education, 18*(2), 189-204.

Li, H. W. R., & Wong, T. Y. (2018). Teaching Them Before We Teach: The Effectiveness of Conducting Classroom Experiments Before Teaching the Underlying Theory. *IAFOR Journal of Education*, *6*(3), 79–92. https://doi.org/10.22492/ije.6.3.05

Li K. C. & Wong B. T. M. (2020). Features and trends of personalized learning: a review of journal publications from 2001 to 2018. *Interactive Learning Environments, 29*(2), 182-195.

Lu, S., Lo, C., & Syu, J. (2021). Project-based learning oriented STEAM: the case of micro–bit paper-cutting lamp. *International Journal of Technology and Design Education*, *32*(5), 2553–2575.

Lui, A. M., & Andrade, H. (2022). The Next Black Box of Formative Assessment: A Model of the Internal Mechanisms of Feedback Processing. *Frontiers in Education, 7*.

Mayer, R. E. (2004). Should There Be a Three-Strikes Rule Against Pure Discovery Learning? *American Psychologist*, *59*(1), 14–19. https://doi.org/10.1037/0003-066x.59.1.14

Milanković Jovanov, J., Ivkov-Džigurski, A., Stanisavljević, J., Ivanović Bibić, L., D. Petrović, M., & Đukičin Vučković, S. (2022). Is the integrative teaching approach beneficial for learning?. *International Journal of Cognitive Research in Science, Engineering and Education, 10*(2), 173-183.

Ministério da Educação (2017). *Plano Estratégico da Educação 2017-2021*, Ministério da Educação, Direção Geral Planeamento, Orçamento e Gestão, Serviço de Estudos, Planeamento e Cooperação. https://minedu.gov.cv/documentos1

Montés, N., Llinares, A. Z., Ruiz, F., Zuccato, L., Rainero, S., Zanetti, A., Gallon, K., Pacheco, G., Mancuso, A., Kofteros, A., & Marathefti, M. (2023). A Novel Methodology to Develop STEAM Projects According to National Curricula. *Education Sciences*, 13(2), 169.

Morris, R. J., Perry, T., & Wardle, L. (2021). Formative assessment and feedback for learning in higher education: A systematic review. *Review of Education*, *9*:e3292. https://doi.org/10.1002/rev3.3292

Nadelson, L. S., & Seifert, A. L. (2017). Integrated STEM defined: Contexts, challenges, and the future. *Journal of Educational Research, 110*(3), 221–223. https://doi.org/10.1080/00220671.2017.1289775

National Research Council. (2000). Inquiry and the national science education standards.Washington, DC: National Academy Press. https://doi.org/10.17226/9596

OECD. (2018). *The Future of Education and Skills: Education 2030*. https://www.oecd.org/education/2030-project/about/documents/E2030%20Position%20Paper%20(05.04.2018).pdf

Passey, D. (2021). Digital Technologies—And Teacher Wellbeing? *Education Sciences*, *11*(3), 117. https://doi.org/10.3390/educsci11030117

Pedagogy in Action: Connecting Theory to Classroom Practice. (2023, April 26). *Classroom Experiments*. Retrieve April, 26, from https://serc.carleton.edu/sp/library/experiments/index.html

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in practice and research: An integrative literature review. *Thinking Skills and Creativity, 31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002

Samsudin, M. A., Zain, A. N. M., Jamali, S. M., & Ebrahim, N. A. (2018). Physics Achievement in Stem Project Based Learning (PjBL): A Gender Study. *Asia Pacific Journal of Educators and Education, 32*, 21–28. https://doi.org/10.21315/apjee2017.32.2

Santyasa, I. W., Rapi, N. K., & Sara, I. W. W. (2020). Project-Based Learning and Academic Procrastination of Students in Learning Physics. *International Journal of Instruction, 13*(1), 489–508.

Smale-Jacobse A. E., Meijer A., Helms-Lorenz M. & Maulana R. (2019). Differentiated Instruction in Secondary Education: A Systematic Review of Research Evidence. *Front. Psychol. 10*.

Strat, T. T. S., & Jegstad, K. M. (2022). Norwegian Teacher Educators' Reflections on Inquiry-Based Teaching and Learning in Science Teacher Education. *Journal of Science Teacher Education*, 1–21. https://doi.org/10.1080/1046560x.2022.2125623

Sweller, J. (2003). Evolution of human cognitive architecture. In *Psychology of Learning and Motivation* (pp.

215–266). Elsevier BV. https://doi.org/10.1016/s0079-7421(03)01015-6

Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners* (2nd ed.). Association for Supervision & Curriculum Development.

Topping, K. (1996). The effectiveness of peer tutoring in further and higher education: A typology and review of the literature. *Higher Education, 32*(3), 321–345. https://doi.org/10.1007/bf00138870

US Department of Education (2017). Office of Educational Technology. *Reimagining the Role of Technology in Education: 2017 National Education Technology Plan Update*. Washington. USA.

Williams, A. T., & Svensson, M. (2020). Student Teachers' Collaborative Learning of Science in Small-Group Discussions. *Scandinavian Journal of Educational Research, 65*(6), 914–927.

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