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Validation of an Instrument to Measure Natural Science Teachers' Self-Perception about Implementing STEAM Approach in Pedagogical Practices

Edison Camacho-Tamayo * and Andres Bernal-Ballen

Faculty of Education, Antonio Nariño University, Bogotá 111821, Colombia; abernal93@uan.edu.co
* Correspondence: ecamacho61@uan.edu.co

Abstract: This study aims to describe the analysis of the validity and reliability of an instrument that determines the self-perception of natural science teachers using the STEAM approach regarding the planning, development, and evaluation of their pedagogical activities. For its design, empirical studies were obtained from a bibliographic review, theoretical criteria on self-perception and STEAM approach, and population characteristics. For the instrument quality assessment, content validity parameters were analyzed by experts, and construct validity and reliability were assessed with the help of the SPSS statistical package. Ten educational doctors served as expert judges and 143 teachers (pre-service and in-service) participated in the pilot test. As the main finding, the instrument applied to a sample presents a high reliability coefficient (Cronbach's alpha = 0.920) and validity (KMO = 0.903) in three factors after performing a factor analysis. Thus, it is concluded that the instrument has structure and coherence both in its internal consistency and meaning grid, which facilitates progress in understanding the self-perception of using the STEAM approach in didactic practices in natural sciences.

Keywords: natural sciences; teacher training; methodology; STEAM; education

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1. Introduction

In the educational field, the approach involving science, technology, engineering, arts, and mathematics (STEAM) is identified as a recently developed interdisciplinary event [1]. It has evolved and takes different terms according to the flexibility of the environment in which it is developed [2], so it has generated positive expectations regarding its results in learning and solving daily problems from a more holistic vision [3,4]. From this perspective, world organizations have set their sights on the STEAM approach in the search to promote its effective integration and as a strategic method to achieve successful education [5,6]. Meanwhile, the scientific community has focused its attention on studying the interdisciplinary STEAM educational phenomenon with a deeper vision in order to advance both conceptual and practical results [7–11]. One of the guidelines proposed to meet this advance is the possibility of providing teachers with an educational opportunity to close the gaps between a changing world and new educational challenges in order to respond to the need for comprehensive training aimed at motivating their learners, especially high school students, to study careers involving the STEAM areas [12–14]. In this context, some studies report that in order to achieve these challenges, it is necessary to start from appropriate teacher training with this approach, a curricular alignment to integrate other disciplines in their subjects, and the consolidation of learning communities for the strengthening of sustainable educational networks [15,16]. On the other hand, there is a solid consensus that the STEAM approach has a relatively low level of standardization and that the theorization criteria are highly diverse, so some studies differ on its vision in terms of inter-, trans- and multidisciplinarity or even the addition and positioning of letters in its acronym [5,17–19], which is also a challenge to overcome. In part, all of this likely creates

some teacher barriers, especially in the natural sciences, that limit the implementation of STEAM in their classrooms [13,20,21].

The STEAM approach and teacher education in natural science teaching is a field that demands considerable attention [9,22–24]. However, natural science teachers might feel more familiar with the STEAM approach because its structure involves the area of knowledge in which they can be considered experts. Several researches suggest that further training and ongoing professional development on this holistic perspective is needed [25–28] in order to expand the knowledge of the integration process, basic strategies and skills needed for its implementation in the classroom [29]. Thus, the interest in teacher training in the natural sciences from an interdisciplinary viewpoint, as well as the discussion on how the curriculum should be integrated with different areas of knowledge to make it evident in the curricula, along with the most appropriate way to implement a STEAM proposal in the classroom and the evaluation of the learning results of disciplinary integration, are in a progressive condition [30–35].

In this context, it is important to strength the pedagogical practices of natural science teachers by incorporating STEAM education within the classroom [36–38]. Likewise, the integral curricular composition of STEAM does not limit to the use of technological instruments, dismissing other significant dimensions of science didactics [2,27,39]. Furthermore, the STEAM approach promotes innovative skills in the classroom, as proposed by this holistic vision, and it does not become a task under the responsibility of science teachers. Finally, it is necessary to understand that these strategies might transform lesson planning, development, and evaluation in science classrooms [40]. Everything mentioned above allows us to know what is expected from natural science teachers in terms of their experience and professional development, as well as in the identification of specific needs for the implementation of the STEAM in their pedagogical practices [20,41]. To identify these shortcomings, it is necessary, in some way, to measure self-perception levels of STEAM's effectiveness in transforming pedagogical practices in science education [42,43].

For this reason, assessing teachers' self-perception is considered a fundamental condition to favor pedagogical strategies and curriculum design [44]. Thus, defining the perception of STEAM use in terms of its application in the classroom to obtain broader scopes towards its correct implementation may require further attention [11].

To be precise, self-perception is defined from the social cognitive theory as a cognitive process in which a self-analysis of attitudes as a teacher is presented, and a cause–effect of their behaviors is observed [44–46]. On the other hand, the importance of the self-perception of the effectiveness of STEAM in the classroom by natural science teachers lies in the influence that this has on the individual's thinking, actions, and emotions [20,28,41,47,48]. The higher the self-perception of efficacy, the higher the academic achievement, which is consistent with the research of Herro and Quigley [49], who states that the scarce empirical evidence in the classroom remains the efficacy of the STEAM approach.

In this aspect, it is essential to highlight that after applying a teacher professional development for its promotion, studies on self-perception and beliefs in STEAM have reported positive transformations [20,48,50–53], from classroom management in terms of organizational innovation, the recognition of the value of STEAM education as a teaching criterion, the motivation for learning new physical and technological tools for problem-solving in the context, the stimulation to acquire new teaching methodologies in line with the dynamics of today's world, and the strengthening of participation in networks and learning communities. However, are teachers' perceptions of using the STEAM approach influencing the design of their classes? It is interesting to establish where these changes in self-perceptions of the use of STEAM are evident concerning the pedagogical practices observed in planning, development, and evaluation. Thus, it is possible to glimpse the effect that STEAM education has on science teaching [54]. Additionally, different studies have reported that teachers' self-perception regarding science teaching is favorable, considering that continuous teacher training in scientific and didactic content is an oppor-

tunity to improve classroom practices. Thus, it is relevant to identify the key concepts that the teacher must master to achieve a conceptual change, the development of innovative strategies to address them, and the evaluation of the degree of understanding them in an interdisciplinary manner [28,55–57].

Although some research has advanced the definition of STEAM and its application from empirical studies that could provide recommendations for its use in the classroom [58–61], there is scarce evidence of a diagnostic instrument to assess the self-perception of the use of STEAM approach by natural science teachers in terms of planning, development, and evaluation of one of their classes.

Thus, this study aims to validate an instrument to observe the levels of self-perception of natural science teachers regarding the STEAM approach in their classroom practices. Its design was based on the work of Espinosa-Ríos [62], who developed a similar instrument based on the theoretical framework proposed by the German government to observe classes in its institutions abroad https://www.auslandsschulwesen.de/Webs/ZfA/DE/Home/home_node.html (accessed on 10 February 2023).

2. Materials and Methods

2.1. Instrument

The instrument was initially composed of 30 items in three categories: preparation, development, and evaluation of a natural science class in which the STEAM approach is investigated. This identification of the categories originated the elaboration of the items (see Table 1) that respond to a frequency scale (1 = Never, 2 = Rarely, 3 = Occasionally, 4 = Frequently, 5 = Very often) [63–66]. At the same time, this instrument collects data from the participants regarding their level of experience, age, educational level, and place where they teach anonymously.

Table 1. Categories and items of the instrument submitted to the expert judges.

Categories	Item
Preparation (PRE)	1. I search for the required information to learn about the contents. 2. I formulate pertinent objectives and seek to promote the development of comprehensive skills and knowledge. 3. I prioritize content fostering critical thinking, creativity, teamwork, and innovation. 4. I consider the comprehensive diagnosis of students and their context. 5. I include strategies or tools such as activities, workshops, laboratory practices, and audiovisual media designed interdisciplinary. 6. I propose tasks related to information and communication technologies, scientific knowledge, and mathematics. 7. I propose relevant activities that can stimulate students' interest, creativity, and teamwork. 8. I provide homework assignments for students to consult answers in documents, books, people, and the Internet. 9. I encourage the student to consult studies on aspects related to the content, explaining the steps to be followed. 10. I propose several assessment tools (exams, checklists, observation guides, and rubrics). 11. I relate situations of daily life with scientific concepts.
Development (DEV)	12. I consider the student's previous knowledge in different areas of knowledge in the learning process. 13. I motivate students towards achievement orientation in a comprehensive way. 14. I promote interaction among students in order to achieve teamwork. 15. I use textbooks, experimental tools, computers, tablets, pocket calculators, dictionaries, and cell phones. 16. I mediate the possible knowledge construction between teachers and students through constant communication. 17. I encourage critical reflection processes in students favoring their learning. 18. I propose relevant activities that can stimulate students' interest, innovation, and creativity. 19. I make use of mistakes as a learning opportunity. 20. I integrally develop scientific knowledge's conceptual, procedural, and attitudinal content in relation to other knowledge in practice. 21. I stimulate interest in students, including the relationship between science, technology, engineering, mathematics, and the arts in the development of classes. 22. I observe in detail my students' state of mind and potential problems that may interfere with their learning process. 23. I provide support to students with difficulties in order to guide their achievement.

Table 1. *Cont.*

Categories	Item
Evaluation (EVA)	24. I close the class considering the progress and achievement of the integral objectives. 25. I generate spaces for feedback where the student's reflection and creativity are privileged. 26. I communicate the results obtained warmly, lovingly, and developmental manner. 27. I use diverse evaluation strategies (project development, case analysis, formulation and solution of problems, portfolio of evidence). 28. I use various assessment tools (exams, checklists, observation guides, and rubrics). 29. I reflect on the planning, design effectiveness, and operationalization of the strategies used in my classes. 30. I enhance collaborative participation in the environment through projects, meetings, conferences, Olympiads, contests, and awards.

Taken and adapted from Espinosa-Ríos [62].

2.2. Validation Participants

A group of expert judges was formed to validate the instrument's content. The criteria to be considered were (1) having a doctorate in education with training in natural sciences or affinity with the STEAM approach, (2) having participated in teacher training processes in natural sciences, and that their line of research is in education or teacher training, and (3) having proven experience in academic research on education.

2.3. Procedure

This study was conducted within the descriptive analysis framework with a mixed approach [63,67]. It was divided into three phases: content validity, construct validity, and reliability.

2.4. Content Validity

For content validity, the expert judges were provided with a rubric that evaluated each item's sufficiency, clarity, relevance, coherence, and observations. For each question, they had to indicate their degree of agreement (1–4 Likert scale points, where four was the highest agreement and one the lowest agreement in terms of level). When the mean overall opinion per item was >3 $\pm$ standard deviation (SD), it was considered valid for discordance [68]. Additionally, the content validation factor for the ten expert judges was calculated using Aiken's V coefficient (V) where V $\geq$ 0.8 [69–71] and a confidence interval value (CI) greater than 0.50 [72] on each item were considered to be approved taking into account the study of George-Reyes and Valerio-Ureña [73].

2.5. Pilot Participants

After validating the instrument's content, a pilot test was conducted with natural science teachers in training and service. The non-probabilistic sample comprised 143 volunteer teachers who have oriented the area [74]. The average age for the participants was 36.7 $\pm$ 11.840. Women participated with 51%, and the two most representative age ranges were between 21 and 35 years (36.6%) and 35 and 50 years (42.7%). With regard to years of experience, the average was 11.447 $\pm$ 10,079. In this case, 13.3% reports less than a year; 25.9% between one and six years; 21% between 7 and 12 years; 25.2% between 13 and 24 years; and the remaining 14% mentioned an experience higher than 25 years. Overall, 75.3% of the participants had an undergraduate in science teaching, whereas 8.5% belonged to the engineering field, and the others obtained tittles in science field. It is important to mention that 47.6% of the participants hold a master's degree and 4.9% have obtained their Ph.D.

2.6. Construct Validity

For the effectiveness of the construct, the data provided by the pilot test were analyzed using SPSS 25 software. Subsequently, the Kaiser-Meyer-Olkin (KMO) and Bartlett tests were performed, in which values higher than 0.7 show an accurate corre-

spondence of the items with their categories. Additionally, this result indicates whether the instrument is a good candidate for factor analysis as a statistical strategy for scale validation [75]. On the other hand, Bartlett's test (small values less than 0.05) verifies that the variables are correlated. Based on these results, an exploratory factor analysis was carried out, factor discrimination of the scale was determined by principal component analysis, and varimax orthogonal rotation was used to analyze factor loadings. Validity of the scale was determined by testing total item correlation of the scale by Pearson's r test

2.7. Reliability

The instrument was analyzed through the reliability index offered by Cronbach's alpha coefficient, which gives the exposed items a significance level. For an adequate level of reliability, this coefficient should be higher than 0.7. Coefficient of internal consistency was conducted to measure reliability of the scale. Cronbach's alpha reliability coefficient, split-half reliability correlation, Spearman–Brown formula, and Guttmann split-half reliability formula were used to determine internal consistency level. [76].

3. Results and Discussion

3.1. Content Validity

Table 2 shows the results of the content validation of the instrument submitted to expert judgment. In the validation process, items 3, 10, and 21 were discarded because they did not meet the permanence criteria. On the other hand, items 4, 5, 7, 8, 9, 11, 12, 14, 16, 17, 18, 19, 28, and 30 were restructured because they were on the tolerance border of 3 in X, 0.8 for VAiken, and 0.5 for ICI. Similar studies to this one, in different fields of knowledge, agree on the treatment of the data and the obtaining of results presented here [70,73,77,78].

Table 2. Results of content validation by expert judges.

Item	Validity	X	SD	VAiken	ICI		Agreement	Permanence
PRE1	Sufficient	3.500	0.972	0.833	0.627	0.905	Yes	Remains
	Clarity	3.500	0.972	0.833	0.455	0.781	Yes	
	Coherence	3.700	0.675	0.900	0.627	0.905	Yes	
	Relevance	3.500	0.850	0.833	0.664	0.927	Yes	
PRE2	Sufficient	3.600	0.966	0.867	0.664	0.927	Yes	Remains
	Clarity	3.800	0.422	0.933	0.664	0.927	Yes	
	Coherence	3.800	0.422	0.933	0.744	0.965	Yes	
	Relevance	3.500	0.972	0.833	0.664	0.927	Yes	
PRE3	Sufficient	3.000	1.247	0.667	0.703	0.947	No	Remove
	Clarity	3.000	1.054	0.667	0.787	0.982	No	
	Coherence	3.300	0.675	0.767	0.787	0.982	No	
	Relevance	3.500	0.972	0.833	0.664	0.927	Yes	
PRE4	Sufficient	3.300	1.252	0.767	0.488	0.808	No	Restructure
	Clarity	3.4	1.075	0.800	0.488	0.808	Yes	
	Coherence	3.700	0.422	0.933	0.591	0.882	Yes	
	Relevance	3.600	0.675	0.900	0.664	0.927	Yes	
PRE5	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.600	0.966	0.867	0.703	0.947	Yes	
	Coherence	3.500	0.707	0.833	0.664	0.927	Yes	
	Relevance	3.500	0.707	0.833	0.664	0.927	Yes	
PRE6	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.800	0.422	0.933	0.787	0.982	Yes	
	Coherence	3.700	0.675	0.900	0.744	0.965	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	

Table 2. *Cont.*

Item	Validity	X	SD	VAiken	ICI		Agreement	Permanence
PRE7	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.400	1.075	0.800	0.627	0.905	Yes	
	Coherence	3.800	0.422	0.933	0.787	0.982	Yes	
	Relevance	3.800	0.422	0.933	0.787	0.982	Yes	
PRE8	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.500	0.850	0.833	0.664	0.927	Yes	
	Relevance	3.500	0.972	0.833	0.664	0.927	Yes	
PRE9	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.400	1.075	0.800	0.627	0.905	Yes	
	Relevance	3.600	0.966	0.867	0.703	0.947	Yes	
PRE10	Sufficient	3.200	1.033	0.733	0.556	0.858	No	Remove
	Clarity	3.200	1.033	0.733	0.556	0.858	No	
	Coherence	3.200	0.789	0.733	0.556	0.858	No	
	Relevance	3.500	0.707	0.833	0.664	0.927	Yes	
PRE11	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.700	0.675	0.900	0.744	0.965	Yes	
	Coherence	3.700	0.675	0.900	0.744	0.965	Yes	
	Relevance	3.900	0.316	0.967	0.833	0.994	Yes	
DES12	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.300	1.059	0.767	0.591	0.882	No	
	Relevance	3.400	1.075	0.800	0.627	0.905	Yes	
DES13	Sufficient	3.300	1.252	0.767	0.591	0.882	No	Restructure
	Clarity	3.400	1.075	0.8	0.627	0.905	Yes	
	Coherence	3.400	1.075	0.8	0.627	0.905	Yes	
	Relevance	3.600	0.966	0.867	0.703	0.947	Yes	
DES14	Sufficient	3.700	0.949	0.9	0.744	0.965	Yes	Remains
	Clarity	4.000	0. 000	1. 000	0.886	1.000	Yes	
	Coherence	3.800	0.632	0.933	0.787	0.982	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
DES15	Sufficient	3.300	1.059	0.767	0.591	0.882	No	Restructure
	Clarity	3.200	1.033	0.733	0.556	0.858	No	
	Coherence	3.600	0.699	0.867	0.703	0.947	Yes	
	Relevance	3.500	0.707	0.833	0.664	0.927	Yes	
DES16	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.700	0.675	0.900	0.744	0.965	Yes	
	Coherence	3.600	0.699	0.867	0.703	0.947	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
DES17	Sufficient	3.300	1.059	0.767	0.591	0.882	No	Restructure
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.700	0.675	0.900	0.744	0.965	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
DES18	Sufficient	3.200	1.229	0.733	0.556	0.858	No	Restructure
	Clarity	3.300	1.059	0.767	0.591	0.882	No	
	Coherence	3.700	0.483	0.900	0.744	0.965	Yes	
	Relevance	3.800	0.422	0.933	0.787	0.982	Yes	
DES19	Sufficient	3.200	1.135	0.733	0.556	0.858	No	Restructure
	Clarity	3.700	0.675	0.900	0.744	0.965	Yes	
	Coherence	3.500	0.850	0.833	0.664	0.927	Yes	
	Relevance	3.500	0.850	0.833	0.664	0.927	Yes	

Table 2. *Cont.*

Item	Validity	X	SD	VAiken	ICI		Agreement	Permanence
DES20	Sufficient	3.400	1.075	0.800	0.627	0.905	Yes	Restructure
	Clarity	3.300	1.059	0.767	0.591	0.882	No	
	Coherence	3.600	0.699	0.867	0.703	0.947	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
DES21	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.500	0.707	0.833	0.664	0.927	Yes	
	Coherence	3.700	0.675	0.900	0.744	0.965	Yes	
	Relevance	3.900	0.316	0.967	0.833	0.994	Yes	
DES22	Sufficient	3. 000	1.414	0.667	0.488	0.808	No	Remove
	Clarity	3.300	1.252	0.767	0.591	0.882	No	
	Coherence	3.300	1.252	0.767	0.591	0.882	No	
	Relevance	3.300	1.252	0.767	0.591	0.882	No	
DES23	Sufficient	3.400	1.075	0.800	0.627	0.905	Yes	Remains
	Clarity	3.400	0.843	0.800	0.627	0.905	Yes	
	Coherence	3.500	0.85	0.833	0.664	0.927	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
EVA24	Sufficient	3.400	1.075	0.800	0.627	0.905	Yes	Remains
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.700	0.675	0.900	0.744	0.965	Yes	
	Relevance	3.700	0.675	0.900	0.744	0.965	Yes	
EVA25	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.700	0.675	0.900	0.744	0.965	Yes	
	Coherence	3.900	0.316	0.967	0.833	0.994	Yes	
	Relevance	3.900	0.316	0.967	0.833	0.994	Yes	
EVA26	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.600	0.699	0.867	0.703	0.947	Yes	
	Coherence	3.900	0.316	0.967	0.833	0.994	Yes	
	Relevance	3.900	0.316	0.967	0.833	0.994	Yes	
EVA27	Sufficient	3.400	1.075	0.800	0.627	0.905	Yes	Remains
	Clarity	3.800	0.422	0.933	0.787	0.982	Yes	
	Coherence	3.900	0.316	0.967	0.833	0.994	Yes	
	Relevance	3.900	0.316	0.967	0.833	0.994	Yes	
EVA28	Sufficient	3.100	1.101	0.700	0.521	0.833	No	Restructure
	Clarity	3.500	0.707	0.833	0.664	0.927	Yes	
	Coherence	3.600	0.699	0.867	0.703	0.947	Yes	
	Relevance	3.600	0.699	0.867	0.703	0.947	Yes	
EVA29	Sufficient	3.600	0.966	0.867	0.703	0.947	Yes	Remains
	Clarity	3.400	1.075	0.800	0.627	0.905	Yes	
	Coherence	3.500	0.972	0.833	0.664	0.927	Yes	
	Relevance	3.500	0.972	0.833	0.664	0.927	Yes	
EVA30	Sufficient	3.300	1.059	0.767	0.591	0.882	No	Restructure
	Clarity	3.700	0.483	0.900	0.744	0.965	Yes	
	Coherence	3.800	0.422	0.933	0.787	0.982	Yes	
	Relevance	3.800	0.422	0.933	0.787	0.982	Yes	

With complete attention to the data provided by the experts in verifying the sufficiency, clarity, coherence, relevance, and evaluation of each item, they were reformulated. Table 3 shows some of the most representative comments of their judgments (Jz# enumeration). Items 4, 7, and 9 show examples of restructuring of the instrument in aspects of form, such as the mixture of typologies, good wording, appropriate use of adjectives, and recommendations, such as the expansion of information and the observation of parity between items.

Table 3. Content validation restructuration by expert judges.

N°	Item	Judges' Validation	Restructuration
4	PRE4: I take into account the comprehensive diagnosis of students and their context.	Jz1"... clarify integral diagnosis." Jz2 "What do you mean by diagnosis?" Jz3 "...should make the purpose explicit." Jz5 "The "integral diagnosis" concept is not clear" Jz8 "The beginning of the course, the subject, the period and integral"	I design material to get to know my students' context and talents to plan the class's topic (e.g., based on a previous knowledge activity, diagnostic test, or entrance ticket).
7	PRE7: I propose appropriate activities that can stimulate students' interest, creativity and teamwork.	Jz1 "The typology of activities is mixed..." Jz7 "This item contains too many criteria..." Jz8 "Avoid adjectivizing"	It is decided to remove and restate it in the Extension section, item 28, in the amended instrument.
9	PRE9: I suggest the learner to consult studies on aspects related to the content, explaining the steps to follow.	Jz4 "It may be feasible to unify the verbs," Jz8 "This is included in the 6 and 7... review before class..."	It is dismissed because it is similar to questions 6 and 7.

Thus, with this analysis provided by the judges in a qualitative and quantitative form, nine items were eliminated [79,80].

In general, from the evaluation of the instrument, it is essential to highlight that 80% of the judges considered the sufficiency, clarity, and coherence of the instrument to be between adequate and high, which means that the items are easy to understand, their syntax is appropriate, there is a logical congruence between the items and the categories chosen, and they go in the same direction, which is enough to obtain a measurement by making the suggested changes. On the other hand, 63.4% consider the instrument pertinent and closely related to the established purpose. These results highlight the importance and relevance of the need to have closer diagnostic evidence of self-awareness in conducting a natural science class with an interdisciplinary approach, which is the subject of this study. It is so that other researchers, in a similar way, have been concerned about delving into this STEAM phenomenon, taking into account the field of science [28,49].

Finally, as a result of the content validity of the instrument and the theoretical strengthening of the self-perception of the effectiveness of the use of the STEAM approach in the natural sciences classroom [28,49,62], 23 items organized in three categories and eight descriptors are consolidated (see Table 4). The categories were selected a priori and tested for construct validity in the modified instrument, as seen in Appendix A.

Table 4. Instrument categories and descriptors.

Categories	Descriptors	Items
PRE	Interdisciplinary objectives and content selection.	1, 2, and 3
	Use of teaching methods and resources.	4, 5, 6, and 7
DES	Interaction strategies among students regarding class development.	8 and 9
	Interdisciplinary classroom practice progress.	10, 11, 12, and 13
	Teaching–learning strategies.	14, 15, and 16
EVA	Communication.	17, 18, and 19
	Use of interdisciplinary assessment strategies and instruments.	20, 21, and 22
	Experience reception. Learning feedback.	23

3.2. Construct Validity

After the adequacy of the data, the KMO and Bartlett's test is performed. The results are shown in Table 5. This covariance matrix shows a good value, which confirms that the

items are related to the selected descriptors and confirms that they can be subjected to a factor analysis [81].

Table 5. Kaiser-Meyer-Olkin (KMO) and Bartlett's test processed in SPSS 25.

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		**0.903**
Bartlett's sphericity test	Approx. Chi-squared	1399.150
	Gl	253
	Sig.	0.000

Bartlett's test shows an appropriate value for the significance of the instrument. This result suggests that the variables analyzed are sufficiently correlated in the sample. Additionally, when the significance is less than 0.05, the instrument can be a candidate for a dimensional analysis due to its low significance values [82].

In the first analysis, when natural factor distribution was examined, there were five factors whose eigenvalue were above 1. However, a considerable part of the items was gathered under three factors, and eigenvalues of these factors were quite large. Thus, factor analysis started as a three-factor solution.

Exploratory factor analysis was carried out based on the obtained scores. Scale discrimination was determined from factor loadings and principal component analysis. For that purpose, the varimax steep rotation technique was used. The factor analysis completed in this study determined whether the items were grouped into the factors suggested [83–86]. In order to discriminate the items whose loadings are divided into the proposed factors, the following exclusion criteria were considered (in the principal component analysis): (a) the factor loadings should be less than 0.300 and (b) the difference between the factor loadings should be at least 0.100 [83].

Factor loadings are the elementary judgment for evaluating the results of factor analysis [87]. The high factor loading indicates that the variable can be added to the proposed factor [83].

The factor loadings of 23 items of the scale were located between 0.181 and 0.600 without being exposed to rotation; however, by means of the varimax steep rotation technique, they were located between 0.425 and 0.775. The literature for behavioral science suggests that at least 40% of the total variance is sufficient [88,89]. Thus, 49.541% of the total variance is explained by the items and factors included in the scale of this study.

Consequently, from these processes, Table 6 presents the respective results of the loadings of the 23 items that resulted from the scale according to the factors and their quantities related to their eigenvalues and variance.

The contribution of the total variance of the first seven items, which correspond to the preparation of the class, is displayed in Table 6. As can be seen, it contributes 21%, while for the next nine items, corresponding to the development of the class, it contributes 15.2%. For the evaluation facto, a value of 13.3% was obtained. Thus, this factor analysis confirms the existence of an underlying construct in the instrument that groups most of the items in these factors.

In this part, correlation between scores of each item in factors and factor scores was calculated and the level of serving for general purpose was tested for each item. Item–factor correlation values of each item are presented in Table 7.

Table 6. Factor analysis results of the scale as per factors.

Items		$\overline{X}$	SD	Com. Factor	F1	F2	F3
Preparation	P4	4.035	0.791	0.600	0.775		
	P2	4.175	0.705	0.585	0.765		
	P6	4.014	0.778	0.529	0.727		
	P5	4.070	0.775	0.458	0.677		
	P1	4.357	0.644	0.433	0.658		
	P3	4.161	0.775	0.412	0.642		
	P7	4.245	0.734	0.319	0.565		
Development	D11	4.021	0.818	0.657		0.810	
	D16	4.028	0.759	0.588		0.767	
	D8	4.084	0.774	0.568		0.753	
	D14	4.000	0.864	0.533		0.730	
	D9	4.287	0.657	0.529		0.727	
	D15	4.000	0.796	0.485		0.697	
	D13	4.112	0.693	0.473		0.688	
	D10	4.280	0.676	0.278		0.527	
	D12	4.175	0.715	0.195		0.441	
Evaluation	E17	3.755	0.833	0.579			0.761
	E18	3.336	0.993	0.561			0.749
	E19	3.755	0.833	0.517			0.719
	E20	3.832	0.839	0.490			0.700
	E21	3.832	0.839	0.412			0.642
	E22	3.734	0.927	0.353			0.594
	E23	4.126	0.730	0.181			0.426
Eigenvalues					4.836	3.492	3.067
Variance explained by the factors (%)					21.024	15.182	13.336
Total variance explained (%)						49.541	
KMO						0.903	
Bartlett's test. sd: 0.903 (χ2/P)						1399.150/<0.000	

Extraction method: principal component analysis. Rotation method: varimax with Kaiser normalization.

Table 7. Item–factor scores correlation analysis.

Preparation		Development		Evaluation	
I	r	I	r	I	r
PRE1	0.645 **	DES8	0.744 **	EVA17	0.701 **
PRE2	0.743 **	DES9	0.700 **	EVA18	0.461 **
PRE3	0.654 **	DES10	0.544 **	EVA19	0.604 **
PRE4	0.770 **	DES11	0.799 **	EVA20	0.681 **
PRE5	0.681 **	DES12	0.488 **	EVA21	0.754 **
PRE6	0.727 **	DES13	0.689 **	EVA22	0.764 **
PRE7	0.590 **	DES14	0.736 **	EVA23	0.628 **
		DES15	0.698 **		
		DES16	0.754 **		

N = 143; ** = $p < 001$.

This confirms that a data set is grouped in a standard qualifier limited by the initial eigenvalues. From this, it is highlighted that the factors (categories) of the instrument and their eigenvalues exceed unity, which confirms the *a priori* determination made in the content validity since it is statistically indicated that the items agree and saturate the model with three categories.

3.3. Reliability through Cronbach's Alpha

Reliability analysis of each factor as well as the global scale are shown in Table 8, and it was calculated using Cronbach's alpha coefficient.

Table 8. Reliability analysis according to the factors.

Factor	Number of items	Two Congruent Halves Correlation	Spearman–Brown	Guttmann Split-Half Cronbach's	Cronbach's Alpha
Preparation	7	0.716	0.837	0.833	0.813
Development	9	0.778	0.876	0.870	0.859
Evaluation	7	0.658	0.796	0.793	0.782
Self-perception used STEAM in class nature science	23	0.896	0.945	0.945	0.920

According to Table 8, these results might indicate that both the whole of the scale and their factors are consistent measurements.

The total statistic is evaluated to determine whether excluding any item would increase Cronbach's alpha. However, the change is insignificant if a modification is made, and there would be a risk of losing some information. This result indicates that the items in the instrument, from the results obtained in the sample, have a high correlation and favorable internal consistency [90].

4. Conclusions

Considering the obtained results, the five-digit Likert-type scale can be grouped into 23 items and three factors. The evaluation by expert judges using the VAiken and an exploratory factor analysis was carried out in order to verify the structure of the instrument. In this context, the scale has structural validity as it was evidenced by the factor analysis, a factor loading, and the explanation of the factors from the total variance. Thus, based on the obtained results of the exploratory factor analysis, for a variance between the score achieved for each item, and the score achieved for the factor to which the item belongs, it was adequate. [88].

Between 0.590 and 0.770 for the preparation; 0.488 and 0.799 for the development; and 0.461 and 0.764 for the evaluation of the class with STEAM approach is the variance through which each item of the scale and the points achieved of the factor to which the item corresponds oscillate. In this sense, it is possible to uphold that each factor together with its items fulfills a significant function in measuring the quality of the scale in general, where each item differs in the expected level.

The internal consistency coefficients were calculated using Cronbach's alpha. The obtained value was 0.920. In turn, the reliability coefficients of each factor were situated between 0.782 and 0.813. Therefore, the scale can perform reliable measurements in relation to these values. As a result, this instrument is a valid and reliable scale that can be used to determine the self-perception of science natural teachers regarding the use of the STEAM approach.

The validation process of the instrument has yielded data that allows for the conclusion that the "Self-perception of natural science teachers about pedagogical practices with STEAM approach" survey has a high metric quality to evaluate the self-perception that the natural science teacher has regarding the use of the STEAM approach when planning, developing, and evaluating one of their classes.

The items correlate appropriately with their categories according to the validity indications, content, and construct. Yet, from the statistical point of view, it is demonstrated that the items are grouped into common factors that correspond to the three categories considered in the content validity, which gives the instrument a multidimensional quality.

Its high reliability guarantees that it is a consistent and reliable instrument because its significance, coherence, syntax, and content are distinctive, evidenced by the high correlation between its variables. This reliability result confirms that the items have a high relationship with the descriptors. It allows the interpretation of the data to be valid and to approach the understanding of the teacher's self-perception regarding science classes,

generating reflection processes and thus strengthening their performance. This adaptation can be similar in international environments, where self-perception influences the thinking patterns, emotionality, and actions teachers consider for their classroom practices.

It is hoped that this instrument can inform future research on the reflection of the natural science teacher on the use of the STEAM approach in pedagogical practices and if these impact the design of their classes in terms of planning, development, and evaluation.

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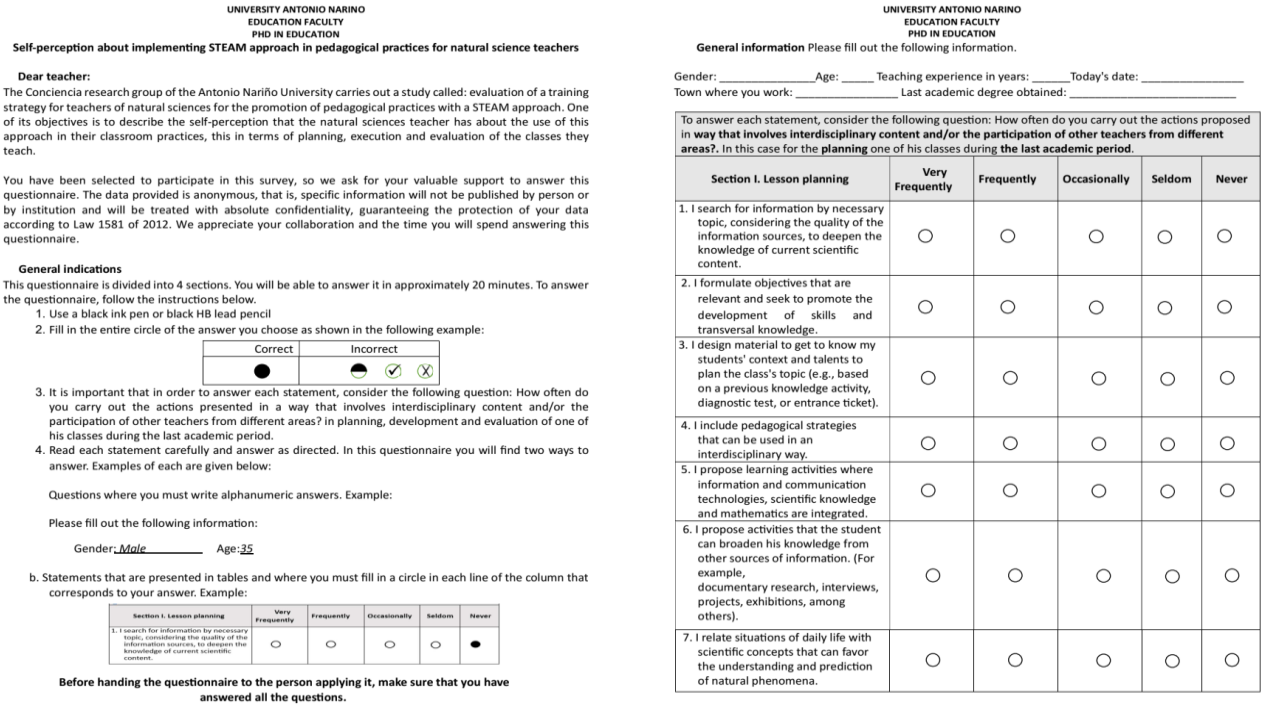
Data Availability Statement: Due to privacy and confidentiality issues the data are not available.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A



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Self-perception about implementing STEAM approach in pedagogical practices for natural science teachers

Dear teacher:

The Conciencia research group of the Antonio Nariño University carries out a study called: evaluation of a training strategy for teachers of natural sciences for the promotion of pedagogical practices with a STEAM approach. One of its objectives is to describe the self-perception that the natural sciences teacher has about the use of this approach in their classroom practices, this in terms of planning, execution and evaluation of the classes they teach.

You have been selected to participate in this survey, so we ask for your valuable support to answer this questionnaire. The data provided is anonymous, that is, specific information will not be published by person or by institution and will be treated with absolute confidentiality, guaranteeing the protection of your data according to Law 1581 of 2012. We appreciate your collaboration and the time you will spend answering this questionnaire.

General indications

This questionnaire is divided into 4 sections. You will be able to answer it in approximately 20 minutes. To answer the questionnaire, follow the instructions below.

1. Use a black ink pen or black HB lead pencil
2. Fill in the entire circle of the answer you choose as shown in the following example:

Correct	Incorrect
●	◓ ✓ ✗

3. It is important that in order to answer each statement, consider the following question: How often do you carry out the actions presented in a way that involves interdisciplinary content and/or the participation of other teachers from different areas? in planning, development and evaluation of one of his classes during the last academic period.
4. Read each statement carefully and answer as directed. In this questionnaire you will find two ways to answer. Examples of each are given below:

Questions where you must write alphanumeric answers. Example:

Please fill out the following information:

Gender: *Male* Age: *35*

b. Statements that are presented in tables and where you must fill in a circle in each line of the column that corresponds to your answer. Example:

Section I. Lesson planning	Very Frequently	Frequently	Occasionally	Seldom	Never
1. I search for information by necessary topic, considering the quality of the information sources, to deepen the knowledge of current scientific content.	○	○	○	○	●

Before handing the questionnaire to the person applying it, make sure that you have answered all the questions.

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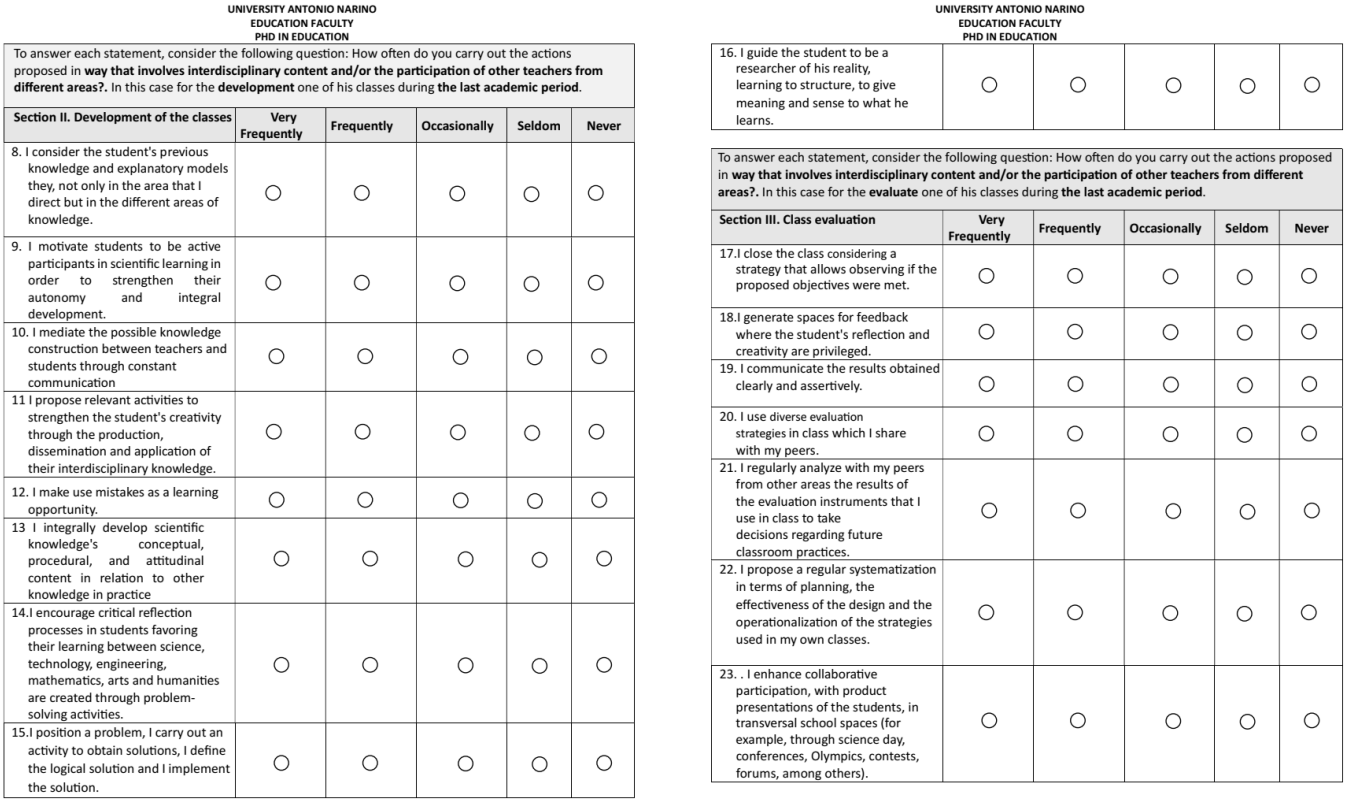
General information Please fill out the following information.

Gender: _____Age: _____ Teaching experience in years: _____Today's date: _____
Town where you work: _____ Last academic degree obtained: _____

To answer each statement, consider the following question: How often do you carry out the actions proposed in **way that involves interdisciplinary content and/or the participation of other teachers from different areas?.** In this case for the **planning** one of his classes during **the last academic period**.

Section I. Lesson planning	Very Frequently	Frequently	Occasionally	Seldom	Never
1. I search for information by necessary topic, considering the quality of the information sources, to deepen the knowledge of current scientific content.	○	○	○	○	○
2. I formulate objectives that are relevant and seek to promote the development of skills and transversal knowledge.	○	○	○	○	○
3. I design material to get to know my students' context and talents to plan the class's topic (e.g., based on a previous knowledge activity, diagnostic test, or entrance ticket).	○	○	○	○	○
4. I include pedagogical strategies that can be used in an interdisciplinary way.	○	○	○	○	○
5. I propose learning activities where information and communication technologies, scientific knowledge and mathematics are integrated.	○	○	○	○	○
6. I propose activities that the student can broaden his knowledge from other sources of information. (For example, documentary research, interviews, projects, exhibitions, among others).	○	○	○	○	○
7. I relate situations of daily life with scientific concepts that can favor the understanding and prediction of natural phenomena.	○	○	○	○	○

Figure A1. Final instrument.



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EDUCATION FACULTY
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To answer each statement, consider the following question: How often do you carry out the actions proposed in **way that involves interdisciplinary content and/or the participation of other teachers from different areas?.** In this case for the **development** one of his classes during **the last academic period**.

Section II. Development of the classes	Very Frequently	Frequently	Occasionally	Seldom	Never
8. I consider the student's previous knowledge and explanatory models they, not only in the area that I direct but in the different areas of knowledge.	○	○	○	○	○
9. I motivate students to be active participants in scientific learning in order to strengthen their autonomy and integral development.	○	○	○	○	○
10. I mediate the possible knowledge construction between teachers and students through constant communication	○	○	○	○	○
11 I propose relevant activities to strengthen the student's creativity through the production, dissemination and application of their interdisciplinary knowledge.	○	○	○	○	○
12. I make use mistakes as a learning opportunity.	○	○	○	○	○
13 I integrally develop scientific knowledge's conceptual, procedural, and attitudinal content in relation to other knowledge in practice	○	○	○	○	○
14.I encourage critical reflection processes in students favoring their learning between science, technology, engineering, mathematics, arts and humanities are created through problem-solving activities.	○	○	○	○	○
15.I position a problem, I carry out an activity to obtain solutions, I define the logical solution and I implement the solution.	○	○	○	○	○

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16. I guide the student to be a researcher of his reality, learning to structure, to give meaning and sense to what he learns.	○	○	○	○	○

To answer each statement, consider the following question: How often do you carry out the actions proposed in **way that involves interdisciplinary content and/or the participation of other teachers from different areas?.** In this case for the **evaluate** one of his classes during **the last academic period**.

Section III. Class evaluation	Very Frequently	Frequently	Occasionally	Seldom	Never
17.I close the class considering a strategy that allows observing if the proposed objectives were met.	○	○	○	○	○
18.I generate spaces for feedback where the student's reflection and creativity are privileged.	○	○	○	○	○
19. I communicate the results obtained clearly and assertively.	○	○	○	○	○
20. I use diverse evaluation strategies in class which I share with my peers.	○	○	○	○	○
21. I regularly analyze with my peers from other areas the results of the evaluation instruments that I use in class to take decisions regarding future classroom practices.	○	○	○	○	○
22. I propose a regular systematization in terms of planning, the effectiveness of the design and the operationalization of the strategies used in my own classes.	○	○	○	○	○
23. . I enhance collaborative participation, with product presentations of the students, in transversal school spaces (for example, through science day, conferences, Olympics, contests, forums, among others).	○	○	○	○	○

Figure A2. Final instrument.

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