Interdisciplinary Educational Approach STEM and HASS Knowledge Fields Using ICTs Support. Case of an Application for a Pilot Experiment

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Abstract—This paper investigates the possibility of a holistic interdisciplinary and cross-thematic educational approach of STEM (Science, Technology, Engineering, and Mathematics) and HASS (Humanities, Arts and Social Sciences) knowledge fields. The interdisciplinary educational approach of STEM and HASS knowledge branches, set out to resolve complex issues in an innovative way, can assist the development of the students into active and knowledgeable citizens so they will be able to face actual problems whose nature is always interdisciplinary. There is reference in elements which advocate the necessity of this holistic cross-thematic approach and additionally theories and techniques are established which are able to support it. Main characteristic of this development is its support with ICTs. Characteristics of a relevant educational scenario are presented. The scenario is implemented as a pilot experiment and relevant results can be extracted. The scenario is recommended as prototype due to its special interdisciplinarity, the educational techniques that were utilized, and its design procedure based on principles of Educational Management & Engineering and due to the positive results from its pilot implementation. Relevant conclusions are projected.

Index Terms—STEM, HASS, ICTs, Educational Engineering in Educational Scenario of Pilot Experiment.

I. INTRODUCTION

The self-contained education of the various knowledge fields in the Curricula of secondary education systems, is crucial to assure the required “internal cohesion” and “unified development of contents” [15]. Although, the high pressure and complicated problems that our world has to face cannot be clarified by a scientific scope, an interdisciplinary approach which is affected from various knowledge fields is essential [8], namely a horizontal interconnection of the exact sciences with the humanities and social sciences through interdisciplinary, is required. Accordingly, a need is emerged for a horizontal interconnection of Analytical Curriculum of individual knowledge fields and a research for extensions and interrelations of the individual courses on the sections of sciences, art, technology as well as in the configuration of mindsets and values, so that the curricula’s subject processing of every knowledge field from every point of view, is acquired [23].

Although interdisciplinarity, in the form of collaborations between the various sciences, natural and social sciences, becomes more and more common educational perception, the humanities that study philosophy, religion, history, philology, literature and arts, often remain marginal. It has, however, been observed that “The humanities and humanities-oriented social sciences can make significant contributions to public policy discussions that heretofore have relied heavily on the sciences and engineering” [11].

To support access to educational opportunities offered by STEM education, its programs should develop integration of other academic fields, such as history and art, and promote holistic-intersectional(well-rounded) education [41]. The benefit of transition, from STEM subjects to humanities courses, is important because it allows the approach of ideas and problems from different points of view and supports the cultivation of ideas in the light of unique perspectives [43].

The present paper attempts to substantiate an integrated intersectional educational management of STEM and HASS educational subject fields, which is complemented by the presentation of an educational teaching approach entitled 'Sky-shaped Temples', which deals with the synthesis of a pilot ICT instructional scenario, of intersectional approach of Religion (RE) and Technology courses. There is a pilot experimental implementation of the approach and results and conclusions are extracted from the application of the cross-thematic integration didactic approach of objects of branches of STEAM and HASS in secondary education.

The educational approach is interdisciplinarily related to the knowledge subjects of Visual and Plastic Arts (Art History), Language, History, Mathematics, Engineering and ICTs, which are used as a framework for linking teaching subjects as well as a tool for the development of metacognitive skills of the students. The whole project, both in theoretical and practical level, is dealt based on modern educational concepts by applying discovery learning in the context of complex constructivist theory aimed at the effectiveness of the teaching-learning intervention. The pilot implementation of the scenario is estimated based on the Experimental Method of Research and is analyzed based on the statistical control t in dependent samples [42].

II. INTERDISCIPLINARY APPROACH STEM AND HASS

The acronym STEM is used as an aggregate term, denoting interdisciplinary or multidisciplinary and refers to integrated academic or educational treatment of the four knowledge branches (Science, Technology, Engineering and Mathematics), although in some cases it is widely utilized in order to include psychology and social sciences [13]. The STEM academic “counterpoint” is considered the HASS
which refers to the Humanities, Arts and Social Sciences [39] and has an extensive influence on the conformation of the way we view our society and evaluate change and developments (Australian Science and Technology Council [ASTEC], 1993).

STEM education, while still a central political question [13], displays significant challenges, because, as it is claimed, is capable of inducing significant innovation in education and providing guidance for critical points of its reform [9]. However, STEM education analysts claim that the commitment to certain knowledge fields is very static and that these fields should focus on a set of practices and processes that cross their boundaries from which the distinct knowledge and education will emerge [27]. On the other hand, it is claimed that education in HASS curriculum should be an essential prerequisite of the learning journey that each student must make during his/her circular studies [33], because the courses of the program provide a wide understanding of the world so that students can evolve into well-informed and active citizens with the high-level skills required in the 21st century [1].

The last decade has been an increase in cooperation between academic fields and many international initiatives have been driven in order to enhance it. Cross-sectoral collaboration takes place when members of the science, technology and engineering (STEM) industry collaborate with members of the humanities, arts and social sciences (HASS) in order to solve common problems and achieve common goals [25]. During the collaboration between the HASS and STEM sectors, complementary but contrasting resources, approaches and skills are compiled, therefore the whole is greater than the sum of its parts. Intersectional or interdisciplinary collaboration can lead to the establishment of integrated thematic areas such as environmental management, medical sciences-humanities and scientific communication [26]. Cooperation between the HASS and STEM sectors has developed useful and productive relationships that operate at various levels. In many cases these relationships are simple and unilateral, with one sector using the tools of the other. For example, tools from the social sciences can make natural sciences more accessible. In this case HASS is introduced to assist STEM. Similarly, computer technology and ICTs promote creativity and provide new tools in the HASS sectors. Collaboration between sectors occurs when one or more members of each field combine their efforts to solve common problems and achieve common goals [32].

Despite remarks about HASS's role and spot in the student-centered education system, [29] notes that research is raising concerns that school experiences in Australia do not promote an active and informed citizen. As it has been highlighted, this concern has been exacerbated by the emphasis given on STEM in schools and the apparent depreciation of HASS [29]. Respectively in an academic level, STEM disciplines are considered as the main source of innovation and the contribution of the HASS disciplines as secondary [39]. It is not surprising, then, that political focus on STEM initiates reactions from industry supporters (HASS) [26],[39]. Despite the interesting and perhaps controversial debate about the contribution of HASS, we must bear in mind that the complex social, economic and environmental challenges require a fundamental change in the way we deal with problem solving and innovation, therefore the contribution of all disciplines is useful, either from science, technology and mathematics (STEM) or from the field of humanities, art and social sciences (HASS) [39]. Consequently, at a level of political projects and systems, more opportunities for HASS learning in schools should be encouraged. This would mean that schools should identify the HASS educational experiences offered to their students and place greater emphasis on teaching HASS courses [29].

A curriculum that promotes holistic-intersectional knowledge, which deals with concepts from various knowledge fields, is based on the principles of constructive theory. In addition, it is based on the fact that real-world problems do not occur in individual knowledge areas - as they are commonly taught in school education - but in more [35], [30].

Cross-thematic integration, a more general term than the one of interdisciplinary in school practice, catalyzes the distinct courses and enables the student to form a unified set of knowledge and skills, a holistic multi-concept of knowledge that will allow him to form a personal opinion. Within the school, it is implemented mainly with intra-sectoral cohesion within each knowledge field, with cross-sectoral correlations between knowledge areas and with subject-centered applications [22]. The interdisciplinary approach to knowledge is applied to the pedagogical side of the project, a teaching process which refers to the conception, implementation and evaluation of a particular learning process. More specific teaching techniques (brainstorming, concept mapping, lecture, discussion, case study, survey research, library research, field study, role play, dilemma, the analysis and clarification of values, simulation, games and experiments, etc.) are usually adopted during the course of a project, depending on the targeted goals each time, which nevertheless are part of the same pedagogical philosophy, namely advocating the active participation of the learner in the learning process, in teamwork, in the development of critical thinking [10].

III. EDUCATIONAL SCENARIO. A CASE OF APPLICATION IN RE AND TECHNOLOGY COURSES WITH ICTS SUPPORT

A. The development of the Scenario

Submit your manuscript electronically for review. The development of the Scenario was initiated by the challenge of validating the ability of the design and implements an educational scenario which combines knowledge from all the academic fields of STEM and HASS on an interdisciplinary and cross-thematic approach. STEM education displays significant challenges. STEM has the ability of extensive novelty in education, which could align with the standards of modern education and provide guidance on critical elements of its reform [9].

The Educational Scenario utilizes the principles of Discovery and Inquiry-based Learning proposed by Bruner [7], as well as elements and practices of Lev Vygotsky's Sociocultural theory, where learning is considered as the result of students' participation, communication and interaction in groups [44]. For the design of the holistic
interdisciplinary approach, research recognitions of wider acceptance are taken into account, such as Bruner’s [6] basic assumption that students are active trainees who construct their own knowledge and that learning takes place through association, integration and assimilation of concepts and proposals in the already existing propositional networks and the broader cognitive structures of the learner [5].

It is an educational challenge to investigate the effectiveness of two incongruous subjects whose cross-thematic educational approach is a novelty inherent to educational future. The educational benefit of the transition from STEM topics to humanitarian courses is essential. For example, the cross-thematic approach of STEM and HASS fields, allows the student to engage in both focused and diffused learning, creating learning experiences that are overlapping in nature, unlike cut-off learning. This allows one to approach ideas and problems from different points of view, to support and cultivate ideas from unique perspectives [43].

B. Educational Management & Engineering Exploiting

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Problems were discovered in organizational and planning level. This was due to fact that the idea of developing the Scenario specified its structure as the result of knowledge areas synthesis and the diverse nature of factors and also as a synergy of a large number of people involved and resources. For the effective planning and consistent implementation of the Scenario, the process definition of essential importance and process monitoring were accomplished. This was achieved through the utilization and implementation of suggested procedures and tools by Educational Management & Engineering, meaning that, tools and techniques of System Engineering management and engineering were used [34] which were adapted accordingly to the design and implementation of the educational process.

More specifically, organization and coordination meetings were held, guidelines and features for Scenario design were specified, basic characteristics of hardware and software resources were defined, prototype’s pilot application management procedures and control and optimization procedures were described, before the implementation of the Scenario in a normal class. The main tool was the utilization of brainstorming method among teacher-designers. For organizing and coordinating, assistance from an administrative moderator was requested and Gantt and Pert chart software were used (Fig. 1).

![Fig. 1. Utilization of Gantt and Pert digital graphs for the Scenario’s design and implementation management.](image)

An important element was the scenario Prototype Design and the Pilot Implementation based on the prototype control system [14], namely, the feasibility of developing the scenario and its design in order to meet the needs of the students were tested, the learning design were examined in relation to their feasibility and timing, and were implemented by the team of teacher-designers themselves. Finally, through the pilot implementation, reliability was tested, that is, to what extent the Scenario performs the specific functions for the purpose designed under the specific circumstances of teaching management by the teachers carrying out the scenario (International Organization for Standardization [ISO], 2011:[18]).

Scenario optimization followed the usual practice of designing systems by examining two levels, the framework and the system [28]. During the framework examination, alternative approaches were analyzed mainly in the selection and application of teaching techniques and their timing. During the Scenario examination as a system, alternative solutions to its composition were analyzed and mainly to the smooth rotation of the teaching techniques, the complementarities of the teaching subjects and the students' behavior. The final selection of an - in the teachers' view - optimal set of features and processes was followed, carried on by the final design of the Scenario.

C. General Description of the Scenario

Below is a list of the general development axes of the Scenario [37]. In particular, the identity, the reasoning, the implementation framework and the general description of its processes are described.

1) Identity

The title of the scenario is “Sky-shaped Temples”. Its knowledge field develops interdisciplinary in the STEM and HASS knowledge branches and particularly in school teaching sections provided by the curriculum for Technology, Information Technology and RE courses. The subject being negotiated relates to the construction of the dome of St Sophia’s Church in Constantinople and its knowledge extensions in the political, social and religious fields.
2) Reasoning

An interdisciplinary educational scenario is being implemented in the context of three Junior High school (Gymnasium) subjects: RE course, Technology course and Computer Studies course. The implementation of the Scenario seeks to provide a comprehensive educational approach to theological issues and related technological applications. It attempts to connect people's social and worship needs and to meet these needs with the contribution of technology. Introduced innovation is the framework of interdisciplinarity, seemingly heterogeneous subjects, which aims at holistically handling of aspects of religious construction technology subjects, in the light of social and humanitarian need and in the light of technological need. Support of the subject with ICT is an innovation, which facilitates the development of teaching, makes an experiential approach to its important aspects and imparts metacognitive skills to students in all knowledge fields of the Scenario [31]. The integration of ICT into the process follows the approach of Infusion as the indicated one for the school system and its technical capabilities. This approach allows students’ access to technology, enables them to select ICT projects and tools which stimulate learning and display their knowledge across all subject areas. Based on this approach, students undertake greater responsibility for their own learning and assessment [3]. Innovation can also be considered the design and organization of a scenario based on the principles of Educational Management & Engineering because of its complexity.

3) Framework

It is addressed to students, Junior High schools, who have been taught, in the same or previous classes, RE, technology, mathematics and computer science courses and are capable of utilizing relevant software. The reason why this is addressed to them is because middle school third grade is the level of completion of the prerequisite knowledge for the completion of the scenario based on curriculum. The Scenario seeks to achieve knowledge, social, cultural and technological goals of the individual subjects of the cross-thematic approach. It also seeks to establish an innovative cross-thematic approach to the selected STEM and HASS subjects in teaching practice.

The operation process consists - basically - of three parts, the parts of preparation, main implementation and evaluation.

The first part refers to preparing students for the main implementation. There is a Precursor Approach developed by the teachers. Its title is "Pyramids of Giza". Precursor Approach is of limited duration but is of related subject to that of the main approach in order to accomplish revival, update of previous ones, and develop new prerequisite knowledge and skills for students. It also attempts to develop metacognitive skills in students, specialized in the subject.

The second part concerns the full development of teaching through the Collaborative Learning (Project) [23]. Students are divided into groups, becoming aware of collaboration issues. Key components of cooperation are coherence as the development of the perception of interdependence among team members, promotional interaction, namely, the willingness of team members to encourage and facilitate each other's efforts and individual responsibility, that is, responsibility of a person to ensure that he/she completes his/her part of the project [12]. Subsequently they receive instructional material and plan for themselves the structure of the final written paper as deliverable and as a type of educational contract that essentially clarifies the responsibilities of the student group and defines what each student and each teacher will do with purpose to effectively promote learning in given objects [40]. The project’s outputs are: research paper in the form of a scientific article (abstract, problem description, methodology, implementation, conclusions and bibliography), 3D-drawing dome images (Fig. 2), 2D dome drawings, relevant religious images, historical dome descriptions and their corresponded annotations.

The third part deals with student assessment and - in part - of the scenario. This is how the evaluation of students is accomplished, based on the estimation of their effort as this is reflected in their paper being delivered and its involvement in it. Also, a student assessment is provided. This is based on an integrated self-evaluation spreadsheet from each student. This assessment follows the steps of the Constructive framework and the stages of scheduled teaching and project implementation in each activity [36].

4) Description

Description of the Educational Scenario as - approximately - is exported from the online Learning Design software, follows (Fig. 3a, Fig. 3b, Fig. 3c.).

Fig. 2. Project Output: 3D-drawing dome image (St Sofia in Constantinople)
IV. EDUCATIONAL SCENARIO HASS&STEM. EVALUATION OF THE PILOT EXPERIMENT

A. The problem

The concept of “cross-thematic integration didactic approach of objects of branches of STEAM and HASS” will be onwards stated as “HASS&STEM”.

Finally, the development of applications HASS&STEM in class, affects the improvement of the children’s performance concerning the solution of real problems fields of HASS and STEM through the interdisciplinary integration;

This paper attempts to document the positive impact of the development of HASS&STEM applications on students' performance in secondary education. In the authors' view an important role in the documentation of this positive (or negative) impact should be the confirmation of the effectiveness of applying the Scenario to the real classroom, in real school conditions. The estimation of the results of the proposed Scriptural teaching approach in experimental implementation is a key factor in order to estimate the need (or not) to develop HASS&STEM. Here the word influence is used in the sense of a significant change in student behavior based on the HASS&STEM learning experience in relation to the experience of the independent teaching approach to the same objects [45]. The magnitude of this effect is attempted to be determined through the evaluation process of the implementation of the proposed Scenario.

B. Methodology

The Experimental Method of research is followed based on the statistical control \( t \) in dependent samples [42].
Due to the innovative nature of the Scenario, a pilot experiment with a small number of subjects is followed to confirm that the future - large - scale Experimental Method, on the same topic, will work and will help future researchers control tools and techniques and research design [42]. The pilot experimental application is about measuring the difference in students' actual problem-solving skills related to Technology/Engineering and Religious/Social Sciences in two different Teaching Approaches.

The first concerns the Didactical Approach, the application of two different educational scenarios that approach HASS and STEM courses separately according to official curricula.

The second concerns the Didactical Approach, the implementation of the HASS&STEM Educational Scenario as described above. The second educational approach is the Independent Variable of the experiment. Dependent variable is the performance of students (subjects) on real-world HASS and STEM interdisciplinary problem-solving tests.

Thus, the Experimental Controlled Situation is based on the above two Didactical Approaches to the same subjects and their relative performance evaluations. The subjects are selected students from a random third class of a middle school. Subjects that are absent even in one of the experiment procedures are not counted.

The experimental procedure is specified. This is as follows:

Experimental research is performed without a control group, the technique of repetitive measurements is applied to the same group of subjects, namely pre-test and post-test is applied to the students themselves, before and after the implementation of the HASS&STEM Scenario. Specifically:

- The first Didactical Approach is being implemented. Subjects are taught independently the subjects provided in the official curricula related to Technology and Religion.
- Two weeks later they complete an evaluation test called 'Test-Before', which asks them to investigate, with the help of WEB 2.0 tools, an unknown to them, real technical problem related to social and religious needs, locate it, report some of its components and look for solutions. In particular, they are asked to work on the construction of the Pantheon of Rome. Students answer four related questions (Answers b1 to b4) using a small number of words (30 to 50). Each issue is about achieving a (still not taught) Scenario aim (Fig. 3). Each answer to the test is evaluated by the teachers on each issue. Four scores are derived on a scale of 0 - 20.
  - The first grade concerns the student's response to identifying and analyzing dimensions (degree of effect and influence) of a HASS subject in a STEM subject.
  - The second concerns the student's response to finding associations between social needs (HASS) and technical structure components (STEM).
  - The third concerns the success of identifying technical problems (STEM) in meeting social needs (HASS).
  - The fourth concerns the investigation of technical solutions (STEM) they use to solve problems designed to meet social needs (HASS).
- After two weeks, the second Didactical Approach based on the Educational Script as described above takes place.
- After two more weeks, subjects complete the assessment test called “Test-After” (post-test) in which they are asked to investigate a real technical problem of great similarity (in teachers' estimation) to that of “Test-Before”. In particular, they are asked to work on the construction of Duomo, the Cattedrale di Santa Maria del Fiore. The test is evaluated by the same teachers on each subject.

External (non-experimental) variables are identified that may influence the results of the experiment and are attempted to be directed. These are:

- Teachers and evaluators. They are the same in all stages of the experiment.
- The technical conditions (computer lab, module teaching times). They are intended to be the same in both teaching approaches.
- The educational methodology. Attempts were made to apply similar methods to the same extent in both teaching approaches. It is the project method, discovery learning method with the support of ICTs in constructivist contexts.
- Scenario planning and development elements. Innovative or less innovative elements of scenario development and implementation such as designing it with the principles and tools of educational engineering and applying it with ICTs support, in the authors' view are non-experimental variables as they are thought to have influenced or utilized in the same way in both Teaching Approaches.
- The non-experimental maturation variable is attempted to be inactivated after two weeks of each individual experiment procedure.

There are four hypotheses related to achieving the four objectives of the scenarios. The hypotheses of the experiment are as follows:

- The common null hypothesis $H_0$ that there is no significant difference in students’ performance when teaching the subjects in independent teaching approaches than whether the subjects are taught in a unified integrated approach. Common alternative hypothesis $H_1$ that there is a difference. These statistical assumptions are defined as $H_0$: $\mu_d = \mu_0$ versus $H_1$: $\mu_d \neq \mu_0$ where $H_0$ is the null hypothesis, $H_1$ is the alternative hypothesis, $\mu_d$ is the population mean of the differences (between the estimates of the corresponding Answers of Test-Before and Test-After) and $\mu_0$ are the hypothesized mean of the differences.
- Consequently, we have the corresponding individual hypotheses ($b$:before, $a$:after): $H_0^{b1}$ vs $H_1^{a1}$, $H_0^{b2}$ vs $H_1^{a2}$, $H_0^{b3}$ vs $H_1^{a3}$, $H_0^{b4}$ vs $H_1^{a4}$.
- The sample size is 23 (23 students), the confidence interval (CI) is selected at 90% (as a pilot experiment with a small sample population) and an alpha level ($\alpha$-level) equal to 0,05.

C. Results

The results are estimated using the paired $t$-test. This test was selected because a paired $t$-test is appropriate for testing the mean difference between paired observations when paired differences follow a normal distribution (Minitab 16 Statistical Software, 2010). Before the paired $t$-test, the

DOI: http://dx.doi.org/10.24018/ejers.2020.0.CIE.1797
coefficient *Cronbach’s alpha* is calculated, in order to estimate the *t*-equivalent reliability of both tests (Test-Before and Test-After).

The *Cronbach’s alpha* coefficient of Test-Before is calculated 0.9504 and is characterized as excellent. The *Cronbach’s alpha* coefficient of Test-After is calculated 0.9289 and is also characterized as excellent.

That means that the Internal Consistency of the measurements of the two tests to the extent that the questions measure students’ performance in dealing with complex HASS and STEM problems, is highly consistent or correlated both with and in relation to that performance in general.

A paired *t*-test is following with the grades in each individual question of the Test-Before with the corresponding one of Test-After for Independent sample. The corresponding paired *t*-test showed the following results:

| TABLE I: PAIRED T FOR ANSWER A1 - ANSWER B1 |
|-----------------|-----------------|-----------------|-----------------|
|                  | Mean  | SE Mean | StDev   |                  |
| Answer a1        | 23     | 17.30   | 2.052   | 0.428           |
| Answer b1        | 23     | 16.00   | 1.834   | 0.382           |
| Difference       | 23     | 1.130   | 1.058   | 0.221           |
| 90% CI for mean difference: (0.752; 1.509) |
| T-Test of mean difference = 0 (vs not = 0): 
  T-Value = 5.13 P-Value = 0.000 |

1) Results of Paired *T* statistical test for Answer a1 - Answer b1 (Table I.)

The Confidence Interval (CI) for the Mean Difference between the two tests for the Answer 1 (a1 & b1), does not include zero, which suggests a difference between them. Also the small P-Value (0.000) suggests that the data are inconsistent with *H₀*: *mₐ=*0, that is, the performance of the students in the two Answers does not equally. Since the P-Value (0.000) is smaller than chosen *α*-level (0.05), there is evidence for a difference in performance level of students to this Answer 1 after Scenario application than to the Answer 2 before.

Based on such results, we would to reject the null hypothesis and would conclude that there is significant difference in the performance of the two answers’ results, in confidence interval 90% (Minitab 16 Statistical Software, 2010). Finally, examining the Difference of Means we can support that the students answered by 1,130 more successfully in the question regarding “analyzing the dimensions of the “sanctuary” in art and technology”.

| TABLE II: PAIRED T FOR ANSWER A2 - ANSWER B2 |
|-----------------|-----------------|-----------------|-----------------|
|                  | Mean  | SE Mean | StDev   |                  |
| Answer a2        | 23     | 16,652  | 2,187   | 0,456           |
| Answer b2        | 23     | 16,174  | 1,825   | 0,381           |
| Difference       | 23     | 0,478   | 1,275   | 0,266           |
| 90% CI for mean difference: (0.022; 0.935) |
| T-Test of mean difference = 0 (vs not = 0): 
  T-Value = 1.80 P-Value = 0.086 |

2) Results of Paired *T* statistical test for Answer a2 - Answer b2 (Table II).

The CI for the Mean Difference between the two tests for the Answer 2 (a2 & b2), does not include zero, which suggests a difference between them. But the “medium” P-Value (0.086) suggests that the data are not inconsistent with *H₀*: *mₐ=*0, that is, the performance of the students in both Answers is equally. Since the P-Value (0.086) is greater than chosen *α*-level (0.05), there is no evidence for a difference in success level of students to the Answer 2 after Scenario application than to the Answer 2 before. Based on such results, we would fail to reject the null hypothesis, the null hypothesis is true (*H₀*: *mₐ=*0), and would conclude that there is no significant difference in the performance of the students in the two answers’ results, in confidence interval 90% (Minitab 16 Statistical Software, 2010). Finally, examining the Difference of Means we can support that the students responded by 0.4780 more successfully in the question regarding “relating political, social and worship needs to the shape and the form of technological constructions”.

| TABLE III: PAIRED T FOR ANSWER A3 - ANSWER B3 |
|-----------------|-----------------|-----------------|-----------------|
|                  | Mean  | StDev   | SE Mean |
| Answer a3        | 23     | 16,870  | 2,5802  | 0,496          |
| Answer b3        | 23     | 16,304  | 2,344   | 0,489          |
| Difference       | 23     | 0,565   | 1,161   | 0,242          |
| 90% CI for mean difference: (0.150; 0.981) |
| T-Test of mean difference = 0 (vs not = 0): 
  T-Value = 2.33 P-Value = 0.029 |

3) Results of Paired *T* statistical test for Answer a3 - Answer b3 (Table III)

The CI for the Mean Difference between the two tests for the Answer 3 (a3 & b3), does not include zero, which suggests a difference between them. Also the small P-Value (0.029) suggests that the data are inconsistent with *H₀*: *mₐ=*0, that is, the performance of the students in both Answers is not equally. Since the P-Value (0.029) is smaller than chosen *α*-level (0.05), there is evidence for a difference in success level of students to the Answer 3 after Scenario application than to the Answer 3 before. Based on such results, we would to reject the null hypothesis and would conclude that there is significant difference in the performance of the two answers, in confidence interval 90% (Minitab 16 Statistical Software, 2010). Finally, examining the Difference of Means we can support that the students answered by 0.565 (in a scale 0-20) more successfully in the question concerning “recognizing technical problems in buildings that were constructed to meet political, social and worship needs”.

| TABLE IV: PAIRED T FOR ANSWER A4 - ANSWER B4 |
|-----------------|-----------------|-----------------|-----------------|
|                  | Mean  | StDev   | SE Mean |
| Answer a3        | 23     | 16,652  | 2,479   | 0,517          |
| Answer b3        | 23     | 14,870  | 2,074   | 0,432          |
| Difference       | 23     | 1,783   | 1,476   | 0,308          |
| 90% CI for mean difference: (1.254; 2.311) |
| T-Test of mean difference = 0 (vs not = 0): 
  T-Value = 5.79 P-Value = 0.000 |

4) Results of Paired *T* statistical test for Answer a4 - Answer b4 (Table IV)

The CI for the Mean Difference between the two tests for the Answer 4 (a4 & b4), does not include zero, which suggests a difference between them. Also the “extra” small P-Value (0.000) suggests that the data are inconsistent with *H₀*: *mₐ=*0, that is, the performance of the students in both Answers is not equally. Since the P-Value (0.000) is smaller
than chosen $\alpha$-level (0.05), there is evidence for a difference in success level of students to the Answer 4 after Scenario application than to the Answer 4 before. Based on such results, we would to reject the null hypothesis ($H_0: \mu_2 = \mu_1$), and would conclude that there is significant difference in the performance of the two answers, in confidence interval 90% [17]. Finally, examining the Difference of Means we can support that the students answered by 1,783 more successfully to the question concerning “investigating technical solutions they are used or they were used to solve problems in buildings designed to meet political, social and worship needs”.

V. CONCLUSIONS AND DISCUSSION

The cross-thematic integration teaching/learning of HASS and STEM knowledge branches is not an educational innovation. It has been known and applied in education for a long time [23]. This type of education has not only followers but there are divergent views for its level of influence and effectiveness [19]. The enthusiasm for applying interdisciplinary educational approaches dates back to the 1920s, and it has been bibliographically supported that participation in an interdisciplinary curriculum is associated with positive changes in students’ progress, behavior and attitudes [2]. Basic argument for the necessity of interdisciplinary approaches as a pedagogical practice is projected the interdisciplinary dimension of actual problems. Therefore, students should be able to think interdisciplinarily, a skill necessary for understanding and solving complex social problems [38].

Effective ways, light paths, should therefore be established, which will be part of an at least partial application of this interdisciplinary approach. Tools should also be identified which will help this holistic challenge encounter of interdisciplinary in teaching.

This article presents a cross-thematic integration Educational Scenario of HASS and STEM objects. In fact, it describes objects, important ‘motley’ such as those of RE and those of Technology and Engineering. The application of ICTs was a link and development tool. This Scenario is attempted to become a driving force for the development of similar scenarios.

This tripartite existence of the Scenario, the integrated approach, the expected results of students’ cognitive and metacognitive background development and the emerging difficulty of planning and its implementation, have been a challenge for the teachers and administrators involved.

The scenario was designed, implemented in a real classroom-laboratory and partially evaluated. His initial design stipulated different things from those that eventually occurred. This was despite the fact that it was designed by experienced teachers. Its pilot application surfaced the improvements that had to be implemented. For example, the estimated teaching time was doubled, the Precursor Approach was attached, and software applications were adapted to the students’ cognitive level. This indicates that the implementation of Educational Management & Engineering techniques was considered to be successful as it raised problems that were resolved.

The students responded to the fullest. According to their teachers, they collaborated effectively, participated enthusiastically, and opened ‘windows’ into new knowledge and interdisciplinary problem solving. Their average self-assessment approaches excellence as well as their projects evaluation. It is also considered by its teachers/contributors that the Scenario has contributed to the upgrade of their teaching skills and educational experience. In addition, teachers/contributors reported that such an approach would not be possible without the use of ICTs, both at a level of design and classroom implementation. Looking into this aspect and taking into account the seamless and in our point of view, effective completion of the Scenario processes, we conclude that process support from ICTs is a crucial factor in implementing complex cross-thematic scenarios [20].

The Scenario constitutes the independent variable of a pilot experiment, in which we tried to trace indications that HASS&STEM improves students’ performance in the solution of complex real problems that concern fields of knowledge in HASS and STEM. We refer to indications and not proofs, due to the pilot nature of the experiment, because of the limited number of participating subjects and because the sample of subjects is no certainly representative.

The results show that there are important indications of the improvement of students in the subject of analyzing dimensions (of the degree of effect and influence) that have elements of the fields of knowledge of STEM in fields of HASS and vice versa.

Additionally, there are indications that there is an improvement in performance in the identification of real technical problems that are cause by specific social behaviors and needs, namely complex problems in interdisciplinary STEM and HASS. Still, there are important indications that the performance of students is improved in the search and investigation of problem solutions that are caused in areas of HASS and are solved by activities and techniques of STEM.

There are no indications of improvement observed concerning the possibility of social needs (HASS) and construction elements of technical structures (STEM)

The authors consider that the Scenario was not fully evaluated.

The Scenario was not fully evaluated. We consider that a supplementary evaluation of the whole scenario should follow based on the Multivariable Analysis methodology [21].

We therefore conclude that it is feasible to design and implement teaching approaches that refer to cross-thematic integration branches of STEAM and HASS. We consider an important success factor, these teaching approaches to be based on modern educational theories and to utilize modern teaching techniques.

Based on the above findings, it is concluded that there is strong evidence that cross-thematic integration of STEAM and HASS branches promotes students’ performance in dealing with complex real-world problems in interdisciplinary integration of STEAM and HASS.

REFERENCES


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