Environments and contexts STEM – STEAM education

A Systematic Literature Review

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Abstract — **The objective of this research is to describe STEM education, even more so with the incorporation of art being STEAM, taking into account studies in science, technology, engineering, art and mathematics worldwide through a systematic literature review.**

83 articles were taken from the Scopus database, selected through a methodology for engineering and education, based on the environments in which they are developed, the intervention of art and the contexts of STEAM education.

The results indicate that STEAM education is carried out in settings under educational policies and reforms to improve teaching - learning, requiring change and its integration into the curriculum, STEAM learning environments should be created based on the study plans of the Ministry of Education to integrate all subjects. The incorporation of art has allowed the development of new skills such as creativity and collaboration. On the other hand, the case studies that have given good results in countries such as: Malaysia, United Kingdom, Mexico, United States, China, Hong Kong, Australia, India and Indonesia, Japan, Germany, Qatar, South Korea, Taiwan, Turkey where they make an adaptation of the curriculum and learning policies based on projects and technological design.

Keywords - innovation; steam; stem; tecnologyt.

I. Introduction (Heading 1)

Currently individuals must have different skills to face the daily problems that arise, so education must provide the necessary tools where it is multidisciplinary that allow the integration of knowledge in a creative way, thus STEM education arises that allows individuals to develop the scientific, technological, engineering and mathematical part, but over time it has been proven that this is not enough, so the letter A is inserted in this acronym, resulting in STEAM that includes the arts to this type of education, "*the generation that will constitute the labor force of the future is expected to have the skills of 21st century like reasonable thinking, problem solving, communicating, having a facility with teamwork, innovativeness and productivity, working systematically, as well as utilizing the technology*" [1], in addition "*art infusion naturally shares some of the basic ideas and principles of STEAM education, thereby benefiting both art and non-art subject areas as the arts and artistic pedagogies are in place for the STEM subjects to be woven among them*" [2].

This research allows exploring STEM - STEAM education and answering questions regarding the current state, environments in which they develop, how art intervenes in STEM education and contexts in which it develops.

In this research, a systematic review of the STEM - STEAM Art, Environments and Contexts literature has been carried out applying the Torres-Carrion method [3], which proposes a conceptual mindset, to obtain the research questions and build a script for Searches in the Scopus scientific databases. Three research questions related to STEAM education are proposed, in the end 83 valid documents were analyzed to answer the research questions.

II. Systematic Literature Review

The work has been carried out in three phases: planning, production and presentation of the proposed report in [3] that applies to engineering and education:

A. Planning

Current state of STEAM education

2021 16th Iberian Conference on Information Systems and Technologies (CISTI)
23 – 26 June 2021, Chaves, Portugal
ISBN: 978-989-54659-1-0

The implementation of Steam education is increasingly gaining ground in educational institutions, allowing to generate new skills in students with the integration of art, on the other hand, it is important to know in which environments this type of education is developed and implemented.

Research questions

Three research questions have been defined to address the environments and different contexts of STEAM education.

RQ1: ¿What environments are developed in STEM - STEAM education?
RQ2: ¿How does art intervene in STEM education?
RQ3: ¿How has STEM -STEAM education been adapted in different contexts?

Conceptual Mindset

The conceptual mindset allows us to guide the systematic review regarding STEAM - STEM education, defined on the left side are the characteristics linked to this type of education, on the right side we find the concepts that are excluded from research and at the bottom are the words with which the searches were performed in the database.

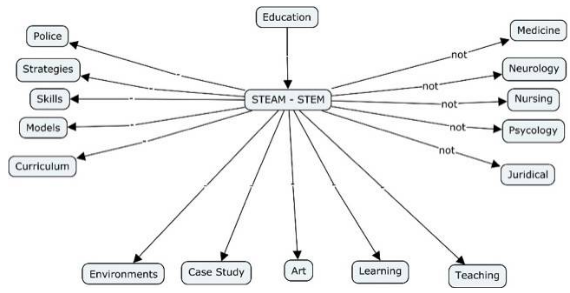

Figure 1. Minset

Search semantic structure

It has been structured taking into account 5 steps, the first according to the defined mind-fact, the second defined according to the environments in which education was developed; the fifth related to the introduction of art in STEM; the seventh referring to the case studies that exist worldwide and finally the research questions related to STEAM - STEM education.

TABLE 1. REVIEW STRUCTURE

L1	Education	(“stem education" OR "steam education" OR "science, technology, engineering, mathematics" OR s.t.e.m. OR s.t.e.a.m)
L2	Environments	(attitudes OR factors OR policies OR PISA)
L3	Art	(art)
L4	Contexts	(case* OR "case study")
L5	Questions	Q1: (Environments where STEM -STEAM education is developed) Q2: (Art in STEM education) Q3: (STEM -STEAM education contexts)

B. Conducting Review

Related systematic reviews

During the research, it was possible to identify a literature review that is of great importance so that the study has a high impact and originality, which is carried out through the systematic search in the SCOPUS database, making it difficult for this review is tailored to the research questions posed in the proposed research, the findings of the review found are presented below.

TABLE II. RELATED REVIEWS.

Study	Analysis	Papers Reviewed
[4]	It is based on student projects in Stem education programs, to motivate and facilitate interest in engineering and mathematics. Likewise, it investigates strengths and weaknesses to place greater emphasis on new research	31

Selection of magazines and databases

The database used was Scopus organized into 83 indexed journal articles.

TABLE III. RESEARCH MAGAZINES

Magazine Name	SJR		h5 Google
	IF	Q	
Electronics (Switzerland)	0,46	Q1	39
International Journal of Engineering Education	0,43	Q1	23
International Journal of Science Education	0,92	Q1	38
International Journal of Technology and Design Education	0,56	Q1	25
Studies in Higher Education	1,89	Q1	52
Journal of Education for Teaching	0,82	Q1	25
Journal of Science Education	0,92	Q1	38
Journal of Science Education and Technology	1,04	Q1	33
Man in India	0,14	Q2	12
Eurasian Journal of Educational Research	0,17	Q4	19
Research in Science Education	0,85	Q1	27
Robotics and Autonomous Systems	0,83	Q1	49
Journal of Science Education and Technology	1,04	Q1	33
Egitim ve Bilim	0,29	Q3	23
International Journal of Advanced Robotic Systems	0,33	Q2	26
Vjesnik Bibliotekara Hrvatske	0,19	Q3	6
Australian Journal of Teacher Education	0,37	Q2	28
Education and Information Technologies	0,6	Q1	34
Journal of Engineering Science and Technology	0,16	Q3	14
Hacettepe Egitim Dergisi	0,22	Q3	5
International Journal of Science Education	0,92	Q2	38
International Journal of Technology and Design Education	0,56	Q1	25
Journal of Science Teacher Education	0,96	Q1	27
Eurasia Journal of Mathematics, Science and Technology Education	0,33	Q3	31
Turkish Online Journal of Educational Technology	0,13	Q4	30
International Journal of Science and Mathematics Education	0,7	Q1	32
Advances in Intelligent Systems and Computing	0,17	Q3	9

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Definition of inclusion and exclusion criteria

The research contemplates different selection criteria which allow to answer the research questions posed and fulfill the objective.

General criteria: The exploration of the publications related to the topic covered, includes the period 2015-2020. Studies involve STEM - STEAM education, with its components in the areas of Science, technology, engineering, mathematics, art.

Specific criteria: Studies comprise STEM education development environments – STEAM. Studies expose how STEM - STEAM education develops in different contexts. Studies that show how Art intervenes in STEM education – STEAM

Exclusion parameters: Robotics studies. Studies in specific areas (Medicine, neurology, nursing, psychology)

C. Reporting the Review

TABLE IV. ENVIRONMENTS IN WHICH THEY DEVELOP IN STEM -STEAM EDUCATION

Variable	Reference	*f*
Attitudes	[1]	1
Factors	[5][6]	2
Policies	[7][8][9][10][11][12][13][14][15]	9
PISA	[16]	1

STEM education environments are developed under policies given by governments and teachers apply them to offer opportunities, scholarships, alliances, networks and strategies with national and international companies and institutions so that students develop skills to innovate the fields of science, engineering, technology and mathematics.

The studies observed are based on the implementation of educational policies and reforms in scientific development to improve teaching - learning and training for teachers in STEM education, as countries that have designated good financing as States have done throughout the years. United, United Kingdom, Australia and England; On the other hand, inclusive policies are shown as strategic partnerships with other countries at the school level for the use of young people as qualified labor for future challenges in the industries.

It is necessary to mention that the development of STEM education is being limited in some countries due to educational policies that entail modifications and extensions of the secondary school curricula and the process of entering the university.

TABLE V. Art intervention in STEM education

Variable	Reference	*f*
Art	[9][17][18][19][2][20][21][22]	8

The development of STEAM education (Science, Technology, Engineering, Arts and Mathematics) is changing learning since the arts are being integrated, forming this education as a field, where theater projects are applied with robots which can interact with dance and sounds, combining science and engineering to bring plays to life, as well as STEM-focused prototypes based on crafts (puppets) that serve teachers to make teaching more innovative.

Creativity and collaboration are important skills to revolutionize education, today they can be combined with devices and augmented reality for interaction with images for surreal art classes, creating an educational environment in the visual arts with a variety of approaches with results positive for the student since it helps the compression, content retention and development of new skills.

TABLE VI. ADAPTATION OF STEM -STEAM EDUCATION IN DIFFERENT CONTEXTS

Variable	Reference	*f*
Study cases	[4][12][20][23][24][25][26][27][28][29][30][31][32][33][34][35][36][37][38][39][40][41][42][43][44][45][46][47][48][49][50][51][52][53][54][55][56][57][58][59][60][61][62][63][64][65][66][67][68][69][70][71][72][73][74][75][76][77][78][79][80][81][82]	64
Teams	[82][83][84]	3

Most of the implementations of Stem - Steam education are given in the countries of: Malaysia, United Kingdom, Mexico, United States, China, Hong Kong, Australia, India and Indonesia, Japan, Germany, Qatar, South Korea, Taiwan, Turkey, where they present different cases and that have given great results.

The results have been in the adaptation of the curriculum, curriculum and educational policies of project-based learning and in the technological design in studies of mathematics and engineering, both undergraduate and postgraduate based on real-world applications, in China include in their curricular units, Steam education.

As for teachers, they apply active learning techniques, resources and curricular materials to stimulate student participation, training, courses, workshops, electronic personal education planners, and Stem - Steam educational activity outreach programs are of importance for improving student performance.

It has been possible to observe as a success case the financing for the implementation of Steam in educational institutions, collective activities of teachers, in addition to development networks with teaching-learning resources, as well as the use of research methods to awaken in students the research and subsequently innovation integrating both mathematics, technology, engineering and art.

The design strategies and activity plans that students use to build and innovate their own objectives, in some cases making use of models and environments in 2D and 3D, scanners, printers, using programming, computing.

The incorporation of educational robotics to promote Stem - Steam education, which includes programming, computing with the help of mobile devices, the use of Scratch and Lego Mindstorms for the development of robots that contribute to the education of students, in order to link computational thinking in them, awakening creativity, innovation and collaborative learning, fostering new skills.

On the other hand, gender equality is a factor that is slowly gaining ground in this type of education for both students and teachers, as well as in the case of special needs for students with disabilities.

III. CONCLUSIONS

83 relevant investigations that are important to our study have been identified, which answered six research questions raised regarding STEAM-SYSTEM education: (Q1) It has been observed that Steam education develops policy environments given by the governments and educational reforms; (Q2) The inclusion of art in STEM has allowed developing skills such as creativity and collaboration and has allowed combining science and engineering, making teaching more innovative; (Q3) Most cases have occurred in the adaptation of the curriculum, curriculum and educational policies of project-based learning and in the technological design in studies of mathematics and engineering, in the case of teachers apply active learning techniques , curricular resources and materials to stimulate student participation; On the other hand, financing for the implementation of Steam in educational institutions, collective activities of teachers, as well as development networks with teaching-learning resources with design strategies and activity plans used by students is important. to build and innovate their own goals using 2D and 3D models and environments, using programming, computing; In addition, the incorporation of educational robotics to promote Stem - Steam education, gender equality is a factor that is slowly gaining ground in this type of education, both in students and teachers, likewise, in the case of special needs for students with disabilities.

REFERENCES

[1] H. Özcan and E. Koca, "The impact of teaching the subject 'pressure' with STEM approach on the academic achievements of the secondary school 7th grade students and their attitudes towards STEM," *Egit. ve Bilim*, vol. 44, no. 198, pp. 201–227, 2019.

[2] T. Hunter-Doniger, "Art Infusion: Ideal Conditions for STEAM," *Art Educ.*, vol. 71, no. 2, pp. 22–27, 2018.

[3] P. V. Torres-Carrion, C. S. Gonzalez-Gonzalez, S. Aciar, and G. Rodriguez-Morales, "Methodology for systematic literature review applied to engineering and education," *IEEE Glob. Eng. Educ. Conf. EDUCON*, vol. 2018-April, pp. 1364–1373, 2018.

[4] J. L. Hess, B. Sorge, and C. Feldhaus, "The efficacy of project lead the way: A systematic literature review," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2016, vol. 2016-June.

[5] N. S. Kamsi, R. B. Radin Firdaus, F. D. Abdul Razak, and M. Ridha Siregar, "Realizing Industry 4.0 Through STEM Education: But Why STEM Is Not Preferred?," in *IOP Conference Series: Materials Science and Engineering*, 2019, vol. 506, no. 1.

[6] M. Stebbins and T. Goris, "Evaluating STEM education in the U.S. Secondary schools: Pros and cons of the «project lead the way» platform," *Int. J. Eng. Pedagog.*, vol. 9, no. 1, pp. 50–56, 2019.

[7] J. P. Kennedy, F. Quinn, and T. Lyons, "Australian enrolment trends in technology and engineering: putting the T and E back into school STEM," *Int. J. Technol. Des. Educ.*, vol. 28, no. 2, pp. 553–571, 2018.

[8] D. Ralls, L. Bianchi, and S. Choudry, "'Across the Divide': Developing Professional Learning Ecosystems in STEM Education," *Res. Sci. Educ.*, vol. 50, no. 6, pp. 2463–2481, 2020.

[9] J. Katz-Buonincontro, "Gathering STE(A)M: Policy, curricular, and programmatic developments in arts-based science, technology, engineering, and mathematics education Introduction to the special issue of Arts Education Policy Review: STEAM Focus," *Arts Educ. Policy Rev.*, vol. 119, no. 2, pp. 73–76, 2018.

[10] J. Sharma and P. K. D. V. Yarlagadda, "Perspectives of 'STEM education and policies' for the development of a skilled workforce in Australia and India," *Int. J. Sci. Educ.*, vol. 40, no. 16, pp. 1999–2022, 2018.

[11] L. Carter, "Neoliberalism and STEM Education: Some Australian Policy Discourse," *Can. J. Sci. Math. Technol. Educ.*, vol. 17, no. 4, pp. 247–257, 2017.

[12] M. A. Rose, V. Carter, J. Brown, and S. Shumway, "Status of elementary teacher development: Preparing elementary teachers to deliver technology and engineering experiences," *J. Technol. Educ.*, vol. 28, no. 2, pp. 2–18, 2017.

[13] V. Wong, J. Dillon, and H. King, "STEM in England: meanings and motivations in the policy arena," *Int. J. Sci. Educ.*, vol. 38, no. 15, pp. 2346–2366, 2016.

[14] S. Blackley and J. Howell, "A STEM narrative: 15 years in the making," *Aust. J. Teach. Educ.*, vol. 40, no. 7, pp. 102–112, 2015.

[15] S. Blackley and R. Sheffield, "Appraising the E in STEM education: Creative alternatives to 'engineering,'" *Int. J. Innov. Sci. Math. Educ.*, vol. 23, no. 3, pp. 1–10, 2015.

[16] M. S. Khine, *Science education in East Asia: Pedagogical innovations and research-informed practices*. Springer International Publishing, 2015.

[17] D. Arrieta and J. Kern, "Art outreach toward STEAM and academic libraries," *New Libr. World*, vol. 116, no. 11–12, pp. 677–695, 2015.

[18] J. Barnes, S. M. Fakhrhosseini, E. Vasey, J. Ryan, C. H. Park, and M. Jeon, "Promoting STEAM Education with Child-Robot Musical Theater," in *ACM/IEEE International Conference on Human-Robot Interaction*, 2019, vol. 2019-March.

[19] M. Nitsche and C. Eng, "Making Puppet Circuits," *Lect. Notes Inst. Comput. Sci. Soc. Telecommun. Eng. LNICST*, vol. 265, pp. 418–428, 2019.

[20] M. N. A. Azman *et al.*, "Retooling science teaching on stability topic for STEM education: Malaysian case study," *J. Eng. Sci. Technol.*, vol. 13, no. 10, pp. 3116–3128, 2018.

[21] S. Cools, P. Conradie, M.-C. Ciocci, and J. Saldien, "The diorama project: Development of a tangible medium to foster STEAM education using storytelling and electronics," *Smart Innov. Syst. Technol.*, vol. 80, pp. 169–178, 2018, doi: 10.1007/978-3-319-61322-2_17.

[22] J. C. Sanabria and J. Arámburo-Lizárraga, "Enhancing 21st century skills with AR: Using the gradual immersion method to develop collaborative creativity," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 13, no. 2, pp. 487–501, 2017, doi: 10.12973/eurasia.2017.00627a.

[23] A. Valls, J. Albó-Canals, and X. Canaleta, "Creativity and contextualization activities in educational robotics to improve engineering and computational thinking," *Adv. Intell. Syst. Comput.*, vol. 630, pp. 100–112, 2018.

[24] A. Ioannou and E. Makridou, "Exploring the potentials of educational robotics in the development of computational thinking: A summary of current research and practical proposal for future work," *Educ. Inf. Technol.*, vol. 23, no. 6, pp. 2531–2544, 2018.

[25] J. G. Wells, "Efficacy of the technological/engineering design approach: Imposed cognitive demands within design-based biotechnology instruction," *J. Technol. Educ.*, vol. 27, no. 2, pp. 4–

ISBN: 978-989-54659-1-0

20, 2016.

[26] J. Maderer, J. Pirker, and C. Gütl, “Enhanced Assessment Approaches in Immersive Environments: Meeting Competency-Oriented Requirements in the Classroom,” *Adv. Intell. Syst. Comput.*, vol. 916, pp. 778–789, 2020.

[27] B. H. Kim and J. Kim, “Development and validation of evaluation indicators for teaching competency in STEAM education in Korea,” *Eurasia J. Math. Sci. Technol. Educ.*, vol. 12, no. 7, pp. 1909–1924, 2016.

[28] S. G. Yıldız and A. Ş. Özdemir, “A content analysis study about stem education,” *Turkish Online J. Educ. Technol.*, vol. 2015, pp. 15–23, 2015.

[29] T.-M. T. Tembo and C.-S. Lee, “Effectiveness of debugging-design in 2D simulations to facilitate STEAM learning,” in *ICCE 2018 - 26th International Conference on Computers in Education, Workshop Proceedings*, 2018, pp. 722–731.

[30] P. D. Swaminathan and P. Zhao, “Increased student engagement in problem solving courses in engineering through active learning,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2018, vol. 2018-June.

[31] C. Montgomery and J. M. Fernández-Cárdenas, “Teaching STEM education through dialogue and transformative learning: global significance and local interactions in Mexico and the UK,” *J. Educ. Teach.*, vol. 44, no. 1, pp. 2–13, 2018.

[32] C. H. Ng and M. Adnan, “Integrating STEM education through Project-Based Inquiry Learning (PIL) in topic space among year one pupils,” in *IOP Conference Series: Materials Science and Engineering*, 2018, vol. 296, no. 1.

[33] D. Acar, N. Tertemiz, and A. Taşdemir, “The effects of STEM training on the academic achievement of 4th graders in science and mathematics and their views on STEM training teachers,” *Int. Electron. J. Elem. Educ.*, vol. 10, no. 4, pp. 505–513, 2018.

[34] F. Ruiz Vicente, A. Zapatera, N. Montes, and N. Rosillo, “Steam robotic puzzles to teach in primary school. a sustainable city project case,” *Adv. Intell. Syst. Comput.*, vol. 1023, pp. 65–76, 2020.

[35] D. Lecorchick and B. Peterson, “Work in progress: Curricular STEMification, in-service teacher education, and course development in a semi-periphery country: An American and Chinese collaboration,” in *IEEE Global Engineering Education Conference, EDUCON*, 2019, vol. April-2019, pp. 1397–1399.

[36] K. Q. Fisher, C. Smith, A. Sitomer, J. Ivanovitch, J. Bouwma-Gearhart, and M. Koretsky, “Identifying features of engineering academic units that influence teaching and learning improvement,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2016, vol. 2016-June.

[37] Ö. Ö. Sümen and H. Çalışıcı, “Pre-service teachers’ mind maps and opinions on STEM education implemented in an environmental literacy course,” *Kuram ve Uygulamada Egit. Bilim.*, vol. 16, no. 2, pp. 459–476, 2016.

[38] P. Babb *et al.*, “Pioneering STEM in undergraduate education: A course for pre-service teachers,” in *IEEE Global Engineering Education Conference, EDUCON*, 2016, vol. 10-13-Apri, pp. 324–331.

[39] B. E. Rincon and C. E. George-Jackson, “STEM intervention programs: funding practices and challenges,” *Stud. High. Educ.*, vol. 41, no. 3, pp. 429–444, 2016, doi: 10.1080/03075079.2014.927845.

[40] S. Govaerts, Y. Cao, N. Faltin, F. Cherradi, and D. Gillet, “Tutoring teachers - building an online tutoring platform for the teacher community,” *Commun. Comput. Inf. Sci.*, vol. 486, pp. 39–51, 2015, doi: 10.1007/978-3-319-22017-8_4.

[41] Z. S. Dan and W. K. W. Gary, “Teachers’ perceptions of professional development in integrated STEM education in primary schools,” in *IEEE Global Engineering Education Conference, EDUCON*, 2018, vol. 2018-April, pp. 472–477.

[42] M. Hacker and M. Barak, “Important engineering and technology concepts and skills for all high school students in the United States: Comparing perceptions of engineering educators and high school teachers,” *J. Technol. Educ.*, vol. 28, no. 2, pp. 31–52, 2017.

[43] “SIGITE 2020 - Proceedings of the 21st Annual Conference on Information Technology Education,” 2020.

[44] S. N. Ashford, R. E. Lanehart, G. K. Kersaint, R. S. Lee, and J. D. Kromrey, “STEM Pathways: Examining Persistence in Rigorous Math and Science Course Taking,” *J. Sci. Educ. Technol.*, vol. 25, no. 6, pp. 961–975, 2016.

[45] S. S. Guzey, T. J. Moore, and M. Harwell, “Building up stem: An analysis of teacher-developed engineering design-based stem integration curricular materials,” *J. Pre-College Eng. Educ. Res.*, vol. 6, no. 1, 2016.

[46] M. Barger and M. A. Boyette, “Do K12 robotics activities lead to engineering and technology career choices?,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2015.

[47] K. T. Lee, “Demo: Use of tangible learning in STEM education,” 2016.

[48] H. Pillay and W. Kappus, “E-learning intervention for stem education: Developing country case study,” *Commun. Comput. Inf. Sci.*, vol. 533, pp. 255–267, 2015.

[49] W. W. M. So, Y. Zhan, S. C. F. Chow, and C. F. Leung, “Analysis of STEM Activities in Primary Students’ Science Projects in an Informal Learning Environment,” *Int. J. Sci. Math. Educ.*, vol. 16, no. 6, pp. 1003–1023, 2018.

[50] J. Watson, N. Fitzallen, L. English, and S. Wright, “Introducing statistical variation in Year 3 in a STEM context: manufacturing licorice,” *Int. J. Math. Educ. Sci. Technol.*, 2019.

[51] P. Mildenhall, B. Cowie, and B. Sherriff, “A STEM extended learning project to raise awareness of social justice in a Year 3 primary classroom,” *Int. J. Sci. Educ.*, vol. 41, no. 4, pp. 471–489, 2019.

[52] L. D. English and D. King, “STEM Integration in Sixth Grade: Desligning and Constructing Paper Bridges,” *Int. J. Sci. Math. Educ.*, vol. 17, no. 5, pp. 863–884, 2019.

[53] H. ÖZcan and E. Koca, “Turkish adaptation of the attitude towards STEM scale: A validity and reliability study [STEM’e yönelik tutum ölçeğinin türkçeye uyarlanması: Geçerlik ve güvenirlik çalışması],” *Hacettepe Egit. Derg.*, vol. 34, no. 2, pp. 387–401, 2019.

[54] G. A. Pillar, M. S. Prudente, and S. E. Aguja, “Perspectives on creativity and innovation levels among robotics elite team student members,” in *ACM International Conference Proceeding Series*, 2019, pp. 174–178.

[55] A. Bermúdez, R. Casado, G. Fernández, M. Guijarro, and P. Olivas, “Drone challenge: A platform for promoting programming and robotics skills in K-12 education,” *Int. J. Adv. Robot. Syst.*, vol. 16, no. 1, 2019.

[56] A. Leung, “Exploring STEM Pedagogy in the Mathematics Classroom: a Tool-Based Experiment Lesson on Estimation,” *Int. J. Sci. Math. Educ.*, vol. 17, no. 7, pp. 1339–1358, 2019.

[57] L. Huang, Y. Han, K. Li, Y. Zheng, and L. Liu, “Study on the instructional design of a STEAM course with Chinese characteristics – take ‘making handmade wood-burning ceramic cups’ as a case,” *Lect. Notes Comput. Sci. (including Subser. Lect. Notes Artif. Intell. Lect. Notes Bioinformatics)*, vol. 11546 LNCS, pp. 277–288, 2019.

[58] L. D. English, “Learning while designing in a fourth-grade integrated STEM problem,” *Int. J. Technol. Des. Educ.*, 2018.

[59] E. E. Peters-Burton and T. Johnson, “Cross-case analysis of engineering education experiences in inclusive STEM-focused high schools in the United States,” *Int. J. Educ. Math. Sci. Technol.*, vol. 6, no. 4, pp. 320–342, 2018.

[60] E. B. Altan, N. Ozturk, and A. Y. Turkoglu, “Socio-scientific issues as a context for STEM education: A case study research with pre-service science teachers,” *Eur. J. Educ. Res.*, vol. 7, no. 4, pp. 805–812, 2018.

[61] S. F. Freeman and C. P. Scianna, “First-year engineering student expectations and experiences: Community, college, and curriculum,” in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2018, vol. 2018-June.

[62] S. Doyle, L. Forehand, E. Hunt, N. Loughrey, S. Schneider, and N. Senske, “Cyborg sessions: A case study for gender equity in

ISBN: 978-989-54659-1-0

technology," in *CAADRIA 2018 - 23rd International Conference on Computer-Aided Architectural Design Research in Asia: Learning, Prototyping and Adapting*, 2018, vol. 1, pp. 71–80.

[63] M. Belevski, "New library services for children and youth: Stem workshops in the zadar public library [Nove knjižnične usluge za djecu i mlade: Stem-radionice u gradskoj knjižnici zadar]," *Vjesn. Bibl. Hrvat.*, vol. 61, no. 1, pp. 363–393, 2018.

[64] R. Sheffield, R. Koul, S. Blackley, E. Fitriani, Y. Rahmawati, and D. Resek, "Transnational examination of STEM education," *Int. J. Innov. Sci. Math. Educ.*, vol. 26, no. 8, pp. 67–80, 2018.

[65] W. Zhao, "STEM education in English of early childhood in China," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 14, no. 6, pp. 2367–2378, 2018.

[66] B. Yildirim and C. Turk, "The effectiveness of argumentation-assisted STEM practices," *Cypriot J. Educ. Sci.*, vol. 13, no. 3, pp. 259–274, 2018.

[67] H. Kermani and J. Aldemir, "Exploring the impact of a STEM integration teacher professional development program on early childhood teacher's pedagogical beliefs," in *Proceedings of the 15th International Conference on Cognition and Exploratory Learning in the Digital Age, CELDA 2018*, 2018, pp. 321–324.

[68] M. Yee-King, M. Grierson, and M. D'Inverno, "STEAM WORKS: Student coders experiment more and experimenters gain higher grades," in *IEEE Global Engineering Education Conference, EDUCON*, 2017, pp. 359–366.

[69] J. C. R. Caetano and M. Jacquinet, "Immersive learning as an opportunity to upgrade learning outcomes and improving skills in political and social sciences," *Commun. Comput. Inf. Sci.*, vol. 725, pp. 243–254, 2017.

[70] R. Csőke and Z. E. Tóth, "Governmental theories – Students' responses: Student strategies reacting to changes in Hungarian higher education," *Qual. Innov. Prosper.*, vol. 21, no. 3, pp. 143–157, 2017.

[71] M. Zapp, "Higher education expansion and the growth of science: The institutionalization of higher education systems in seven countries, 1945-2015," *Int. Perspect. Educ. Soc.*, vol. 33, pp. 37–53, 2017.

[72] R. Tytler, D. Symington, G. Williams, and P. White, *Enlivening STEM education through school-community partnerships*. Springer Singapore, 2017.

[73] M. E. Alimisis D. Moro M., Ed., "International Conference on Educational Robotics, EDUROBOTICS 2016," *Adv. Intell. Syst. Comput.*, vol. 560, pp. 1–257, 2017.

[74] X. Wu and X. Feng, "A case study of project-based industrial collaborative learning courses for teaching high school programming development in China," in *IMSCI 2016 - 10th International Multi-Conference on Society, Cybernetics and Informatics, Proceedings*, 2016, pp. 148–151.

[75] Y. Li, Z. Huang, M. Jiang, and T.-W. Chang, "The effect on pupils' science performance and problem-solving ability through Lego: An engineering design-based modeling approach," *Educ. Technol. Soc.*, vol. 19, no. 3, pp. 143–156, 2016.

[76] D. Slavit, T. H. Nelson, and K. Lesseig, "The teachers' role in developing, opening, and nurturing an inclusive STEM-focused school," *Int. J. STEM Educ.*, vol. 3, no. 1, 2016.

[77] A. C. Strong, M. Chua, and S. Cutler, "Talking 'Faculty development' with engineering educators, then talking 'engineering education' with faculty developers: A collaborative reflection on working across communities," in *ASEE Annual Conference and Exposition, Conference Proceedings*, 2016, vol. 2016-June.

[78] Z. Koyunlu Unlu, İ. Dokme, and V. Unlu, "Adaptation of the science, technology, engineering, and mathematics career interest survey (STEM-CIS) into Turkish [Fen, Teknoloji, Matematik ve Mühendislik Mesleklerine Yönelik İlgi Ölçeğinin (FeTeMM-MYİÖ) Türkçeye Uyarlanması]," *Egit. Arastirmalari - Eurasian J. Educ. Res.*, no. 63, pp. 21–36, 2016.

[79] S. Eng and W. Szmodis, "Stem learning achievement among cambodian middle school students: An examination of gender and psychosocial factors," *Int. Perspect. Educ. Soc.*, vol. 28, pp. 279–305, 2016.

[80] S. Li, J. V Ernst, and T. O. Williams, "Supporting students with disabilities and limited English proficiency: STEM educator professional development participation and perceived utility," *Int. J. STEM Educ.*, vol. 2, no. 1, 2015.

[81] S. Psycharis, "Inquiry based-computational experiment, acquisition of threshold concepts and argumentation in science and mathematics education," *Educ. Technol. Soc.*, vol. 19, no. 3, pp. 282–293, 2016.

[82] A. Eguchi, "RoboCupJunior for promoting STEM education, 21st century skills, and technological advancement through robotics competition," *Rob. Auton. Syst.*, vol. 75, pp. 692–699, 2016.

[83] I. S. Milara, K. Pitkänen, A. Niva, M. Iwata, J. Laru, and J. Riekki, "'The STEAM path': Building a community of practice for local schools around STEAM and digital fabrication," 2019.

[84] M. A. Marciniak, "Mentoring STEM Undergraduate Research Projects in a Large Community College," *PRIMUS*, 2019.

ISBN: 978-989-54659-1-0