RESEARCH ON EDUCATION AND PSYCHOLOGY (REP)

Received: August 9, 2023
Accepted: October 2, 2023
http://dergipark.org.tr/rep

e-ISSN: 2602-3733

October 2023 ◆ 7 (Special Issue 2) ◆ 128-139

Research Article

https://doi.org/10.54535/rep.1340404

Integration of STEM Education to Humanities: Examining Interdisciplinary Links in Basic Chemistry Course According to Student Views

M. Said Doğru[1]
Kastamonu University

Abstract

Science standards for the next generation, as well as other educational reforms, encourage the creation of solid ties between STEM disciplines. Education societies regard integrated STEM as the best practice in various fields. Besides, the integration of disciplines other than STEM has yet to be adequately studied, and the integration of artistic disciplines is limited. Humanist STEM combines the STEM studies in terms of culture, human relationships, level of well-being, and values. This study investigates whether incorporating humanities in an electronic chemistry lecture affects student communication between course themes and interdisciplinary viewpoints. Students were explicitly asked to link STEM subjects between the scientific and the non-scientific, between the scientific and the physical reality from a broader scientific view. This study was conducted with 85 first-year student-teacher candidates studying at the Faculty of Education, Department of Mathematics and Science Education of a Western Black Sea region university in the 2019-2020 academic year. In the study, homework was designed to make evaluations throughout the course. In addition, cross-sectional study analysis was used in the study. A 5-point Likert-type scale was used. All data were analyzed with StatDisk 13 using the required 2 (chi-square) tests. In the data obtained from the research, most students agree that education creates a strong relationship and understanding between science and other undergraduate courses and STEM fields, humanities, and the environment in which they live. This has been observed in traditional (practical) and interdisciplinary (post-implementation) approaches. The findings from this study contribute to the idea of positively altering interdisciplinary perspectives as part of an introductory chemistry course. Today, it is seen that multidisciplinary science is widespread in the fields, and our academic courses need to be shaped according to the specific discipline approaches desired.

Key Words

Basic chemistry course • Multidisciplinary approach • Humanistic and integrated STEM• Science education

[1]**Correspondence to:** Kastamonu University, Araç Rafet Vergili Vocational School, Araç/Kastamonu, Türkiye. E-mail: msaid.dogru@yahoo.com **ORCID:** 0000-0002-9516-1442

Citation: Doğru, M. S. (2023). Integration of STEM education to humanities: Examining interdisciplinary links in basic chemistry course according to student views. *Research on Education and Psychology (REP)*, *7*(Special Issue 2), 128-139.

Introduction

In today's world, some problems are waiting to be solved. The interdisciplinary knowledge is needed to understand and solve such issues. In every area, methods for other fields that provide meaning, intellectual research, and multi-perspective analysis are added to concepts. The consistency and harmony of these connections are essential for the information to be balanced (Fogarty, 1991; Trullen et al., 2020). It connects one STEM discipline to another or integrates multiple domains to enhance student learning in the curriculum. A harmonious integration comprises the following disciplinary components: 1) scientific research, in which students create questions and study their own; 2) technical literacy, where students use software, scientific study into which students generate questions and research; 3) design of a systemic problem-solving strategy that adds to the context and offers the ability, throughout the learning process, to use experience and skills, 4) Mathematical thought (English, 2016; Marginson, 2013).

Integration may involve interdisciplinary approaches (seeing one discipline from another's viewpoint) (Bridle et al., 2013), multidisciplinary approaches (exploring a problem from multiple perspectives) (Nguyena & Mougenot, 2022), and interdisciplinary approaches (integrating the knowledge, attitude, and skills of various disciplines with a precise focus) point of views (Ashby & Exter, 2019; Stember, 1991).

Includes a unique, specific, and fascinating background; it focuses on implementation and integration; student-centered approaches and problem-solving through real-world problems; it fosters development of originality and higher-order thinking skills; and it enhances cooperation, and communication skills (Kelley & Knowles, 2016).

Science, technology, engineering, and mathematics educators believe that STEM integration is the most advantageous approach (Sanders, 2012). The STEM disciplines will establish a good relationship between science and other educational reforms in the next century (Haag & Megowan, 2015). Because the integration of curricula creates potential knowledge gaps in faculties (Stinson et al., 2009).

Art is either not evaluated according to learning aims or considered less important. In the studies conducted, this situation was observed in students. (LaJevic, 2013). Although there has recently been a trend toward integrating STEM disciplines and STEM, it has attracted much less attention than integrating the humanities field into STEM (Ortiz-Revilla et al., 2020). A contemporary approach is humanistic STEM, which combines scientific, technological, engineering, and mathematical studies alongside human relations, values, and culture. Just like in STEM disciplines, humanities, and arts disciplines also need basic portable abilities and analytical reasoning patterns such as innovation, context-based viewpoint, intellectuality and inquisitiveness, reason, perseverance, self-reflection, openness to new ideas, and adaptation (Faulconer et al., 2020; Zeidler, 2016). Disciplines within the humanities, such as language, philosophy, and logic, can provide students with different perspectives. For instance, each sentence has a problem-solving approach (Table 1). Students may benefit from using various skills and abilities from multiple fields to learn and practice problem-solving. The integration of STEM, although its effects are not mentioned much in the literature, is seen that students who receive education with an integrated curriculum are more successful than students who study with a divided curriculum (Fan & Yu, 2017). An integrated approach increases the ability to think and solve problems. This is perhaps due to the integration of intellectual, pedagogical, and practical consequences. (English & King, 2015; Fan & Yu, 2017; Stohlmann et al., 2012). More research must be done to determine the impact of interventions, scaffolding, and teaching designs (Belland et al., 2017; Sanders, 2012). Since attitudes to STEM affect students' motivation (Altakhyneh & Abumusa, 2020), the effect of integration on attitudes and perspectives is essential to understand. This study investigates the influence of small-scale multidisciplinary decomposition in a chemistry course on students' perceptions of the program's commitment to different subjects, programs, and daily life.

Table 1

Compilation of problem-solving abilities from various disciplines (Alkhatip, 2019; Faulconer et al.,2020; Kelly & Knowles, 2016; Nurdyansyah et al., 2017)

Key Ability for Dealing with Challenges	**Disciplinary Skill**			
	Science	Engineering & Technology	Mathematics	Humanities Meta Discipline
Comprehension of a challenge through…	Observing and inquiring	Defining requirements and restrictions	Creating abstractions about a circumstance, illustrated through icons	Identifying key elements of a problem
Schedule an examination through…	Development and declaration	Evaluate the current solutions	Seeking points of entry for solutions	Challenge beliefs and determine current info
The right instruments…	Strategically	Strategically	Strategically	Strategically
Perform an investigation by…	Systematic experimentation and modeling	Designing and running models	Logic and reason	Organizing information
Iteration towards…	Understanding	A good enough solution	Generalized models and proof	Interpretation
Analyze data…	With logical and quantity-based reasoning	With quantity-based reasoning to find the best layout	With quantity-based reasoning	Searching for a template by combining a mixture of techniques
Build an arguable case out of…	Evidence	Evidence	Evidence	Evidence
Knowledge-driven decisions and backing up…	Overall findings	Design choices	Possible methods of resolution	Possible findings
Communication of…	Ideas, results, explanations, and implications	Ideas, design decisions, and explanations	Potential models	Thoughts, Explanations & Implications
The Job and repute are…	Collective	Collective	Collective	Collective

Therefore, the following research questions were addressed in this study for this purpose:

After this course, can students see a concrete relationship among science, technology, engineering, and mathematics?

After completing this course

-Can students understand the connections or relationships among different scientific disciplines?

-Can students see a concrete relationship between the world and science in their environment after the course?

-Can students see a concrete relationship between science and other lessons after the course?

Method

Research model

A descriptive scanning method was employed in this study. The questions were applied to the students with a 5-point Likert-type scale. Subsequently, both quantitative and qualitative stages were used. Qualitative content analysis was used here due to valid and repetitive inferences in the texts (Krippendorff, 2013; Schreier, 2012). During the content analysis, it was examined by two experts in the field.

Study Sample

This study was conducted with 85 (45 female, 40 male) freshman college student-teacher candidates enrolled in the Colleges of Education, Department of Mathematics and Science Education at a stage university within the boundaries of the western Black Sea during the second term 2019-2020. The ages of the students participating in the study are around 19-20. The screening method was used in the study. The socio-cultural characteristics of the students are close to each other. End-of-course evaluations are provided with data. While the mean return rate of the survey before implementation had been 54.2% from 48 people, the mean return rate of the study after implementation had been 60.2% from 37 people. Demographic data were not collected separately in the course where online distanced education was carried out. Since schools were closed due to COVID-19, the education process continued with distance education. The application was carried out in the compulsory course.

Intervention

A multidisciplinary team worked together to make minor changes to the course that did not affect evaluations, task designs, or prominent points (Table 2). The initial name for the first module is "Chemistry Introduction." For instance, the term "meat and gunpowder" was changed. A quotation by Roger Bacon concerning this relationship between science and maths started with the module overview. Roger Bacon, a British philosopher, is known for his innovative work on gunpowder; therefore, the module's title draws inspiration from his contributions. The module also includes a mathematics video on dimensional analysis for chemistry in the overview. Finally, the module ended with an evaluation study.

The impact of these activities on the expectations of students was assessed by adding final assessment questions. The same questions were asked to the groups before and after the application. Students were requested to respond to the following claims using the 5-point Likert scale established and arranged by the researcher, Faulconer, Wood, and Griffith (2020).

& The program has established obvious links across STEM disciplines.

& The program has established obvious links between scientific and non-scientific subjects such as literature, history, and the humanities.

& The program has helped me understand science's relationship to the environment surrounding me.

& The program has broadened my understanding of the integration of science to the rest of my undergraduate studies.'

All data has been collected individually without student identification information. Besides, as a different measure of impact, the researcher collected the data from the students' final lecture grades to show that the rich content of the application did not decrease the student's grades. The data were collected after the end of the classes; personal information was removed and evaluated collectively.

Table 2

Built-in STEM integrations

Type of modifications	**Explanation of Integration**	**Extend of Integration**
Cross-disciplinary Changes	Human-centered STEM courses	8 Courses (all)
	Include videos of alchemy in debate prompts	2 Courses
	Include citations from scientists with philosophical backgrounds in summaries/abstracts	8 Courses (all)
Interdisciplinary Changes	Attach a video clip explaining the calculations involved in chemistry	1 Course
	Modify the debate prompts to involve engineering as well as technology viewpoints.	3 Courses
	Include a video clip on cross-disciplinary applications of certain chemistry concepts	1 Course

Data Collection Tools and Statistical Analysis

Data were collected online. Beforehand, the students were informed that a survey would be conducted via e-mail. An adaptation of the survey administered to students was made. Reliability and validity studies were carried out by adapting the questionnaire. Cross-sectional study analysis has been used to decide whether the subject links the STEM areas, the humanities, and their surroundings and whether science is related to the rest of the undergraduate programs and to ascertain the expectations of students. The students were unaware of their participation in a research study that avoided any John Henry effect or Hawthorne effect. This effect can be explained in education or training processes as follows: The John Henry effect refers to a situation in which students are motivated to exert more effort when they are in competition with each other in lessons or exams. The Hawthorne effect refers to a situation in which students change their behavior when they are under observation without being aware of it (Irving & Holden, 2013). All data were treated as nominal and analyzed with StatDisk 13 using the necessary 2 (chi-square) test. The responses to the 'Strong Accord' and 'Accept' scales were grouped under the category "I agree," and the answers to the 'Neutral' scale were grouped under the category "Disagreement" and the 'Strongly Disagree' scale. As for all of the four issues concerning science and the learner's understanding of science, a corrected alpha from Bonferroni was used. ($\alpha = .0125$) (Gay et al., 2006).

The final lecture grades of the groups before and after submission were assessed using a special t-test (independent samples).

Findings

Two related Chi-square analyses tested four study questions (Table 3). Chi-square probability tables were used to test the difference in perceptions before and after the application.

Most noticeably, many of the students agree that the training creates a strong correlation and understanding of the relationship of science and other undergraduate courses to STEM fields, humanities, and the environment in which they live. This condition has been observed in both conventional (application) and interdisciplinary (post-application) approaches.

While there is no statistically distinct difference between pretreatment (traditional) and posttreatment (interdisciplinary), constructive intervention is motivating under the first two criteria. STEM discipline connections increased from 72.3% before the application to 85.9% after the application. STEM and humanities association rose from 65.3% to 75.4% after treatment. In this practice, a small-scale, interdisciplinary effect of perspectives was used. A statistically notable shift in students' views was observed here as the courses continued to change to emphasize the humanities. The fact that the real-world commitment is very high, at 88.7%, indicates that a statistically significant effect of the application has little importance.

Final grades were compared between the pre-application mean (65.24) and post-application mean (62.12) groups. Overall results have been analyzed by comparing groups before the application mean (65.24) and after the application average (62.12). Dilutive components did not statistically affect student learning office measured by recent course grades, and this is a desirable question since minor improvements did not preclude chemistry principles from being learned.

Table 3

Tests of the study (pre-post) tesfreq, chi-square, and sig. values

	Before-Treatment				After-Treatment				Comparing Before-treatment and After-Treatment	
	Approve	Disapprove	χ2	**P**	Approve	Disapprove	χ2	**P**	**P**	χ2
Obvious links among STEM	42 (%87)	6 (13%)	43.687	< .001*	34(%91)	3(%9)	26.537	< .001*	.897	.295
Obvious links between scientific and non-scientific subject matter and fields like history, art, humanities	35(%72)	13(%28)	28.745	.004*	32(%82)	7(%18)	19.476	< .001*	1.673	.349
Obvious links between the surrounding environment and science	43(%89)	5(%11)	44.954	< .001*	29(%78)	8(%22)	15.129	< .001*	.341	.642
Broadened their perspectives on how science connects to other courses in their degree program	38(%79)	10(%21)	33.329	< .001*	33(%87)	5(%13)	25.328	< .001*	.294	.785

*** *P values denoted by "*" are significantly important when applying Bonferroni correction (=.0125). The percentage amounts stated are rounded to the closest integer.*

Discussion

The effect of this study should be assessed for some critical limitations. The primary limitation of this survey is the sample group. Rather than conducting a broader analysis of students' impact on such practices, the study focused on ensuring that incorporating interdisciplinary perspectives did not adversely influence students' perceptions. A second limitation pertains to unanswered questionnaires. S ince completing the questionnaire was optional during data collection, it was observed that not the entire sample participated in the survey because they were not encouraged to do so. Volunteer survey responses can introduce bias, leading to a high degree of representation of both positive and negative opinions In survey research, overcoming this limitation is challenging, but it is unlikely to significantly impact the results, given that the questions align with the study's purpose.

Marcone (2022) emphasizes in his study that the cooperation between Social Sciences, Humanities, and STEM education can contribute to achieving Sustainable Development Goals. It has been mentioned that these disciplines come together and participate in producing solutions to social problems and integrating STEM education in social sciences and humanities to achieve sustainable development goals. In their study, Gorbaneva and Shramko (2022) emphasized the importance of developing students' cultural awareness by combining STEM education and Humanities. The aim here is to develop students not only scientific and technical knowledge but also the skills to understand, respect, and interact with people's cultural differences. At the same time, the study explains how students can integrate cultural content in STEM courses to increase their cultural awareness. Another study emphasized that when data science education is growing, the Humanities can play an essential role in this field. Data science is generally considered a technical discipline that includes extensive data analysis, artificial intelligence, statistics, and programming, while Humanities focuses on people's behavior, culture, history, and social interactions. The study emphasized how Humanities can be included in data science education, why this integration is essential, and that this integration has various benefits. It also highlights that by integrating STEM into the humanities, students can gain broader thinking skills and improve their ability to carry out data science projects more ethically and socially responsibly. Combining Humanities with data science can better equip students in the field of data science and contribute to the understanding of social problems (Vance et al., 2022). Studies in the literature are compatible with our research.

The findings from this study contributed to the idea of positively changing interdisciplinary perspectives as an introduction to a chemistry course. Today, multidisciplinary science is widespread in the fields; our academic courses are not shaped according to the desired particular disciplinary approaches. An interdisciplinary perspective will help our learners to work effectively with people from different backgrounds and disciplines and contribute to understanding the world around them. Our findings are similar to the studies in the literature (Faulconer et al., 2020).

As a result of this study, it was seen that clear connections were established between the students in the courses applied science, technology, engineering, and mathematics. It has been observed how science and non-scientific subjects and subjects such as arts, history, and humanities link to other issues in the undergraduate program within the framework of the world. The connection between this discipline has emerged.

This study's data supported the idea of positively changing interdisciplinary perspectives as an introductory chemistry course. Nowadays, multidisciplinary science is used extensively, but our academic courses must be structured along certain desired disciplinary lines. An interdisciplinary approach would better prepare our students to understand the world and work effectively with people from different backgrounds and disciplines.

Future studies aligned with design-based research will increase the presence of a humanities perspective in the course to see whether more substantial separation can yield statistically significant results. In the following study, validated tools will be used to measure student attitudes (e.g., learning attitudes about science (Adams et al., 2006; Nuhoğlu, 2008), and data collection and evaluation of different course contents are planned.

In line with research focused on design, future studies will increase the involvement of a scientific point of view to see if a more decisive distinction will yield essential statistics. The following research will be based on the validated tools used to test the students' attitudes and the phases of data collection and assessment of different courses (for example, study manners about science.

Various studies can contribute to the existing literature. For instance , humanities can be studied in STEM courses. It can be shaped by student work. Other than that, research on achieving greater collaboration between disciplines and between the Humanities and STEM disciplines may include similar study topics. Studies on the impact of such studies on STEM education and what role the Humanities can play in these reforms can also address a similar theme. These research efforts can explore the relationships between STEM education and humanities from the perspectives of students, teachers, and educational policies. Such studies are essential for addressing STEM education with a more comprehensive, multifaceted, and student-centered approach.

Ethic

The ethics committee's approval of the research data should be stated. (12.10.2020, 3-19, Kastamonu University)

Author Contributions

The author carried out all processes of the article (Introduction, Method, Results, and Conclusion).

Conflict of Interest

The author declares that they have no conflict of interest.

Funding

Scholarships or payments have not been received from any institution for the article.

References

Adams, W. K., Perkins, K. K., Podolefsky, N. S., & Dubson, M. (2006). A new instrument for measuring student beliefs about physics and learning physics: the Colorado learning attitudes about science survey. *Physical Review Special Topics - Physics Education Research, 2*(1), 1. https://doi.org/10.1103/PhysRevSTPER.2.010101

Altakhyneh, B. H., & Abumusa, M. (2020). Attitudes of university students towards stem approach. *International Journal of Technology in Education, 3*(1), 39-48. https://doi.org/10.46328/ijte.v3i1.16

Ashby, I., & Exter, M. (2019). Designing for interdisciplinarity in higher education: Considerations for instructional designers. *TechTrends, 63*(2), 202-208. https://doi.org/10.1007/s11528-018-0352-z

Belland, B. R., Walker, A. E., Kim, N. J., & Lefler, M. (2017). Synthesizing results from empirical research on computer-based scaffolding in STEM education: A meta-analysis. *Review of Educational Research, 87*(2), 309-344. https://doi.org/10.3102/0034654316670999

Bridle, H., Vrieling, A., Cardillo, M., Araya, Y., & Hinojosa, L. (2013). Preparing for An interdisciplinary future: A perspective from early-career researchers. *Futures*, *53*, 22 32. https://doi:10.1016/j.futures.2013.09.003

English, L. D., & King, D. T. (2015). STEM learning through engineering design: fourth-grade students' investigations in aerospace. *International Journal of STEM Education, 2*(14). https://doi.org/10.1186/s40594-015-0027-7

English, L. D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM education, 3*(1), 1-8. https://doi.org/10.1186/s40594-016-0036-1

Fan, S. C., & Yu, K.C. (2017). How an integrative STEM curriculum can benefit students in engineering design practices. *International Journal of Technology and Design Education, 27*(1), 107–129. https://doi.org/10.1007/s10798-015-9328-x

Faulconer, E.K., Wood, B., & Griffiths, J.C. (2020). Infusing humanities in STEM education: student opinions of disciplinary disciplinary connections in an introductory connection in an introductory chemistry course. *Journal of Science Education and Technology, 29*, 340-345. https://doi.org/10.1007/s10956-020-09819-7

Fogarty, R. (1991). Ten ways to integrate curriculum. *Educational Leadership, 49*(2), 61–65. https://spada.uns.ac.id/pluginfile.php/517519/mod_resource/content/1/Fogarty%20-%201991%20-%20Ten%20ways%20to%20integrate%20curriculum.pdf

Haag, S., & Megowan, C. (2015). Next generation science standards: a national mixed ‐ methods study on teacher readiness. *School Science and Mathematics, 115*(8), 416-426. https://doi.org/10.1111/ssm.12145

Gorbaneva, V., & Shramko, L. (2022, April). Integrating STEM Education and Humanities for Fostering Students' Cultural Awareness Through CLIL Methodology. In *Proceedings of the Conference "Integrating Engineering Education and Humanities for Global Intercultural Perspectives*" (pp. 405-414). Cham: Springer International Publishing. https://doi.org/10.1007/978-3-031-11435-9_44

Irving, G., & Holden, J. (2013). The John Henry effect. *BMJ, 346*. https://doi.org/10.1136/bmj.f1804

Kelley, T., & Knowles, G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(11), 1–11. https://doi.org/10.1186/s40594-016-0046-z

Krippendorff, K. (2018). Content analysis: An introduction to its methodology. Sage publications. https://books.google.com.tr/books?hl=tr&lr=&id=nE1aDwAAQBAJ&oi=fnd&pg=PP1&dq=Krippendorff,+K.+(2018).+Content+analysis:+An+introduction+to+its+methodology.+Sage+publications.&ots=yZgiYwgR8z&sig=sSE0MlU25btOzfBC719ph7f-dlU&redir_esc=y#v=onepage&q=Krippendorff%2C%20K.%20(2018).%20Content%20analysis%3A%20An%20introduction%20to%20its%20methodology.%20Sage%20publications.&f=false

LaJevic, L. (2013). Arts integration: What is happening in the elementary classroom? *Journal for Learning through the Arts, 9*(1), n1. https://doi.org/10.21977/D99112615

Marcone, G. (2022). Humanities and social sciences with sustainable development goals and stem education. *Sustainability, 14*(6), 3279. https://doi.org/10.3390/su14063279

Marginson, S. (2013). The impossibility of capitalist markets in higher education. J*ournal of Education Policy, 28(*3), 353–370. https://doi.org/10.1080/02680939.2012.747109

Nguyen, M., & Mougenot, C. (2022). A systematic review of empirical studies on multidisciplinary design collaboration: Findings, methods, and challenges. *Design Studies, 81*, 101120. https://doi.org/10.1016/j.destud.2022.101120

Nuhoğlu, H. (2008). The Development of an Attitude Scale for Science and Technology Course. *Ilkogretim Online, 7*(3). https://dergipark.org.tr/en/pub/ilkonline/issue/8600/107084

Nurdyansyah, N., Siti, M., & Bachtiar, S. B. (2017). Problem-solving model with integration pattern: student's problem-solving capability. 1st International Conference on Education Innovation (IEEE). https://doi.org/10.2991/icei-17.2018.67

Ortiz-Revilla, J., Adúriz-Bravo, A., & Greca, I. M. (2020). A framework for epistemological discussion on integrated STEM education. *Science & Education, 29*(4), 857-880. https://doi.org/10.1007/s11191-020-00131-9

Sanders, M. E. (2012). Integrative STEM education as “best practice”. İçinde 7th Biennial International Technology Education Research Conference. Queensland: Australia. http://hdl.handle.net/10919/51563

Schreier, M. (2012). Qualitative content analysis in practice. *Qualitative content analysis in practice*, 1–280. https://daneshnamehicsa.ir/userfiles/files/1/9-%20Qualitative%20Content%20Analysis%20in%20Practice%20(2013,%20SAGE%20Publications).pdf

Stember, M. (1991). Advancing the social sciences through interdisciplinary enterprise. *The Social Science Journal, 28*(1), 1–14. https://doi.org/10.1016/0362-3319(91)90040-B

Stinson, K., Harkness, S., Meyer, H., & Stallworth, J. (2009). Mathematics and science integration: models and characterizations. *School Science and Mathematics*, *109*(3), 153–161. https://doi.org/10.1111/j.1949-8594.2009.tb17951.x

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, *2*(1). https://doi.org/10.5703/1288284314653

Trullen, J., Bos‐Nehles, A., & Valverde, M. (2020). From intended to actual and beyond A cross‐disciplinary view of (human resource management) implementation. *International Journal of Management Reviews*, *22*(2), 150-176. https://doi.org/10.1111/ijmr.12220

Vance, E. A., Glimp, D. R., Pieplow, N. D., Garrity, J. M., & Melbourne, B. A. (2022). Integratıng the humanıtıes ınto data scıence educatıon. *Statistics Education Research Journal*, *21*(2), 9-9. https://orcid.org/0000-0001-5545-1878

Zeidler, D.L. (2016). STEM education: A deficit framework for the twenty-first century? A sociocultural socioscientific response. *Cultural Studies of Science Education*, *11*, 11-26. https://doi.org/10.1007/s11422-014-9578-z