## ФИЗИКА-МАТЕМАТИКА ҒЫЛЫМДАРЫ

## PHYSICAL AND MATHEMATICAL SCIENCES

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# PERSPECTIVES ON STEM EDUCATION INTEGRATION

**Abstract.** The science, technology, engineering, and mathematics (STEM) acronym is frequently utilizedas a part of reference to only one of the disciplines, regularly science. STEM disciplines' integration is progressively encouraged in the literature but studies thatfocus on multiple disciplines seem insufficient with diversedata and incompetentways for STEM improvement. Points of view on how training combination can be accomplished are shifted, with reference to multidisciplinary and interdisciplinary methodologies adding to the verbal confrontations. Such approaches contain center ideas and aptitudes from at least two disciplines with the point of developing comprehension and abilities. Research about STEM integration is an embryonic field with respect to advancing curriculum development and various student outcomes. For instance, despite everything we require more reviews on how understudy gaining results emerge from various types of STEM incorporation as well as from the specific trains that are being coordinated. Drawing on proposals from the writing, recommendations are offered for tendingto the difficulties of coordinating different orders confronted by the STEM community.

**Key words:** STEM integration, STEM research, multidisciplinary and interdisciplinary integrations.

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**Аңдатпа.** Ғылым, технология, техника және математика салаларының аббревиатурасы болып табылатын STEM білім беру әдісі қазіргі таңда тек ғылым бағытында қолданылуда. STEM салаларының интеграциясы әдебиеттерде кең талдауға салынғанына қарамастан, бірнеше саланы қамтыған зерттеулер жеткіліксіз, әрі STEM бағытының жетілуіне қажетсіз бағыттар ұсынылуда. Пәнаралық әдістерді пайдалана отырып, STEM пәндерін толық интеграциялау мүмкіншілігі де біршама зерттеу жұмыстарында қарастырылған. Мұндай әдістер екі немесе одан да көп STEM пәндерінің негізгі ұғымдарын бірлестіре отырып ұсыну арқылы оқушылардың түсінігін тереңдетуді және шынайы әлемдегі мәселелерді шешуге дайындауды көздейді. Алайда зерттеу жұмыстарында бұл әдістерді енгізу оқушылардың үлгеріміне, немесе математика секілді маңызды бір пәннің толық меңгерілуіне кері әсерін тигізері де айтылған. Сол себепті, STEM пәндерінің интеграциялануы толық зерттелмеген бір алаң болып табылады. Ұсынылып отырған мақалада, осыған дейін жасалған зерттеулерге сүйене отырып, STEM пәндерін интеграциялаудың бірнеше әдістері қарастырылған.

**Кілт сөздер:** STEM, STEM зерттеулер, пәнаралық интеграция.

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**Аннотация.** Аббревиатура науки, технологии, техники и математики (STEM) часто используется в отношении только одной из дисциплин. Хотя интеграция дисциплин STEM все чаще пропагандируется в литературе, исследования, которые касаются множественных дисциплин, кажутся скудными со смешанными результатами и неадекватными направлениями продвижения STEM. Перспективы по достижению интеграции дисциплин разнообразны, принимая во внимание многодисциплинарные и междисциплинарные подходы. Такие подходы включают основные концепции и навыки из двух или более дисциплин с целью углубления понимания и навыков. Исследования, нацеленные на интеграцию STEM, представляют собой эмбриональное поле в отношении развития учебной программы и результатов учащихся. Все еще необходимо больше исследований о том, как на результаты обучения студентов влияют не только разные формы интеграции STEM, но и конкретные дисциплины, которые интегрируются. Опираясь на рекомендации из литературы, предлагаются предложения для решения задач интеграции нескольких дисциплин, с которыми сталкивается сообщество STEM.

**Ключевые слова:** STEM, исследования STEM, междисциплинарная интеграция.

The issues that we challenge in our continually changing, progressively worldwide society are multidisciplinary, and many require the combination of different science, technology, engineering, and mathematics (STEM) ideas to deal with them. These complicatedissues are main motivation behind overall calls for changes in STEM training. In spite of the fact thatinstructors know about the significance of STEM training, neither teachers nor scientists reliably concur or comprehend what STEM instruction should be about in K-12 education. Currently, STEM disciplines are taught in silos. But the nature of the work of most STEM experts obscures the lines between disciplines. Thus, teaching STEM disciplines through integrating them would be more in accordance with the nature of STEM. As the nature of STEM is an integration of the four subjects, science, technology, engineering, and mathematics, many questions remain ill-defined in K-12 STEM education. One of the greatest instructive difficulties in K-12 STEM education is that few general rules or models exist for educators to seek regarding how to teach using STEM integration approaches in their classroom.

STEM education is generally used to mean something contemporary and appealing but it mayremain disconnected subjects [1].Kennedy and Odellnoted that the current state of STEM education: «has evolved into a meta-discipline, an integrated effort that removes the traditional barriers between these subjects, and instead focuses on innovation and the applied process of designing solution to complex contextual problems using current tools and technologies. Engaging students in high quality STEM education requires programs to include rigorous curriculum, instruction, and the assessment, integrate technology and engineering into science and mathematics curriculum, and also promotes scientific inquiry and the engineering design process [2]».

Over the last few decades, STEM education was centralized on advancing science and mathematics as confined disciplines [3] with little combination and consideration given to technology and engineering. Moreover, STEM subjects regularly are educated detached from the arts, creativity, and design. Sanders described integrated STEM education as "approaches that explore teaching and learning between/among any two or more STEM subject areas, and/or between a STEM subject and one or more other school subjects" [4]. Sanders advocates that results for studying at least one of the other STEM subjects should be explicitly composed in a course – such as a math or science learning result in a technology or engineering class.

STEM integration in the classroom is a type of curriculum integration. The idea of curriculum integration is complicated and difficult, as it is more than simply collecting different subject areas together. The main point in curriculum integration is awareness of educators that real world problems are not separated into isolate disciplines that are taught in schools [5]. In many situations, people need abilities more than they could get from learning just the disciplines. Even with this fact, researchers and educators have not come to an agreement around a clear meaning and determination of curriculum integration. Research studies are often not clear about the terminology that has been used to describe integration.

Two phrases that have been used regularly in the literature to explain integration are «multidisciplinary» and «interdisciplinary». Most of the researchers try to differentiate these two by wayof focusing at the paths and degree of integration. Lederman and Niess used the metaphor of chicken noodle soup versus tomato soup to provide an explanation for the general variations among multidisciplinary and interdisciplinaryapproaches to integration. In their explanation, multidisciplinary integration was described as a bowl of chicken noodle soup, wherein every ingredient/subject preserved its distinctiveness without explicit mixture, but still came together to make a whole. On the other hand, tomato soup expressed an interdisciplinary approach to integration, in which all ingredients/subjects were combined together and could not easily be disjointed.

Alternatively, they indicated that in the multidisciplinary approach, each subject could easily be determinedby a student. On the contrary, in interdisciplinary approach boundaries among subjects were blurry like in melting pot. Overall, multidisciplinary starts and finishes with the subject-based content and abilities, and students were anticipated to attach the content and skills in different subjects that had been taught in different classrooms. As for interdisciplinary, the approach starts with a problem or an issue that combines the content and skills in multiple disciplinary subjects [6]. The concepts of interdisciplinary integration are interconnected beyond a theme, such that they cut across subject areas and focus on interdisciplinary content and skills, rather than subject-based content and skill [7].

Interdisciplinary curriculum is accepted as the best form of curriculum integration by many researchers. Interdisciplinary curricula begin with real world problems or issues. The fundamental aspects that should be examined in an interdisciplinary curriculum involve such abilities and learning as analytical reasoning, inquiring skills, and making relations with training experiences that link with personal meanings.

If STEM integration is accepted as a type of curriculum integration, it demonstrates its explanation; curricular approach that integrates science, technology, engineering and mathematics. STEM integration provides students one of the best conveniences to experience knowledge in an actuality situation, accommodate them at a later time. As long as there is an enduring demand to apparently determine an analyticalstructurefor STEM integration, also understand curricular and classroom practices, the objectives for an efficient STEM education have been actively discussed.

By using engineering accreditation standards, Sanders argued that the focuses of STEM education should apply knowledge of mathematics, science and engineering, design and conduct experiments, analyze and interpret data, and communicate and corporate with multidisciplinary teams. As considered in the report Improving Undergraduate Instruction in Science, Technology, Engineering, and Mathematics an effective STEM education should not only concentrate on science content, but also support “inquisitiveness, cognitive skills of evidence-based reasoning, and an understanding and appreciation of the process of scientific investigation” [8]. Additionally, Morrison provided criteria for what an effective STEM instruction should look like in a classroom. She suggested in a STEM integration classroom students should be able to perform as 1) problem-solvers, 2) innovators, 3) inventors, 4) logical thinkers, and also be able to understand and develop the skills needed for 5) self-reliance and 6) technological literacy. An analysis of different STEM programs and curricula designs revealed that many researchers and educators agreed on the two major foci of STEM integration: (1) problem solving through developing solutions and (2) inquiry [9]. Therefore, teaching STEM integration not only needs to focus on content knowledge but also needs to include problem-solving skills and inquiry-based instruction.

«Researchers on the Illinois State University's Integrated Mathematics, Science, and Technology project [10] found five characteristics for an inquiry-based curriculum to effectively promote STEM faculties. First, students get a variety and choice of learning tasks to involve them in the learning process and increase their motivation to complete the project. Second, they receive explicit communications and explanations to curtail any ambiguity caused by a problem's open-endedness. Third, they have opportunities to model solutions, practice solving problems, and receive constructive feedback on high-level tasks from peers and coaches. Forth, they engage in a student-centered instructional environment that focuses on the interests and needs of the individual learners. And fifth, each learner receives support for their individual learning needs and levels of development, from the high achievers to the struggling learners.

Developing students' understanding and appreciation of how integrated content, skills, and modes of thinking interact, including how they support and complement one another, is not an easy task. As noted in a research [11] just because these connections might be emphasized in a curriculum, there is no guarantee that students will identify them or make the connections on their own. Consequently, the desired integrated STEM learning may well be lost. Likewise with respect to mathematics, Shaughnessy [12] stressed that the «M» must be made «transparent and explicit». We cannot assume that all students will "see" the mathematics that is inherent in a particular problem. More research is called for on ways to help students make STEM connections more transparent and meaningful across disciplines, including how this might be achieved at different grade levels. At the same time, further research is required on ways of assisting teachers to foster these connections, especially when appropriate curriculum frameworks and resources might be lacking.

Research on student outcomes in STEM integration appears limited and inconclusive, especially from a long-term perspective. A number of research issues arise including how integrated STEM programs might encourage more student engagement, motivation, and perseverance [13]. Unfortunately, review of research reports indicated that such aspects, especially from a log-term view, are rarely measured in evaluations of these programs. Their review revealed that «few data convincingly correlate integrated STEM education with student outcome». This finding is of particular concern, especially with respect to students' achievements in each of the STEM disciplines at different grade levels. Studies have yielded varied results. For example, Becker and Park's meta-analysis [14] of studies investigating the possible differential effects of integration types on students' learning showed a large effect size (1.76) when all disciplines were integrated. In contrast, the effect size for integrating engineering and mathematics was small (0.03), as was the case when mathematics was integrated with science and technology (0.23).

Given that a number of studies analyzed by Becker and Park did not report on students' mathematics achievements, there remains the problem of inadequate research of the effects of integrative approaches on mathematics learning. Honey [13 p. 144] review suggests that mathematics achievement is difficult to promote through STEM integration. If this is the case, then possible reasons for this need further investigation including whether a sequenced and structured approach to mathematics instruction hinders in-depth learning within STEM integration.

Clearly, there remain many research questions regarding STEM integration. In an effort to provide much-needed direction to future research, Honey [13p.32] developed a descriptive framework of core features and subcomponents of integrated STEM education incorporating goals and outcomes for students and educators, together with the nature and scope of integration and features of implementation. Emanating from this framework, their recommendations include as a necessary starting point a consistent use of terminology that establishes a common STEM language.

The development and application of substantial theoretical frameworks, and a better delineation of the nature of STEM integration programs, including how evidence for learning is gathered and the types of learning supports provided, are also essential to advancing the field. With respect to program implementation, I noted the need to investigate ways to make connections among STEM disciplines more transparent for both students and teachers. One expectation of effective STEM education program is that students are encouraged to make new and productive connections across two or more of the disciplines, which may be evidenced in improved student learning and transfer as well as interest and engagement. It is hoped that this article has prompted further avenues for research and discussion on how we can advance the STEM field including keeping abreast of the exponential growth in the technology.

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Алматы қ., Қазақстан

# ОРТА МЕКТЕПТІҢ 6-СЫНЫПТАРЫНА ОҚЫТЫЛАТЫН ЕКІ АЙНЫМАЛЫСЫ БАР СЫЗЫҚТЫҚ ТЕҢДЕУЛЕР ЖҮЙЕСІН ШЕШУ ӘДІСТЕРІН ЗЕРТТЕУ МӘСЕЛЕЛЕРІ

**Аңдатпа.** Сызықтық теңдеулер теориясының әдістері білім салаларының әртүрлі тармақтарында кең қолданыс тапқан негізгі