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STEM education: content integration in English classes (SCILLA project)

Abstract. STEM education is a progressive trend in modern education. Its aim is to develop students' critical thinking, research abilities, engineering thinking based on scientific methods, technical applications, mathematical modelling, etc. Implementation of STEM approach will expand the boundaries of students' thinking, bring Kazakhstani education closer to the international standard, and open new opportunities for students. Statistics on the implementation of STEM education in the Kazakhstan education system shows that the transition in the pilot phase began in 2012, in the conditions of updated content in Nazarbayev Intellectual Schools, Haileybury, Quantum School, etc. However, at the level of university education this topic is highly significant. The application of STEM-education technologies in teaching foreign languages is of particular interest.

The article presents an analysis of the results of the international project, which was funded under the grant program of the U.S. Mission in Kazakhstan. The article considers STEM education as a means of teaching a foreign language at the university, which allows to include students in the activities in the natural-scientific field, thus ensuring the success of future specialists in the world of constantly changing information technologies. All this is possible due to the interdisciplinary applied nature of STEM education. In the course of the study, a meta-analysis was conducted to determine the impact of STEM educational practices on student learning outcomes in teaching and learning process. The research makes an overview of universities in Kazakhstan in terms of students' demographics, language level, etc. Then the context is provided on teacher training, teacher preparation, lesson planning, a model for planning and delivering instruction to university students. This context lays the foundation for the development of an integrated STEM learning module that utilizes STEM + Language learning approach.

Keywords: STEM education, meta-analysis, learning outcomes, scientific education.

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Introduction

English language learners make up the fastest growing subgroup of the student population in Kazakhstan. This significant population needs to master English language as well as become proficient in the content defined by academically rigorous science and technology. In addition,

computer science or computational thinking is becoming increasingly important for all students to become professionals or active members in our informative and very fast developing society.

A progressive direction in modern education is STEM education. Its essence lies in the fact that allows you to develop students' intellect, research abilities, engineering thinking based on scientific methods, technical applications, mathematical modelling, engineering design. Of particular interest is the use of STEM education model in teaching English in universities. STEM education is not a separate subject, it involves the integration of knowledge from different areas, thanks to this STEM education can be used in teaching different subject areas. The integration of knowledge from various fields allows future professionals to be successful in most spheres. Almost all experts note that progressive technologies increase motivation for learning and expand basic knowledge in different fields.

Problem Statement

This article highlights the problem and perspectives associated with STEM (Science, Technology, Engineering, and Mathematics) education and Foreign Language education and draw attention to the national need for such an interdisciplinary education. The purpose of the article is to outline these underlying constructs and perspectives for discussion among the broader educational community. The research and discussion presented here aims to encourage integrated interdisciplinary studies between English language fields with the STEM subjects by reviewing current STEM Education literature and programs; current foreign language programs; pedagogy relating to the integration of the subjects; and any effort to combine the two content areas. The development of the STEM approach in education begins in the 1990s. Over the years, the US National Science Foundation first used the acronym SMET, which later changed to the well-known STEM in 2001. STEM is based on the idea of simultaneously developing skills in areas such as science, technology, engineering and mathematics. Today, STEM is becoming a priority in global education, as it allows to study several subjects in a single educational scheme.

In the modernization of the education system in Kazakhstan, the main link can be considered is updating the content of educational programs, the development and implementation of new programs that will help ensure a gradual, smooth transition to training focused on the development of personality, culture of thinking, independence and responsibility for decision making [1, p. 193-194]. Today the schools, colleges and universities require such programs that are aimed at forming a high level of technological development.

Our Ministry of Science and Higher Education of the Republic of Kazakhstan is currently in the process of working with teachers, school leaders, parents and children, to redevelop the Curriculum. Amongst the objectives of the redevelopment is to become internationally recognised as providing the highest quality STEM education for all learners across all levels of education.

Methodology

The methodological part of our project's research lays the foundation for the creation of an integrated STEM unit that uses a backward-looking design approach to more clearly define the links between content and language. The research makes an overview of universities in Kazakhstan in terms of students' demographics, language level, etc. Then the context is provided on teacher training, teacher preparation, lesson planning, a model for planning and delivering instruction to university students. This context lays the foundation for the development of an integrated STEM learning module that utilizes STEM + Language learning approach.

A meta-analysis method was used to measure the effects of STEM educational practices in the national and international teaching procedures and training practices. Meta-analyses can be conducted using aggregated data, called summary data (SD), or using data collected for each individual research participant, called individual participant data (IP). This statistical meta-analysis method combined the results of separate research studies. The meta-analysis method

included calculating the impact of independent variations on the dependent variable by using quantitative statistical methods to assess, compare and to integrate quantitative data from experimental and quazi-experimental studies conducted in any educational field [2, p. 43-44].

Results and Discussions

The present research was conducted within the context of a 6 months STEM Experience for Teachers project «STEM Content Integrated with Language Learning Activities (SCILLA)» in 2020, and it was funded by the U.S. Mission in Kazakhstan, the U.S.-Kazakhstan University Partnerships Grants Program. The goal of the project was to improve teacher training and curriculum development for English language teachers, including developing STEM teachers' English skills to prepare them to teach in English.

It was coordinated by professor D. K. Hartman from Michigan State University. The project aimed to support Kazakhstan's efforts to develop STEM education system in Kazakhstan universities. Administered by American Councils for International Education (American Councils), this grant was designed to jointly enhance curricula, deliver improved faculty engagement and educational outcomes, and facilitate joint research and other projects in Kazakhstan and the United States. Grant funding contained supporting faculty and technical experts, materials, conferences, forums fees to implement international projects that advance the specific programme objectives:

- Upgrading the skills of teachers, teaching and learning methodologies of English language, including STEM education;
- Modernisation of content, teaching and learning pedagogy and curricula such as commercialisation of research, STEM and innovations;
- Establish Kazakhstan's institutional capacity to enhance and support international co-operation with US community colleges, colleges and universities.

Modern education globally aims to bring STEM education into the main stream of traditional education. This is due to the fact that STEM education allows students to be included in the language learning activities in the field of science, thus ensuring the success of future specialists in a world of ever-improving information technologies. All of this is made possible by the interdisciplinary applied nature of STEM education. Thus, STEM education is one of the brightest innovations of the 21st century, combining elements of pedagogy of innovation and pedagogy of art. The effectiveness of this approach is associated with practical implementation of synergy of different branches of knowledge in the process of education.

Conducting a review of the research literature on English language teaching in integration with each of the STEM subjects is a challenging task and has been done for math's education [3, 4] and science education [5]. This problem is more challenging because it requires an interdisciplinary approach that goes beyond traditional disciplinary silos.

While there exists substantial academic literature on STEM education, there are fewer resources and studies on teaching English Learners within a STEM education program model. Some articles discuss "modification" or "adaptations" to a STEM curriculum to better serve the needs of English Learners; however, few articles suggest English teaching best practices and STEM education are mutually beneficial programs. STEM inherently includes experiments, engineering design, visuals, realia, and technology.

In our estimation, these components are perfect for teaching English Learners because they bring the curriculum to life in a language-rich and contextualized environment. Conversely, teaching utilizing ESL methods and best practices enhances the learning of all students because it focuses attention on the academic English necessary to communicate effectively in these disciplines. There exists an incredible opportunity to simultaneously teach both STEM subjects and academic language to all students. These traditionally separate teaching areas actually have complementary, and mutually beneficial, planning practices and teaching methodologies.

The study examined published and statistically evaluated articles in national and international scientific journals and doctoral theses, carried out using STEM educational practices

in the national and international educational process in the period from 2014 to 2021. All works and papers have the necessary thoroughly researched quantitative data. Doctoral theses without permission were not included in the survey. During the selection process, the titles and keywords of scientific papers in Kazakh, Russian and English languages were taken into account: «STEM», «STEM education», «STEM activities», «STEM curricula», «STEM application». As a result of the research, international and national papers were included in the sub-analysis according to the criteria when they were reviewed for the purposes of the research. A total of 1200 students in the experimental groups and 1220 in the control groups were included in the meta-analysis. The studies were divided into subgroups based on learning outcomes; including the areas of the discipline in which STEM educational practices were applied. An appropriate form of data coding for the purpose of the study was developed by us to explore the inclusion the cases of the studies found in the research into the meta-analysis and its validity, to compare the cases studies and to identify the statistical information used in the research. In the study, research coding forms were completed by two academic experts with scientific degrees. After coding, the forms of both experts were mutually evaluated. As a result of the evaluation, the reliability of the codes was calculated to be 87% using the formula developed by Miles and Huberman [6, p. 122]. According to the validity formula, results of 70 % are sufficient for reliability, so according to this it can be concluded that the coding done for the research identified for the investigation objectives is reliable.

In our meta-analysis, the impact of STEM educational technologies and STEM-practices on student learning outcomes was studied in the parameters of learners' academic progress, course attendance attitudes and academic process skills, the other categories were excluded from the study. From a practical point of view, the researchers who will work on these topics will be able to study STEM educational practices over a full period of study by researching different factors including the impact on different subjects and can conduct meta-analysis investigations. Moreover, the studies conducted in this meta-analysis were mainly focused on students' academic achievements. It is suspected that STEM educational practices among researchers should focus more on the outcomes of the knowledge achieved.

Theoretical analysis of sources on STEM education has allowed us to identify key features of integrating STEM subjects with language learning education that distinguish it from the traditional system of education. The essence of them is as follows:

- STEM subjects, are academically rigorous and language intensive [7, p. 3];
- the integration of STEM-education content with foreign language learning provides an opportunity for student' independent training, they learn to identify problems and search for ways to solve them in an autonomous self-directed manner through active purposeful and conscious activity;
- students solve problems and through participation in teamwork students have the opportunity to share their analytical and creative findings and misjudgments with other team members [8, p. 517];
- STEM education cultivates and encourages mutual support and mutual assistance in solving learning problems.

Conclusion

The active development of STEM education began in Kazakhstan from 2014. This is confirmed by the designated transition to the updated content of school education in the context of STEM within the framework of the State Program for the Development of Education and Science for 2016-2019. To implement the new educational policy, it is planned to include STEM elements in the curricula aimed at the development of new technologies, scientific innovations, and mathematical modelling.

With the release of the State Program for the Development of Education and Science of the Republic of Kazakhstan for 2020 – 2025 [9], we highlight the importance and perspectives associated with STEM subjects and language with English learners (ELs).

Furthermore, STEM education is integrated with the updated content of Education of the Republic of Kazakhstan, which also uses spiraling form of learning, which involves re-learning of material throughout the training. This is a new interdisciplinary and project-based approach to learning, which allows students to strengthen research and scientific and technological capabilities, develop skills of critical, innovative and creative thinking, problem solving, communication and teamwork [10, p. 91].

The State program defines its first and main aim as the development of such qualitative education that is characterised by global competitive ability of Kazakhstan students to participate in international research and scientific projects, be ready to defend and discuss the results of their research and of their practical activity in international conferences; actively communicate with the colleagues from global community.

In modern national education the participants of the educational process have a wide choice of means, forms and technologies that allow to form the necessary qualities in students. Integration of STEM-education and foreign language teaching is fundamentally different from the traditional system of education. It creates conditions for the development and improvement of analytical and creative abilities of students, develops independence and teamwork in obtaining new knowledge.

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STEM-образование: интеграция контента на уроках английского языка (проект SCILLA)

Аннотация. Прогрессивным направлением в современном образовании является STEM-образование. Его цель в том, что оно позволяет развивать критическое мышление студентов высшей школы, исследовательские способности, инженерное мышление с опорой на научные методы, технические приложения, математическое моделирование и т.д. Реализация STEM-подхода расширит границы сознания студентов, приблизит казахстанское образования к международному стандарту, откроет перед обучающимися новые возможности. Статистика внедрения STEM-образования в систему казахстанского образования показывает, что переход в пилотном режиме начался в 2012 году в условиях обновленного содержания (Назарбаев Интеллектуальные школы, Naileybury, школа Quantum и т.д.). Однако на уровне университетского образования данная тема является актуальной. Особый интерес вызывает применение технологий STEM-образования в обучении иностранным языкам.

В статье представлен анализ результатов международного проекта, который был профинансирован в рамках программы грантов Представительства США в Казахстане. В статье рассматривается STEM-образование как средство преподавания иностранного языка в университете, которое позволяет включать студентов в активную деятельность в естественно-научной области, тем самым обеспечивая успех будущих специалистов в мире постоянно совершенствующихся информационных технологий. Всё это становится возможным благодаря междисциплинарному прикладному характеру STEM-образования. В ходе исследования был проведен метаанализ с целью определить влияние образовательных практик STEM на результаты обучения студентов в учебном процессе. В исследовании представлен контекст обучения преподавателей, их подготовка, планирование уроков, модель планирования и проведения занятий со студентами университетов. Этот контекст закладывает основу для разработки интегрированного учебного модуля STEM, использующего подход STEM + обучение иностранному языку.

Ключевые слова: STEM-образование, метаанализ, результаты обучения, научное образование.

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STEM білімі: ағылшын тілі сабақтарында мазмұнды біріктіру (SCILLA жобасы)

Аңдатпа. Қазіргі білім берудегі прогрессивті бағыт – STEM білім беру. Оның мақсаты – оқушылардың сыни тұрғыдан ойлауын, зерттеушілік дағдыларын, ғылыми әдістерге негізделген инженерлік ойлауын, техникалық қолдану, математикалық модельдеу т.б.

STEM тәсілін енгізу студенттердің сана-сезімінің шекарасын кеңейтіп, қазақстандық білім беруді халықаралық стандартқа жақындатады және студенттер үшін жаңа мүмкіндіктер ашады. Қазақстандық білім беру жүйесінде STEM білім беруді енгізу статистикасы пилоттық режимге көшу 2012 жылы жаңартылған мазмұн жағдайында басталғанын көрсетеді. Дегенмен, университеттік білім деңгейінде бұл тақырып өзекті болып табылады. Шетел тілдерін оқытуда STEM білім беру технологияларын пайдалану ерекше қызығушылық тудырады.

Мақалада АҚШ-тың Қазақстандағы өкілдігінің гранттық бағдарламасы бойынша қаржыландырылған халықаралық жобаның нәтижелеріне талдау берілген. Мақалада STEM

білім беру университетте шет тілін оқыту құралы ретінде қарастырылады, бұл студенттердің жаратылыстану ғылымдарына белсенді қатысуына мүмкіндік береді, сол арқылы болашақ мамандардың үздіксіз жетілдірілген ақпараттық технологиялар әлемінде табысқа жетуін қамтамасыз етеді. Мұның бәрі STEM білім берудің пәнаралық қолданбалы сипатының арқасында мүмкін болады. Зерттеу барысында STEM білім беру тәжірибесінің студенттердің оқу және оқыту үдерісіндегі оқу нәтижелеріне әсерін анықтау үшін мета-талдау жүргізілді. Зерттеу мұғалімдерді оқыту контекстін, мұғалімдерді дайындау, сабақты жоспарлау және университет студенттерімен сабақтарды жоспарлау және өткізу үлгісін ұсынады. Бұл контекст STEM + шет тілін оқыту тәсілін пайдалана отырып, интеграцияланған STEM оқыту модулін әзірлеуге негіз қалайды.

Түйін сөздер: STEM білім беру, мета-анализ, оқыту нәтижелері, жаратылыстану бойынша білім.

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