World Transactions on Engineering and Technology Education
Vol.20, No.2, 2022

Supervising and managing STEM projects for school students by the *school-university* model

Meruert Serik†, Balgyn Akhmetova†, Nurzhan Shyndaliyev† & Meiramgul Mukhambetova‡

L.N. Gumilyov Eurasian National University, Nur-Sultan, Kazakstan†
K. Dosmukhamedov Atyrau University, Atyrau, Kazakhstan‡

ABSTRACT: A plethora of students, after graduating from secondary school, strive to enter a university. The knowledge gained by students at school and the requirements for admission to university are frequently far from each other. Therefore, it is necessary to help the student to overcome this barrier. To do this, it is necessary to create such conditions for studying at the senior level of school that would be close to the university system. Both universities and secondary schools are interested in high school students' preparation for university admission, and should carry out proper preparatory work. It is extremely important to help school graduates make the right choice for further education, prepare for continuing education in higher education, and contribute to the development of the value system of each student. This is how the direction of this study emerged, reflecting the continuity of secondary and higher education. Such continuity allows not only to give students a full secondary education, to prepare them for admission to university, but also to promote the development of their cognitive and communicative abilities, the formation of creative and scientific thinking.

INTRODUCTION

In January 2019, *L.N. Gumilyov* Eurasian National University (ENU), Nur-Sultan, Kazakhstan, became a member of the consortium of universities of the European ERASMUS+ project *Integrated approach to the training of STEM teachers*. The goal of the project is to improve the quality of STEM teacher training at partner universities in accordance with the Bologna Regulations and the needs of the knowledge economy. The idea of the project can certainly be considered one of the priorities in the higher education systems of Kazakhstan.

An integrated approach means a mixed learning environment in where students learn to apply science to real problems. This increases the motivation of school students, improves problem-solving skills and increases technical literacy.

Within the framework of the project, a Master's degree programme in *teacher training in natural science subjects*, a profile called 7M01525 *STEM education* has been developed.

The purpose of the study presented in this article is to prepare students for future professional activity by introducing a training course on the management and maintenance of STEM projects. The content of the course developed by the authors is realised through the supervision and management of STEM projects of school students based on the model of *school - university*.

LITERATURE REVIEW

Informal STEM education acts as a complement to formal education in attracting students to participate in STEM fields. Previous studies have shown the positive effects on students engaged in informal STEM activities in terms of knowledge, attitude and interest in STEM, and the desire to engage in STEM careers. Among the activities carried out outside the classroom are field research, science camps, learning in science centres, visits to museums, zoos, robotics competitions, participation in clubs related to STEM activities and interviews with scientists [1].

The benefits of informal STEM include getting informal mentoring, learning while playing, applying mathematics and science simultaneously, building participants' confidence in the necessary STEM skills and fostering camaraderie among the participants. These skills are indispensable and important for nurturing a competent workforce in the field of STEM in the future [2].

In line with Bandura's social cognitive theory, parents, teachers and friends not only play a role in deciding the choice of a career, but also play an important role in the development of self-efficacy [3].

This is confirmed by previous studies which found that students' self-efficacy or the students' belief in their own ability in STEM subjects increased when parents, teachers and friends stressed the value and importance of STEM skills. Among the types of social influences, earlier studies have indicated that parents are the most influential on students in STEM-related career decision-making [4]. Parents who manage to influence the career choice of their children' have ample information to pass on to their children in order to help in the process of career selection [5].

The emphasis on STEM teachers and their proper preparation for the job is entirely appropriate. As indicated in the 2010 McKinsey report: How the World's Most Improved School Systems Keep Getting Better - *great/excellent* status is largely achieved through the quality of a school system's teachers [6], or as captured in the 2007 McKinsey report: How the World's Best-performing School Systems Come out on Top - *the quality of an education system cannot exceed the quality of its teachers* [7]. Several aspects of teacher training focus on enhancing the student learning experience in STEM subjects, through the introduction of proven innovations in teaching, learning and technology, and on students' engagement with STEM subjects with a particular emphasis on future careers [8]. Ignatiev and Daramaeva identified the main areas of activity including didactic, educational and socio-pedagogical interaction between the school and the university, implemented through three fundamental functions [9].

COURSE DESIGN

Within the framework of the educational programme 7M01525 *STEM education* at *L.N. Gumilyev* Eurasian National University, the practice-oriented course *Management and Support of STEM Projects* was introduced into the educational process in the 2020-2021 academic year, and continued in 2021-2022, which constitutes the first result of this research.

In accordance with the content of the course, the *school-university* model was developed, the implementation of which included the following stages:

1. Appointment of STEM project participants.
2. Awakening the interest of school students in science and promoting the choice of a profession.
3. Obtaining results in the STEAM projects.

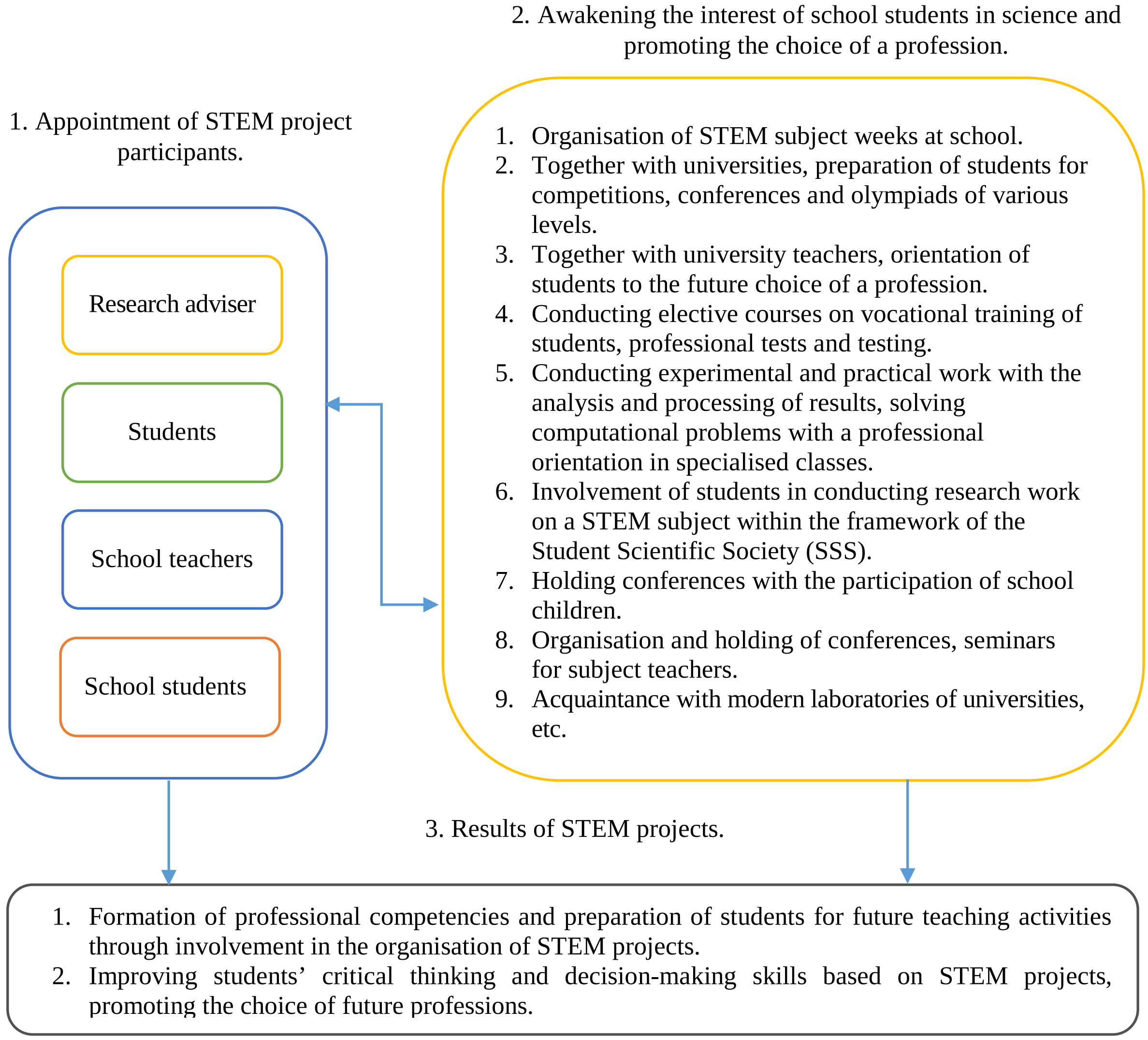

Figure 1: The *school-university* model.

The first stage begins with the appointment of participants in the STEM project in the model structure. The original roles of the research supervisor, student, school teacher and students participating in the project is described below [10][11].

The research supervisor formulates a general educational goal, decomposes it into individual tasks, draws up a work plan, monitors the effectiveness of interaction between the other members of the group and is a permanent consultant at all stages of work on the project.

University students work on the structure of the project product, together with the supervisor choose a set of tools for its creation and are directly involved in the creation of the project product.

School teachers form project groups of school students taking into account their interests, act as consultants for students, help in selecting the necessary information resources for the project and its organisation, monitor the effectiveness of interaction of school students within the group, their co-operation with students and the research supervisor.

School students under the guidance of teachers are engaged in information gathering, its systematisation, generalisation and translation into electronic format. Together with students, under the guidance of a supervisor, they work in the laboratory on the experimental part of the project.

In the study outlined in this article, for the successful implementation of joint project activities, a team was formed consisting of project groups, which include: a research supervisor from the Department of Computer Science, Physics and Biology at *L.N. Gumilyev* Eurasian National University and *S. Seifullin* Kazakh Agrotechnical University, students from 3-4 courses in computer science teacher training, undergraduates from 1-2 courses in STEM education, biology, physics and computer science teachers from *Nazarbayev* Intellectual School of Physics and Mathematics in Nur-Sultan (NIS HUB), school students from grades 8-11 of this school. All of them are located in Kazakhstan.

The second level includes a large number of activities aimed at stimulating students' interest in science and promoting the choice of a profession, which are included in Figure 1 above.

The third stage of the model is an important part aimed at obtaining results for STEM projects. It is described in more detail in the next section.

RESEARCH RESULTS

A crucial and important part of the school-university model that the authors have developed is obtaining results focused on the activities conducted within the STEM projects

The projects were implemented on the basis of the NIS HUB technopark at *Nazarbayev* Intellectual School of Physics and Mathematics in Nur-Sultan. It should be noted that many teachers of this school are undergraduates and doctoral students of *L.N. Gumilyev* ENU.

The NIS HUB format with modern equipment, the ability to work together on projects and scientific support for students have provided additional education for school students.

In order to organise a group project, undergraduates with subject teachers adhered to the following methods:

- determining the purpose and objectives of the project;
- determining the area of research and discussion with students, forming groups (no more than 4-5 people or specific tasks can be set up for individual work of individual students);
- setting up specific tasks for each group; determining time intervals for each task;
- consulting each group on the sources of information needed to solve the tasks;
- organising intermediate thematic discussions and a critical analysis of the work of each group in order to adjust the task of the groups taking into account the results already obtained;
- organising presentations of the final results of the work.

At the NIS HUB, students with competence to see the entire project cycle from the origin of an idea to the final result, creatively approach new tasks, conduct project work and participate in competitions and scientific and technical olympiads.

Below, the authors present some of the successful projects developed under the *school-university* integration programme:

Smart bus system (the project was developed under the guidance of a computer science teacher and a university professor). The system is a complex that ensures the safety of road users. With the help of the camera, the driver's gaze is fixed. If the driver closes their eyes, the system beeps.

The system covers the entire cabin and ensures the integration of drivers with passengers in order to:

1) protect passengers from offenders through face recognition (with 94% accuracy);
2) assess the driver’s condition for driving using a pulse sensor (to check the heartbeat), MQ-3 (to check the state of sobriety), biometric sensor (for authentication) [12];
3) monitor the driver through a camera that recognises drowsiness (drowsiness detection);
4) evaluate of the work of the bus driver and service;
5) recognise the possibility of collisions with other modes of transport.

a) b)

Figure 2: Smart bus system; a) instrument; and b) user.

GrowBox (implemented under the guidance of computer science and biology teachers, and a university professor).

GrowBox is a container for growing plants that allows to regulate the microclimate and maintain favourable environmental conditions. It is equipped with a lighting system and a ventilation system, an air filtration system, a humidification system and a carbon dioxide saturation system. The use of hydrogel ensures that plants can grow even in infertile soil. Hydrogel absorbs moisture and the necessary substances, later giving them to plants.

As a result, ideal conditions are created, such as adjustable temperature, humidity and lighting, which contributes to growth. The Arduino platform was used to automate the project.

Figure 3: GrowBox.

New vision - orbital forest fire detection experiment (implemented under the guidance of computer science and physics teachers).

A project for the use of artificial intelligence in the analysis of satellite images for the presence of fires. Wildfires in the steppes and forests are a big problem for the whole world [13].

Therefore, as a solution to this problem, young intellectuals proposed a system based on convolutional neural networks that can be implemented in drones, drones, nanosatellites and ground stations.

The project *New vision - orbital forest fire detection experiment* took the first place at the VII International Scientific Competition *Young Scientist*. The winners - two students received the gold medal at the Competition, and were granted to study at Woosong University in South Korea. And *the Smart bus system* project was presented at the World Robotics Olympiad in Hungary, the *GrowBox* project is the winner of a regional robotics olympiad.

Figure 4: New vision - orbital forest fire detection experiment by students: A. Pazilov and E. Tauekel.

The research and project work of school students and university students who have become prize-winners and laureates of various competitions shows the effectiveness of pedagogical interaction according to the *school-university* model. At the beginning, the preliminary selection of a contingent takes place, and the construction of individual educational trajectories *school student - university student - teacher - university teacher.* Also, individual or team work is involved through the preparation of research and creative projects, joint defence of projects at conferences of different levels, preparation of scientific publications.

Based on the high awards from conferences, observations and discussions with the stakeholders, the authors believe that the presented experience of *school-university* interaction in the organisation of joint project activities has a positive impact on everyone involved in these activities. For school teachers and students, it results in professional or educational improvement, and for university students - in shaping professional and personal self-determination, the formation of project and research competencies, and development of personal qualities.

CONCLUSIONS

This study was focused on the effectiveness of the STEM educational programme in involving students and school students in engineering practices, and it helped to expand their knowledge and interest in STEM. In conclusion, the authors offer some suggestions for further promotion of STEM in Kazakhstan and in other countries:

- promoting STEM disciplines as crucial for personal development and citizenship in the 21st Century;
- highlighting career opportunities for students who follow the STEM career path not only to students, but also to parents. Parents have a strong influence on the choice of professions by students;
- relating the STEM curriculum and assessment to broader ethical, legal and social issues; for example, the role of STEM in solving global problems (food, water and energy security, loss of biodiversity, etc);
- paying special attention to marketing strategies and the wording and approaches used in this regard;
- integrating engineering and technology into the structure of scientific education at all levels in accordance with the basic ideas of engineering design and technology with the same status as in other major scientific disciplines;
- identifying and promoting the range and diversity of career opportunities available to STEM graduates as early as possible in high school;
- forming partnerships with STEM enterprises (for example, within the framework of the national Smart Future Initiative) to promote STEM careers at all levels of education.

The integration of elements of higher education into the school environment contributes not only to improving the quality of education, but also to the early professional orientation of school children, for whom the higher education system becomes more open and understandable.

The presence of university teachers at school, and school children within the walls of the university erases the boundaries between a general education organisation and a higher education organisation. Thus, the considered form of interaction between the school and the university contributes to the formation of students’ skills in research activities, professional orientation, conscious choice of a future profession, and the formation of a creative, mature and professionally oriented personality. This is the main mission of the interaction between the school and the university.

REFERENCES

1. Archer, L., DeWitt, J. and Willis, B., Adolescent boys' science aspirations: masculinity, capital, and power. *J. of Research in Science Teaching*, 51, **1**, 1-30 (2014).

2. Halim, L., Abd Rahman, N., Wahab, N. and Mohtar, L.E., Factors influencing interest in STEM careers: an exploratory factor analysis? *Proc. Asia-Pacific Forum on Science Learning and Teaching*, 19, **2** (2018).
3. Bandura, A., Self-efficacy: toward a unifying theory of behavioral change. *Psychological Review*, 84, **2,** 191-215 (1977).
4. Nugent, G., Barker, B., Welch, G., Grandgenett, N., Wu, C.R. and Nelson, C.A., Model of factors contributing to STEM learning and career orientation. *Inter. J. of Science Educ*., 37, **7,** 1067-1088 (2015).
5. Nawabi, S., Javed, M.Q., Shujaulla, S. and Ulfat, H., Parental influence on career choice of their children: literature review. *Inter. J. of Advanced Research,* 7, **3**, 221-227 (2019).
6. Mourshed, M., Chijioke, C. and Barber, M., *How the World's Most Improved School Systems keep Getting Better.* London: McKinsey & Company (2010).
7. Barber, M. and Mourshed, M., *How the World's Best Education Systems come out on Top*. London, UK: McKinsey (2007).
8. Baran, E., Bilici, S.C., Mesutoglu, C. and Ocak, C., Moving STEM beyond schools: students' perceptions about an out-of-school STEM education program. *Intern. J. of Educ. Math., Science and Tech.* 4, **1**, 9-19 (2016).
9. Ignatiev, V.P. and Daramaeva, A.A., Three functions of interaction between a university and a school. *Modern Problems of Science and Educ.*, **2** (2021).
10. Shcherbakov, Y.I., Interaction of university and school in modern conditions. *World of Science, Culture, Educ.*, 44, **1**, 105-107 (2014).
11. Ireland Should Aim to be a World Leader in STEM Education. Prof Brian MacCraith MRIA FInstP Chair, STEM Education Review Group. A Report on Science, Technology, Engineering and Mathematics (STEM) Education Analysis and Recommendations. The STEM Education Review Group in Ireland, 18 May 2022, https://www.dcu.ie/news/news/2016/11/ireland-should-aim-to-be-a-world-leader-in-stem-education
12. Serik, M., Nurbekova, G. and Mukhambetova, M., Optimal organisation of a big data training course: big data processing with BigQuery and setting up a Dataproc Hadoop framework. *World Trans. on Engng. and Technol. Educ*., 19, **4**, 417-422 (2021).
13. Serik, M., Nurgaliyeva, S. and Balgozhina, G., Introducing robotics with computer neural network technologies to increase the interest and inventiveness of students. *World Trans. on Engng. and Technol. Educ* 20, **1**, 33-38 (2022).