The need for modern teachers to integrate informatics with STEM education

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ABSTRACT: Society is becoming increasingly dependent on digital technologies, and there is an increasing need to include STEM (science, technology, engineering and mathematics) education, especially informatics, in curricula at all levels. In this article, the authors examine the need for integrating informatics teaching with STEM education by school teachers. The study, based on a quantitative method, included 129 informatics teachers (51 males and 78 females) from 43 schools in Almaty, Kazakhstan, and it aimed at gauging the teachers' perception and attitude towards integrated STEM education. The results imply that teachers who express a higher level of willingness to complete integrated STEM training are also more likely to expect greater improvements in their teaching effectiveness as a result of this training. The results of this study can be used to inform curriculum development and training content changes at higher education institutions leading to better preparation of future informatics teachers for working in schools.

INTRODUCTION

Modern approaches to education reflect a common desire to create a more dynamic and practically oriented education [1]. Therefore, education plays a key role in preparing future generations, especially in the context of STEM (science, technology, engineering and mathematics) [2]. UNESCO emphasises the importance of implementing STEM education for sustainable development [3]. For example, in the USA, STEM education in K-12 prepares teachers through advanced training, as teachers can develop STEM education curricula and improve the perception and understanding of STEM education [4].

In Korea, STEM education is aimed at increasing students' interest in science and technology and their understanding of these disciplines, as well as at developing integrative thinking and problem-solving ability [5]. In Kazakhstan, education is aimed at improving the level of teacher training and professional development, as well as encouraging project-based learning and practical training.

The emphasis on STEM teachers and their proper preparation for work is quite appropriate [6]. Teacher support plays a key role in providing STEM teachers with opportunities to expand their knowledge of STEM content and teaching practice. From a practical point of view, STEM teachers often lack a comprehensive understanding of STEM education. Therefore, they could benefit from the conceptual framework of STEM education [7]. Based on this background, the purpose of this study was to examine the perception and attitude of informatics teachers towards the need to implement integrated STEM learning. Despite the recognised importance of STEM integration, the views of informatics teachers regarding the need and willingness to undergo integrated STEM training remain relatively unexplored. This research sought to address the following questions:

RQ1: What is the current perceived need of informatics teachers for integrated STEM learning?
RQ2: To what extent is there a correlation between the willingness of informatics teachers to undergo integrated STEM training and the expected improvement in teaching effectiveness?

LITERATURE REVIEW

This article proceeds from the theoretical foundations of the technological content of pedagogy and experience-based learning as lenses to identify the needs of informatics teachers for STEM integration [8].

Integrating STEM concepts into educational practice is a dynamic process that often involves learning from experience. Informatics teachers, as practitioners in this field, participate in continuous learning based on their teaching experience [9]. Teachers, including informatics teachers, strive to expand their understanding of STEM content and deepen their understanding of pedagogical content [10]. The key to STEM training for teachers is to start by substantiating their conceptual understanding of integrated STEM education by teaching key learning theories, pedagogical approaches, and raising their awareness of the results of ongoing second-level STEM educational initiatives [11].

This study aims to fill the gap in the literature by examining the perceived need for integrated STEM education among informatics teachers and examining their willingness to participate in such training. Previously, a systematic and meta-analysis was carried out on the topic of integrating STEM in the training of computer science teachers, as a result of which the following obstacles to the development of STEM education were found [12][13]:

- lack of comprehensive understanding of STEM;
- poor teacher training and lack of qualified teachers;
- lack of investment in the professional development of teachers;
- insufficient interdisciplinary research co-operation in the field of STEM education [12][13].

METHOD

This study uses a quantitative research approach to examine the perception and attitude of informatics teachers towards the implementation of integrated STEM learning. The research aims to provide an idea of the feasibility and desirability of implementing integrated STEM learning for informatics teachers. The results obtained can serve as a basis for the development of training programmes and professional development initiatives aimed at improving the teaching skills and effectiveness of informatics teachers.

Participants

The target group for this study consisted of 129 informatics teachers at 43 schools in the city of Almaty, Kazakhstan. The focus was on school teachers with whom there is a contract for the passage of pedagogical practice of students of the Kazakh National Women's Pedagogical University, Kazakhstan.

A questionnaire was developed and distributed via the Google Forms on-line form. Participants received a clear explanation of the study purpose and instructions for completing the questionnaire. This study complies with ethical standards by obtaining informed consent from participants. Confidentiality and anonymity were guaranteed, and participants were informed that their participation was voluntary.

Development of Tools

The questionnaire tool was designed to collect quantitative data. The questionnaire questions were developed in several stages. The developed multiple-choice test was designed for informatics teachers at schools. The questions were created based on a conceptual framework and carefully selected using the Veneziano and Hooper content validity ratio (CVR - content validity ratio) [14] with the help of nine experts. The experts' panel included teachers and heads of departments from seven higher educational institutions in Kazakhstan who train future informatics teachers, and two foreign consultants [15][16].

The experts were expected to evaluate each question on a Likert scale from 1 to 4, where 1 means a low degree of compliance with the content of the subject area, and 4 means a high degree [17]. At the initial stage, the questionnaire consisted of 45 questions. All the experts assessed whether the questions were correctly formulated in accordance with the goals, science and profession. After all the experts have evaluated the content, the reliability coefficient of the content was calculated by the Veneziano and Hooper formula [14]:

$$CVR = Nu/(N/2) - 1 \tag{1}$$

where CVR is the content reliability coefficient of Veneziano and Hooper;
Nu - the number of questions for which consistency has been achieved between experts;
N is the total number of experts [14][15].

According to formula (1), with nine experts, the minimum confidence coefficient is 0.555. As a result of the expert review, there were 15 questions left, which were marked with the symbol * (Table 1).

Table 1: The results of the expert assessment.

Questions	CVR	The number of consents	The number of did not agree	Suggested to change
Question 1	0.1111111111	5	3	1
Question 2*	0.7777777778	8	1	2
Question 3	0.3333333333	6	0	1

Question 4*	0.5555555556	7	0	1
Question 5	0.3333333333	6	1	1
Question 6*	0.5555555556	7	0	1
Question N	……………..	………………….	……………….	………………..
Question N+1	……………..	………………….	……………….	………………..
Question 45*	0.1111111111	5	3	0

The next stage in the development of the scale was the preparation of a measuring instrument, and consequently, the Likert scale was chosen. The scale shows the degree of consistency with the elements, the evaluation of statements from the most positive to the most negative corresponds to an increase or decrease in ratings (Table 2).

Table 2: Measuring instrument in the form of a Likert scale.

Likert-scale description	Positive	Negative
Strongly disagree	5	1
Disagree	4	2
Neutral	3	3
Agree	2	4
Strongly agree	1	5

Procedure

Before the actual introduction, the questionnaire was tested with a small group of 42 informatics teachers in order to study the validity of 15 questions, and as a result, a questionnaire of 12 remaining questions was formed. Three elements were excluded due to insufficient discrimination ability (discrimination value < 0.16).

RESULT

The initial data was processed from two directions. First, an analysis of statistical data was conducted describing the respondents, in order to study the teachers and their willingness to implement this topic. The second direction was the correlation analysis of the data obtained.

Descriptive Statistics

To answer research question 1, which was aimed at studying the need for integrated informatics education with STEM education, sociological questions were included in the questionnaire: gender (male, female), degree of education (after college, Bachelor’s degree, Master’s degree, doctoral degree, etc), specialty (basic education - informatics, informatics-mathematics, informatics-physics, informatics-robotics, information system), age, work experience. The obtained data were processed in IBM SPSS Statistics and the relevant descriptive statistics are presented in Table 3.

Table 3: Descriptive statistics of the respondents on qualitative variables.

Gender	Quantitative percentage %	Degree of study	Quantitative percentage %	Specialty (basic education)	Quantitative percentage %
Male	51/39.5	After college	15/11.6	Informatics	62/48.1
Female	78/60.5	Bachelor	56/43.4	Informatics-mathematics	21/16.3
		Master	51/39.5	Informatics-physics	17/13.2
		Doctor	6/4.7	Informatics-robotics	15/11.6
		Candidate of Science	1/0.8	Information system	14/10.9

Based on the results presented in Table 3, it can be concluded that the majority of respondents were female 60.5%, with a Bachelor’s degree 43.4%, majoring in informatics 48.1%. While as shown in Table 4, the median age was 33 (27-38) years and the work experience was 10 (5-15) years.

Table 4: Median of quantitative variables.

		Age	Work experience
N	Valid	129	129
Median		33.00	10.00
Percentiles	25	27.00	5.00
	50	33.00	10.00
	75	38.00	15.00

Common barriers to participation in integrated STEM learning are shown in Figure 1, and they mainly include: lack of resources 40.3%, compliance with the curriculum 25.6%, time constraints 20.9% as reported by respondents.

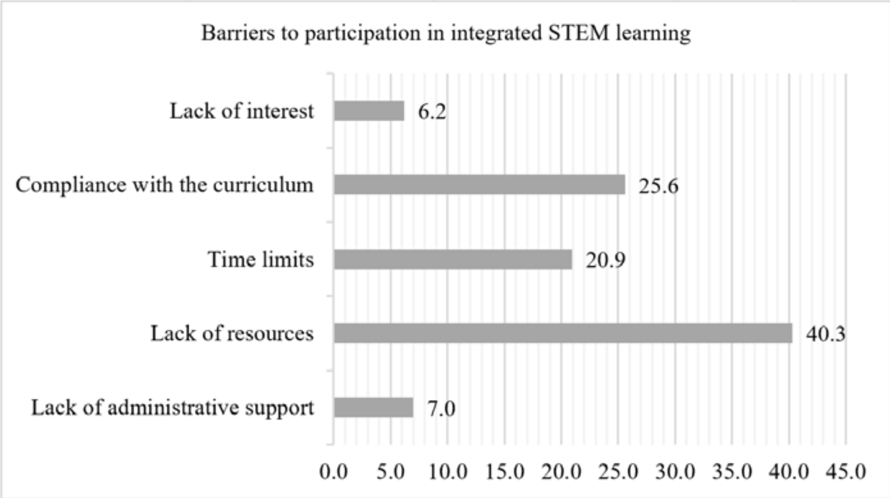

Figure 1: Barriers to participation in integrated STEM learning.

It was also revealed that while the integrated learning formats that teachers choose were more or less the same (Figure 2), there is a significant difference in preferred resources (Figure 3).

The prevalence of barriers, such as lack of resources, curriculum compliance and time constraints highlight the need for targeted interventions to support teachers in overcoming these obstacles. In addition, the observed discrepancies in preferred resources highlight the importance of customisable approaches that take into account the different learning needs and preferences of teachers. It is crucial to develop comprehensive strategies that eliminate the identified barriers and enable teachers to effectively integrate STEM principles into their teaching practice.

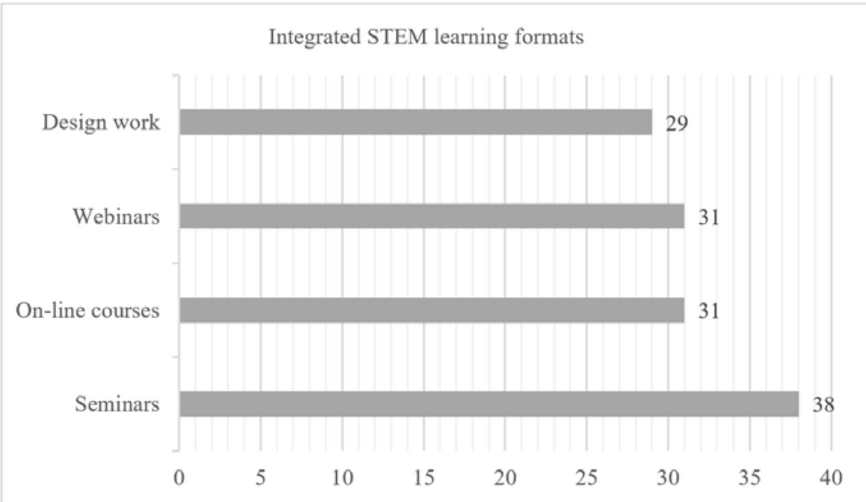

Figure 2: Integrated STEM learning formats.

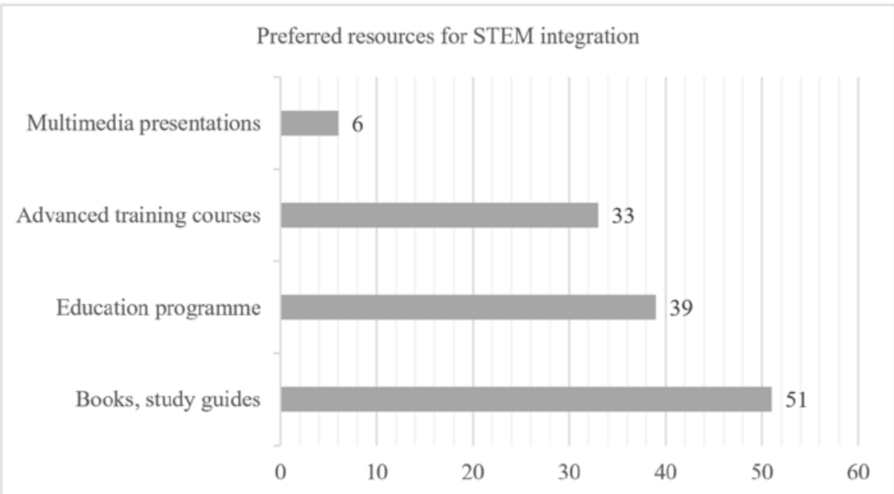

Figure 3: Preferred resources for STEM.

Correlation Analysis

In order to answer the 2nd research question, the Pearson correlation coefficient (r) with the population coefficient (*p*) was used (Table 5). The coefficient was used to assess the strength and direction of the relationship between the variables of informatics teachers' willingness to undergo integrated STEM training and the expected increase in teaching efficiency calculated in IBM SPSS Statistics for 129 respondents (N) [18].

Table 5: Correlation between two variables.

Correlations			
		Expectations of teaching effectiveness as a result of integrated STEM learning	Degrees of readiness to participate in integrated STEM learning
Expectations of teaching effectiveness as a result of integrated STEM learning	The Pearson correlation (r)	1	0.772
	is significant (*p*)		< 0.001
	N	129	129
Degrees of readiness to participate in integrated STEM learning	The Pearson correlation (r)	0.772	1
	is significant (*p*)	< 0.001	
	N	129	129

The results of the correlation analysis using the Pearson correlation coefficient revealed a fairly good correlation, which indicates a positive linear relationship between the variables of readiness to undergo integrated STEM training and the expected increase in teaching efficiency. In particular, the correlation coefficients r = 0.772 were noted, which indicates a stable relationship between these two factors among respondents, and the population correlation coefficient was estimated using a sample from the target population $p < 0.001$. These results imply that informatics teachers who express a higher level of willingness to complete integrated STEM learning are also more likely to expect greater improvements in their teaching effectiveness as a result of learning.

CONCLUSIONS

In conclusion, this study provides valuable information about the perception and attitude of informatics teachers towards integrated STEM learning. By understanding these perspectives, school and university teachers and curriculum developers can work together to improve the quality of informatics education and better prepare students for the challenges of the future. Moreover, it is necessary to make changes and additions to the educational programme and to the content of teaching certain professional disciplines in the training of future informatics teachers. This, in turn, creates the problem of developing a new teaching methodology in combination with STEM in the process of training an informatics teacher.

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