OPPORTUNITIES FOR THE USE OF STEAM PROJECTS IN PRIMARY YEARS CLASSES: THE POINTS OF VIEW OF INTERNATIONAL BACCALAUREATE TEACHERS

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ABSTRACT
Considerable changes to the Lithuanian education system are associated with higher academic achievements, the development of students' critical thinking and research skills, and sustainable practices of integrated teaching and learning in science and mathematics. It is also acknowledged that STEAM (science, technology, engineering, the arts and mathematics) educational approaches address the objectives of integrated learning and teaching effectively. The same objectives are reflected in all the IB programmes. In the scientific discourse on the use of STEAM in science, there is a lack of research and examples of pedagogical practices with insights into different educational programmes and teachers' experiences. The qualitative research (semi-structured interview) focuses on the points of view of teachers who implement the international baccalaureate primary years programme (IBPYP), and have a high level of project-based learning experience, of the possibilities of STEAM project implementation (6). The research findings reveal that teachers acknowledge the benefits of STEAM projects in terms of developing students' research, critical thinking and independent learning skills, while implementing integrated teaching and learning strategies. The informants also recognise the importance of STEAM education in planning and organising integrated mathematics and science lessons.
KEY WORDS: *STEAM education, science, inquiry-based learning*.

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Introduction

Changes in the educational system are related to the necessity for changes in society. One of the most important and long-awaited changes is related to the need to create a smart society (the Lithuanian progress strategy 'Lithuania 2030'). The main idea of a smart society considers people who demonstrate critical thinking, and creative, innovative and technical skills. In order to achieve this aim, the Lithuanian National Progress Plan 2021–2021 (2020) highlights the need to increase the effectiveness of education by aligning levels of instruction with the individual goals and needs of students. It is also essential to increase students' science literacy (3.1.3 indicator) (NPP, 2020). Defining the latter aspects, STEAM education (science, technology, engineering, the arts and mathematics) is considered to be a priority of the Lithuanian educational system, since the STEAM approach meets the demand for innovation culture at schools and the development of students' creativity and various skills ('Lithuania 2030'; the National Education Strategy 2013–2022).

National strategic documents reveal that STEAM education is vitally important in order to achieve qualitative changes in education. The STEAM concept focuses on the integration of five core subjects (science, technology, engineering, the arts and mathematics) and flexible working models at various levels and in va-

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rious contexts of education (Perignat, Katz-Buonincontro, 2019; Sjoberg, 2019). International Baccalaureate programmes target creating a smart society by using a transdisciplinary approach (Fullan, Langworthy, 2014; Gould, 2021). There are five essential elements to the International Baccalaureate Primary Years Programme curriculum: knowledge, concepts, approaches to learning, attitudes, and student-initiated action.

As is mentioned in the programme documents (International Baccalaureate, 2017), teachers implement all five elements by using research, and sometimes STEAM-based practices with real life content. According to Gould (2021), STEAM activities complement the IB programme, since both models are based on a holistic and interdisciplinary approach. (Fullan, Langworthy, 2014; Gould, 2021). Scientific research on the STEAM approach indicates the importance of STEAM modelling while working with children of different ages and skills (Friedl, 2017). Moreover, it is essential to analyse teachers' preparation to integrate different subjects into their curriculum model (Glass, Colleen, 2016; Welch, 2011). There is also a lack of understanding of teachers' attitudes towards the implementation of STEAM activities in terms of inquiry-based learning. The aim of the article is to reveal opportunities to include the STEAM approach in the International Baccalaureate Primary Years Programme (IBPYP) from the teachers' point of view. The research aims to reveal teachers' identified opportunities for the implementation of STEAM projects in the IB Primary Years Programme, and to explain how STEAM activities could be beneficial to students. Methods used in the research: semi-structured interview, content analysis.

1. Theoretical assumptions of STEAM education and inquiry-based learning

The STEAM educational approach reflects most aspects of modern education, such as the effective development of skills and competences of the learner in the new millennium, and preparations to study and acquire the knowledge required for knowledge-intensive professions. In other words, the STEAM approach supports the gradual development of a student's self-efficacy and the ability to inquire, reason and solve real-life problems (Yakman, 2008; Maeda, 2013; Friedl, 2017; Costantino, 2018; Peppler, Wohlwend, 2018; Shatunoval *et al.*, 2019; Perignat, Katz-Buonincontro, 2019).

The STEAM concept enables students not only to become familiar with theoretical material and facts, but also to apply knowledge while solving real-world, social, scientific and technological issues (Bauram-Jacobs, Wieske, Henze, 2019). The ideas and proposals in the STEAM philosophy focus on the integration of five core subjects, and determine the gradual development of critical thinking and problem-solving skills. Also, with the help of the STEAM approach, students learn to establish connections between facts and technological solutions, apply theoretical material in various contexts, and solve real-world issues. These skills and competences are also addressed while implementing the main principles of the International Baccalaureate programmes and those principles. The principles underline the importance and use of an inquiry-based approach and experimental activities. Inquiry-based learning is far less about facts and knowledge, but rather about students' active participation in the learning process. According to Sjoberg (2019), IBSE (inquiry-based science education) should support students' agency and encourage them to generate ideas, design and carry out experiments, discuss the research results, and draw conclusions (Brzozowy *et al.*, 2017; Sjoberg, 2019). According to Fiore (2016) and Sjoberg (2019), the main characteristic of the inquiry-based approach is learning stimulated by questions that require critical thinking and collaboration skills. This characteristic is also evident in the STEAM concept, which highlights the importance of integrated, collaborative, inquiry-based and independent learning (Allina, 2018; Perignat, Katz-Buonincontro, 2019).

The arts have a significant role in STEAM education. However, rather than being an equally important subject, the arts are wrongly perceived as an additional subject that only improves learning (Liao, 2016). In successful STEAM education, the arts are perceived as a learning tool for creative teaching and learning that can also enrich the learning environment (Shatunoval *et al.*, 2019). The development of inquiry-based skills has a major role in STEAM education. Inquiry-based learning consists of various phases, including assessing prior knowledge and planning further research (Brzozowy *et al.*, 2017; Sjoberg, 2019). Following the general principles of the inquiry phases, the inquiry cycle was divided into five essential stages. Similar stages of inquiry can also be identified in the STEAM project process, including creating and implementing an idea for a

project (Bayram-Jacobs, Wieske, Henze, 2019). The inquiry-based learning strategy is linked to problem-based and project-based learning. The basic features of the cycle include students' active participation and reflection.

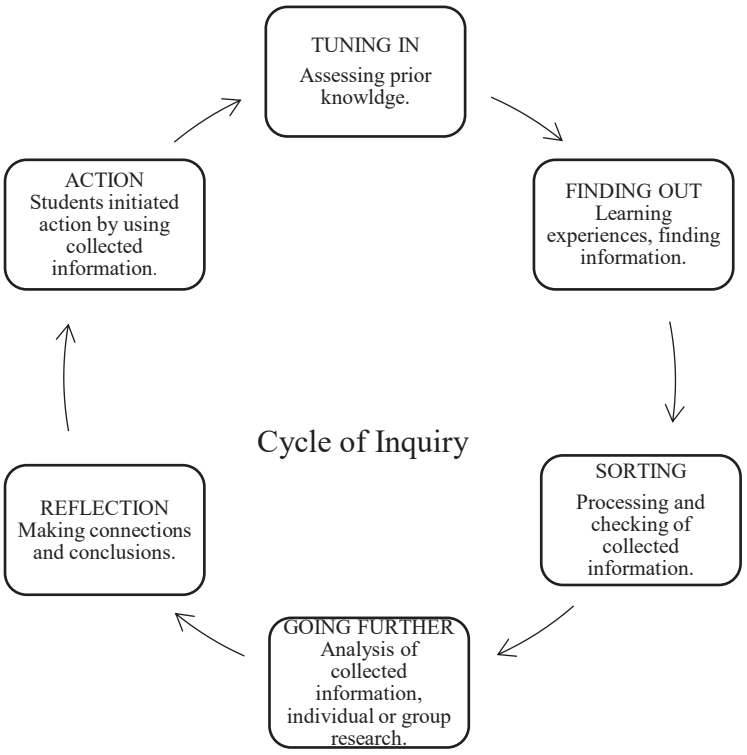

Figure 1. The cycle of inquiry

Source: Kath Murdoch Inquiry Cycle, 2016.

The main difference between the organisation of all these learning strategies lies in the emergence of scientific reasoning (the depth of the interpretation of facts), which is done by formulating problem questions, hypothesis, analysing and interpreting the collected data, and discussing the results of the presented research. Inquiry-based learning and teaching are not limited to the facts or a brief analysis of various problems (Pedaste *et al.*, 2015; Brzozowy *et al.*, 2017; Sjoberg, 2019).

In using the inquiry-based approach, the following aspects emerge as crucially important: student-initiated discussions and questions, the formulation of a hypothesis, planning an inquiry, data collection and interpretation, and argumentation. According to Fauziati (2014), it is expected that questions are asked by students; however, a teacher can perform various roles in the inquiry process, including being a mentor or a facilitator (Pedaste *et al.*, 2015; Bayram-Jacobs, Wieske, Henze, 2019). According to with students' prior knowledge, inquiries can be classified into particular categories: structured inquiry (where the teacher helps students generate their own questions and plan); guided inquiry (where the teacher provides scaffolding to guide students through their inquiries); and open inquiry (where learners are given the question or the idea) (Pedaste *et al.*, 2015). Inquiry-based teaching is widely used in teaching science and social studies in all the International Baccalaureate programmes. Also, with the help of inquiry-based learning, students can improve their communication skills. The improvement of language and communication skills is connected with students being constantly encouraged to ask questions. In terms of the analysis of the development of social skills, it was noticed that during STEAM projects students not only learn to communicate and think critically, but also become more responsible for their own learning, since they have a choice of topics (Alameddine, Ahwal, 2016). The STEAM education approach is associated with transdisciplinary learning (Maeda, 2013). In terms of inquiry-based learning organisation, the

choice of relevant real-world problems, the level of integration of STEAM subjects, subject-specific knowledge and skills are given a vital role. The main emphasis for choosing a particular idea for a STEAM project is added to real-life contexts, sustainability, citizenship, scientific and cultural ideas. Real-life contexts consider unresolved issues faced by students in their families, school and society. It is essential to provide students with ideas that are relevant to them and may be beneficial in terms of curriculum actualisation and increasing learning motivation. For example, a PYP exhibition that can be based on STEAM principles is a culmination of the programme and reflects students' knowledge and experience gained throughout the primary years (Medwell *et al.*, 2017; Sjoberg, 2019). Relevant scientific, cultural and social problems presented and analysed during STEAM projects enable students to see the wider context of any research and interpret the information gathered (facts) by taking into account not only the scientific validity but also the social and moral aspects. In other words, it is essential to encourage moral reasoning and promote ethical discussion in the classroom. It should be emphasised that STEAM projects prioritise inquiry-based learning that includes students' reflection, logical reasoning, the rationalisation of facts, and proposals for further creative solutions.

2. Research methodology

The qualitative research aims to reveal International Baccalaureate primary teachers' attitudes towards the STEAM approach. Primary years teachers working in IB world schools were asked to take part in a semi-structured interview. This research revealed teachers' attitudes towards the possibilities for the implementation of STEAM into the International Baccalaureate Primary Years Programme. The qualitative research was carried out in 2022. The selection of informants was based on the characteristics of the research questions. The informants in the research were experienced in STEAM education and worked in two IB world schools that implement the Primary Years Programme. Six primary years teachers (five females) participated in the research. The number of participants selected in the qualitative research is usually small (Žydžiūnaitė, Sabaliauskas, 2017). In this case, the number of participants depends on the current situation in the country. According to data from the Ministry of Education, Science and Sports, there are ten IB world schools in Lithuania; however, only four of them implement the IB Primary Years Programme. The questions in the semi-structured interview were related to the integration of STEAM projects into the primary years curriculum, the development of inquiry-based learning, and the possibilities for and benefits of STEAM projects.

The research participants signed consent and were coded (teacher T). The interviews were recorded and transcribed. The information collected from the interviews was sorted into categories and subcategories, and processed by using manifest content analysis. The research results are interpreted and based on sorted and textual evidence. In this way, the researchers could interpret information from the interviews on the basis of analysed text (Žydžiūnaitė, Sabaliauskas, 2017).

3. The research results

Informants were asked to describe the implementation of STEAM projects in their everyday teaching. In the category of STEAM project integration, the following subcategories were defined: modelling of the primary programme; planning inquiry-based learning; and students' interest in STEAM activities (Fig. 2). Teachers identified that the International Baccalaureate Primary Years Programme is useful in terms of strengthening transdisciplinary teaching and learning: '…the main topics and teachers who work with the unit are identified in the programme plans. In this way, they can plan STEAM' (T1); 'STEAM topics are usually based on the unit of inquiry' (T2) (T3); 'I always look for STEAM ideas in the plans of inquiry' (T6).

All the informants mentioned that they plan from three to four STEAM activities during a school year; however, they also added that the number could vary: 'the number of projects depends on student age groups and their curiosity' (T4); 'it depends on students' involvement in the unit' (T6). It is important to note that all the teachers acknowledge opportunities for a high degree of integration of STEAM into the curriculum of the Primary Years Programme.

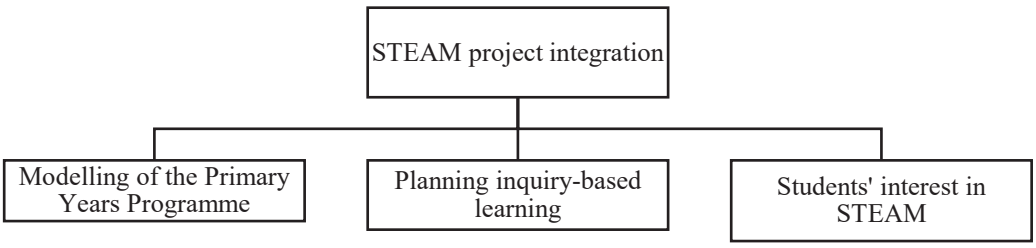

Figure 2. Participants' views of the possibilities for the integration of STEAM into the Primary Years Programme of an IB world school

Source: Author's construction based on research.

During the interviews, teachers stated that the organisation of inquiry-based learning is reflected in the programme documents. STEAM projects enable teachers to teach a unit of a four or eight-week-long inquiry in a more versatile way and work collaboratively with two or more teachers: 'our units of inquiry last from four to eight weeks. Together with the PYP coordinator, two classroom teachers and sometimes a subject teacher, for example, an arts teacher' (T4); 'any STEAM project is usually planned by two or three teachers' (T2). As the teachers mentioned, STEAM projects usually focus on science, mathematics, technology and the arts.

The teachers emphasised the fact that STEAM projects complement the implementation of units of inquiry. Four subcategories were defined in the category of STEAM benefits: feedback, development of cognitive skills, development of creativity, and integrated education.

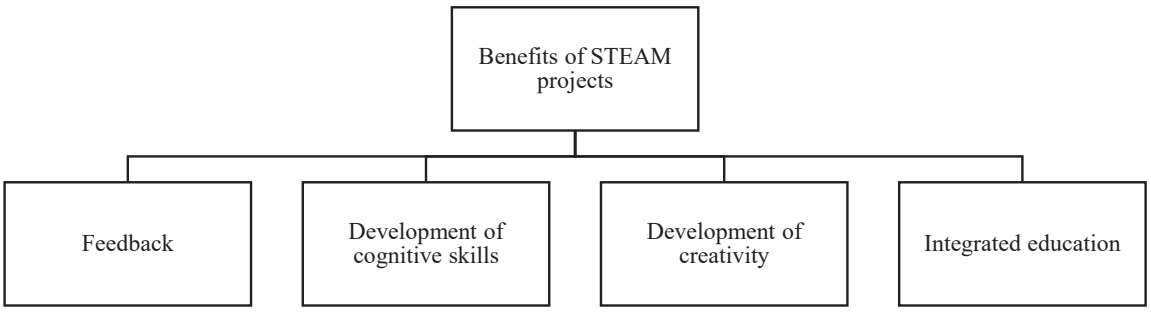

Figure 3. The benefits of STEAM projects

Source: Author's construction based on research.

When discussing the advantages and disadvantages of the STEAM approach, teachers identified mainly advantages. All the teachers mentioned that with the help of STEAM, they were able to develop cognitive skills, including critical thinking, problem-solving and active learning: 'students learn to find, analyse and apply information on their own' (T2); 'during STEAM projects, students take responsibility for their own learning' (T3); 'students learn to apply their knowledge in practice' (T5). It should be noted that all the informants identified the development of creativity as the main benefit of STEAM projects: 'during STEAM projects, students can reveal their creativity, technological creativity, so to speak' (T1); 'they solve problems in a creative way' (T2); 'students interpret their inquiries really originally' (T6). It should be stressed that teachers consider STEAM to be useful in implementing key aspects of the Primary Years Programme and inquiry-based teaching and learning. The teachers noted that a curriculum integrating STEAM provides them with opportunities to develop research skills. However, at the same time, the information from teachers' interviews indicates a lack of assess-

ment and inquiry-based teaching skills. In addition to the benefits of STEAM that consider the development of creativity and critical thinking, primary teachers identified more advantages of STEAM, including opportunities for developing communication (students need to present their findings) and collaboration skills (students collaborate a lot, they learn together), and the possibility for providing students with constructive feedback. As the teachers mentioned, during STEAM projects, students reveal their subject-specific knowledge (science, technology, engineering, the arts, mathematics), and the ability to think critically and solve issues independently: 'STEAM activities reflect what students have learned. It is good feedback' (T3). All the informants stated that a transdisciplinary approach and a versatile education are quite evident in STEAM projects (contrary to other projects): 'with the help of STEAM, students become inquirers, curious, open-minded and risk-takers' (T2). The informants also recognised the importance of STEAM education in planning and organising integrated mathematics and science lessons. The participants in the research acknowledged that the STEAM educational approach fulfils the objectives of integrated learning and teaching effectively.

Conclusions

A high degree of integration of science, technology, engineering, the arts and mathematics is defined in the STEAM concept. Teachers' professional skills are vitally important in order to adopt and use effectively a transdisciplinary approach and engage in STEAM activities.

Primary years teachers who implement the International Baccalaureate Primary Years Programme and carry out STEAM activities in their everyday activities pay special attention to the integration of subjects and students' involvement in the process of inquiry. Teachers also gradually plan STEAM activities in accordance with units of inquiry and the requirements of the programme. During the interviews, teachers identified the benefits of STEAM in terms of planning inquiry-based lessons; however, a lack of assessment skills in STEAM was evident from teachers' answers.

The research findings revealed that all primary teachers identified various possibilities for the implementation of STEAM projects in the Primary Years Programme. STEAM projects support the development of students' creativity, cognitive (critical thinking, problem-solving, learning how to learn), collaboration and communication skills. In addition, the informants noted that STEAM projects are useful in adopting a transdisciplinary approach in the primary years.

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STEAM PROJEKTŲ ĮGYVENDINIMO GALIMYBĖS PRADINĖSE KLASĖSE: TARPTAUTINIO BAKALAUREATO PROGRAMOS MOKYTOJŲ POŽIŪRIU

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Santrauka

Lietuvos švietimo sistema orientuota į kokybinius pokyčius. Vienas iš svarbių kokybinių pokyčių siejamas su gamtos mokslų ir matematikos mokymo(si) organizavimo pokyčiais, kuriais siekiama tiek aukštesnių mokinių akademinių gamtos mokslų, matematikos ir kitų mokomųjų dalykų pasiekimų, tiek ugdyti mokinių kritinį mąstymą, tobulinti tyrinėjimo kompetencijas. Tvarių integruoto mokymo ir mokymosi strategijų paieška čia ypač svarbi. Nors Lietuvos švietime pripažįstama integruoto mokymo(si) reikšmė, siekiant kokybiško mokymosi, kyla problemų sprendžiant integruoto gamtos mokslų ir matematikos organizavimo klausimus pamokose, ieškant tinkamų didaktikos sprendimų organizuojant tiriamąsias mokinių veiklas, lavinant kritinio mąstymo gebėjimus.

STEAM (angl. *Science, Technology, Engineering, Arts, Math*) koncepcija pabrėžia aukštą mokslo, technologijų, inžinerijos, menų ir matematikos integracijos laipsnį. Pripažįstama, kad STEAM ugdymo strategija labiausiai atliepia integruoto mokymosi ir mokymosi tyrinėjant siekinius, panašių siekių kelia ir tarptautinės bakalaureato programos. Moksliniame STEAM taikymo gamtamoksliniame ugdyme diskurse esama mažai tyrimų, pedagoginės praktikos pavyzdžių, kuriuose būtų analizuojamos skirtingų pradinio ugdymo programų galimybės, mokytojų patirčių analizė. Mokytojų profesiniai įgūdžiai yra gyvybiškai svarbūs įgyvendinant tarpdisciplininį požiūrį, modeliuojant ir atliekant STEAM veiklą. Atliktame kokybiniame tyrime (iš dalies struktūruotame interviu) su pradinių klasių mokytojais, kurie dirba tarptautinio bakalaureato programose ir yra sukaupę darbo su įvairiais mokinių tyrinėjimais pagrįstais projektais, analizuotos STEAM projektų taikymo galimybės pradinio ugdymo tarptautinio bakalaureto programos pamokose.

Tyrimo dalyviai – mokytojai, dirbantys su pradinio ugdymo tarptautinio bakalaureto programomis dviejose Lietuvos mokyklose. Tyrimo rezultatai atskleidė, kad mokytojams nekelia abejonių STEAM projektų pradinėse klasėse nauda tobulinant mokinių tyrinėjimo, kritinio mąstymo ir gebėjimų savarankiškai spręsti iškilusias problemas galimybės; mokytojai įžvelgia tarptautinio bakalaureato programos pradiniame ugdyme privalumus ugdant mokinių tyrinėjimo, mokymosi mokytis kompetencijas, įgyvendinant integruotą mokymą ir mokymąsi. Tyrimo dalyviai įžvelgė STEAM ugdymo svarbą planuojant ir organizuojant integruotas matematikos ir gamtamokslinio ugdymo pamokas. Pradinių klasių mokytojai, vykdantys tarptautinę bakalaureato pradinių klasių programą ir kasdienėje veikloje taikantys STEAM veiklą, daug dėmesio skiria dalykų integracijai ir mokinių įtraukimui į apklausų procesą. Mokytojai, dirbantys pagal tarptautinio bakalaureato pradinio ugdymo programą, nuosekliai planuoja visų mokslo metų STEAM veiklas, atsižvelgdami į programoje numatytas pagrindines tiriamųjų veiklų temas (programos reikalavimus).

Tyrimo rezultatai atskleidė, kad visi pradinių klasių mokytojai įžvelgia nemažas STEAM projektų įgyvendinimo vykdant šią programą galimybes, tačiau jiems trūksta integruotos STEAM veiklos vertinimo ir mokinių į(si)vertinimo organizavimo kompetencijų. Vykdant šiuos projektus kryptingai ugdomi šie mokinių gebėjimai: kūrybiškumo, pažintinės kompetencijos (kritinio mąstymo, problemų sprendimo, mokymosi mokytis), bendravimo ir bendradarbiavimo. Be to, tyrime dalyvavę pedagogai pažymėjo išskirtines giluminio integruoto mokymo ir mokymosi pradiniame ugdyme, vykdant STEAM projektus, galimybes.

PAGRINDINIAI ŽODŽIAI: *STEAM švietimas, mokslas, tyrimais pagrįstas mokymasis*.

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