

STUDENT COMPETITIONS: OPPORTUNITIES TO PRACTICE INTERDISCIPLINARY KNOWLEDGE IN PRACTICAL PROBLEM SOLVING

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Abstract

Various recommendations and actions have been taken regarding Estonian educational strategies that emphasise the value of science education. One example is STEAM (Science, Technology, Engineering, Arts and Mathematics). This approach makes scientific content understandable and science-related professions attractive to students. STEAM as an educational approach connects various disciplines. Home economics, as a subject area, can complement a STEAM education with practical activities. It helps to set gained knowledge into a real-life context and strongly supports fostering students' 21st-century skills. The recently developed Science Kitchen learning environment at Tallinn University provides opportunities to connect theoretical understanding and practical activities in a way that supports the transfer of knowledge and skills into learners' everyday lives. Moreover, the student competition Kringel demonstrates the connections between home economics and a STEAM education by focusing on food-related processes grounded in scientific principles. To deepen the Kringel competition's concept and learn from good practices, an online literature search was performed studying scientific peer-reviewed articles from the last decade (2014–2024). We targeted articles on academic competitions for students. This systematic analysis enabled us to provide an overview of the aims, content and organisational issues as well as the possible impact of such events from the students' perspective. A contemporary subject competition has a multi-stage structure, containing theoretical and practical tasks that engage students or student teams in providing solutions to real-life problems. Besides strengthening students' subject-related knowledge, these strongly support the development of 21st-century skills. The findings are used to determine the developmental implications of the Kringel competition.

Keywords: *Students' competitions, home economics, STEAM.*

1. Introduction

Estonian educational strategies (e.g., Haridus- ja Teadusministeerium, 2021) emphasise the importance of science education at all academic levels. Recommendations and actions are taken to make scientific content understandable every day and to make science-related professions attractive to students. STEM is a well-known educational approach that connects various disciplines – science, technology, engineering and mathematics – whereas STEAM merges the arts with STEM subjects (Perignat & Katz-Buonincontro, 2019). The latter is the fundamental approach used in this study. Home economics as a subject area can complement a STEAM education with practical, real-life activities (Paas et al., 2025). Notably, students are more motivated and involved in lessons when they can connect the learning content to their real-world experiences (Christensen, 2019). The field of home economics is, therefore, beneficial because it helps set the knowledge learned from school subjects into real-life contexts and strongly helps foster students' 21st-century skills, namely the 4Cs: collaboration, cooperation, critical thinking and creativity (Taar & Palojoki, 2022). These valuable cross-curricular skills are essential for the future, in further studies, in future professions and generally in everyday life.

Unfortunately, schools often lack the needed equipment and have face-time limitations for teaching the analytical and problem-solving skills that accompany STEM (Morgan, 2015). Therefore, a variety of alternative extracurricular activities and informal learning environments have received attention in educational settings to develop science literacy and promote students' learning (Sahin, 2013; Robelen, 2011). The recently developed Science Kitchen, a learning environment at Tallinn University, provides opportunities to connect theoretical understandings and practical activities in a way that supports the transformation of knowledge and skills into learners' everyday actions. It unites a multifunctional classroom, study kitchen and lab. To support and strengthen the Science Kitchen concept, funding was received from the EU's Horizon Europe Widening Participation and Spreading Excellence Programme for

the project SHAREE, i.e., STE(A)M for Home Economics and Research Exchange (Tallinn University, n.d.).

Several activities have been developed for the SHAREE project to bridge home economics topics with STEAM pedagogy. One activity is the extracurricular national competition Kringel (i.e., the pretzel-shaped striezel, a typical pastry in Estonia), targeting talented science-motivated Estonian high school students aged 16 to 19. Estonia has other STE(A)M-related competitions (e.g., the Estonian Science Olympiad) that combine science subjects and engineering, although the connection with arts or real-life content is not always thoroughly established.

Kringel offers students an interactive way of solving real-life problems rather than working on formal textbook tasks, which might be the case in competitions (Morgan, 2015). Karpov (2003) pointed out that pure scientific knowledge and pure procedural knowledge might remain meaningless for students and non-transferable beyond the classroom. Home economics tasks allow the implementation of knowledge acquired at school into practical knowledge applied at home or to other school subjects, as noted by Taar and Palojoki (2022). Furthermore, combining STEAM and home economics allows students to engage in practical activities that integrate STEAM concepts into concrete situations (Paas et al., 2025).

In addition, extracurricular competitions with hands-on experiences motivate future scientists and help students develop skills relevant to STEM careers (Stringer, Mace, Clark & Donahue, 2020; Miller, Sonnert & Sadler, 2018). Furthermore, competitions and other STEM-related extracurricular activities are gateways to STEM-related higher education and careers for many students (Morgan, 2015).

2. Methods

This paper shares the results of a decade-long review (2014–2024) of scientific peer-reviewed articles, including research and review articles, to deepen the Kringel concept. We performed an online literature search using EBSCOhost e-databases available to registered library users at Tallinn University. The search terms were ‘national competition for students’, ‘school contests’, ‘STEM competition AND education’, ‘STEM contest AND education’ and ‘STEM Olympiad AND education’. Articles concentrating only on theoretical competitions, music or sports competitions, the winners’ profile or coaches’ role were excluded from the analysis. Additionally, the chosen articles were limited to secondary and higher education levels.

Overall, 398 topical scientific articles were available with full access to the database, while 15 relevant papers remained eligible for inclusion after careful reading. The thematic analysis (Ezzy, 2002) was used to pinpoint the four key themes in the articles, namely content, competition aims, organisational issues and the possible impact of such events from the students’ perspective. Two researchers read the texts several times, coded and recoded the topical extracts ($n = 106$) and systemized the codes into categories.

3. Results

The findings of the analysis are presented, relying on the four key themes. The chosen sample represented competitions with both national and international influence. Most international competitions act as a final level at which students compete, meaning that if students win at the local and national stages, they are expected to represent the country internationally. International competitions are organised for students from the upper grades, mostly at the high school level.

The first theme to discuss is competitions’ content, which strongly relates to the science aspect of STEM (Table 1). Nevertheless, the content did not integrate all the subject fields into the same competition. Rather, specific subject areas, such as physics or robotics, are represented, opening up the subject content in more detail. None of the STEAM competitions was represented in the sample. Since scientific articles aim to address a broader aspect of competition (e.g. gender equality or motivational aspects), several articles fell short in thoroughly describing the content or nature of the competition.

The second theme, the aim of the competition, was described in more detail in the analysed articles. Three categories summarise the aims of the sample, namely subject-specific content ($n = 19$), 21st-century skills (collaboration, cooperation, critical thinking and creativity; $n = 8$) and performance aspects ($n = 4$). The most common aim of the competitions relates to subject-specific content.

Competitions are organised to enhance participants’ knowledge and skills ($n = 13$) or, more broadly, to strengthen their interest or motivation in the subject area ($n = 4$). Interest and motivation are perceived as crucial factors in students’ future career choices, which was mentioned as a long-term aim concerning the two analysed competitions.

Table 1. The content overview of the analysed data.

	Title of the competition	Influence area	Subject area	Target group
A1	World Robot Olympiad	International	Robotics	Aged 10-16
A2	World Robot Olympiad	Asia	Robotics	Primary, secondary school
A3	InfoSukces Contest	Poland	Informatics	Aged 14-18
A4	Cryptography Competition	Bulgaria	Cryptography	Grades 5-7
A5	Ireland's Future is MINE	Iceland	Minecraft	Grades 3-6
A6	National Technology Competition	Taiwan	Technology	Middle school
A7	1 st European Physics Olympiad	International	Physics	High school
A8	XXII Ibero-American Physics Olympiad	International	Physics	High school
A9	German Physics Olympiad	Germany	Physics	Secondary school
A10	SciChallenge	International	Science	Aged 10-20
A11	International Sustainable World Energy, Engineering, and Environment Olympiad	International	Science	High school
A12	Sleek Geeks Science Eureka Prize	Australia	Science	Primary, secondary school
A13	National Chemistry Competition	Macedonia	Chemistry	Grade 8
A14	Plant Science competition	Australia	Plant science	Up to year 12
A15	10 th International Earth Science Olympiad	International	Earth science	High school

The development of students' 21st-century skills is also considered important because all 4Cs are represented in the aims of the competitions. For example, the German physics competition mainly concentrates on the development of such skills, listing collaboration, creativity and critical thinking among the aims of that competition. There was little emphasis on the competitive aspect of the event, for example, evaluating one's performing or identifying the most talented students.

The third theme is impact. Compared with the aims, the organisers have set more demanding expectations for the impact (n = 83) of students' competitions. Again, codes were grouped into three categories – subject-specific impact (n = 33), impact on 21st-century skills (n = 26) and impact on students' personal strengths (n = 24). When studying subject-specific expectations, it becomes evident that competitions should provide content knowledge and deepen students' understanding (n = 12) of given topics. Moreover, the competition's content could attract students and enhance their interest (n = 11) in specific subject fields. As stated earlier, the results also demonstrate strong hope that competitions will strengthen students' choices of STEM careers.

Developing students' communication skills (n = 10) is in the lead in terms of 21st-century skills, predominantly in competitions where students work in groups. In addition, competitions offer opportunities to become familiar with subject enthusiasts globally. Teamwork is also considered to strengthen collaboration skills (n = 6). Critical thinking (n = 5) through analytical ability, logical capability or just broad thinking skills, as well as creative problem solving (n = 6) are perceived as an added value of competitions.

Moreover, expectations of students' personal strengths become visible through various aspects pointed out in the articles. For example, the articles note aspects of competing (n = 6) and expressions such as 'learning to challenge themselves'(A2), 'to cope with pressure'(A2) or 'nurture students' individual potential and interests regardless of success'(A9). New experiences (n = 3) can present both 'stressful situations' and the possibilities of taking part 'in the fun activities' as part of extra-competition activities. Students, organisers and coaches observe the benefit of competitions in students' confidence (n = 4), discipline-specific development (n = 3) and in their life attitudes (4). In addition, students gain new learning tools and practice time management.

The fourth theme, organisational aspects, reflects practical examples of how the studied competitions are structured and held. Two categories emerged from the data: practicalities (n = 88) and engagement (n = 14). The practicalities first include the method of participation. Not all articles mentioned such details; therefore, the overall tendency is impossible to say. However, based on the available information, there are equally many competitions in which students participate individually or in teams. In some competitions, it is even possible to choose how to participate. Descriptions reflect that students prefer working with peers and having the opportunity to discuss possible solutions.

One of the criteria in the article search was practical tasks; therefore, all the represented competitions contained some kind of practical activity in which students had to use their knowledge in

real-life situations. Some competitions ($n = 7$) also included theoretical tests. In four competitions, the content was only practical, and in four competitions, we did not obtain sufficient information on the given aspect. Based on the available information, at least 10 competitions were organised in different stages. Usually, there is a local-level preliminary stage for engaging more students to participate. Larger competitions are held in various age groups in parallel. The practicalities also include providing supportive materials for coaches. Information sheets, training materials or lists of additional materials provide teachers with basic information about a particular topic or the societal challenges of a given issue. Award-related information was again unequally mentioned by the articles. However, winners are always awarded, in some cases with medals or even with an impressive monetary prize.

The category 'engagement' includes various examples of including stakeholders in the competition's organisation. In the pre-competitions phase, collaborative partners are sought to support the event in both content and funding, for example supporting students with scholarships to participate in international events. During the event, scientists might engage in networking to enable students to make contacts and have discussions with experts. Quite ordinary in these international competitions is offering extra-competition activities, such as 'a rich programme of talks, exercises and excursions that allows exchange among the students'(A9). Gifted students enjoy meeting new friends with similar interests. The public should be invited to follow the event at the venue or through social media. In any case, engagement attracts participants by adding value to their work in the competition and achieving a greater impact for the event.

4. Discussion

Similar to Christensen (2019), we have observed that subject competitions encompass a range of educational themes and pedagogical approaches. Nevertheless, the competitions are designed to engage students in real-world problem-solving tasks, enhance their interest in specific subject areas and foster their awareness of potential career paths. Because our findings have predominantly developmental implications, we hereby describe the details of the Kringel competition by considering the results gained through the analysis.

We define the Kringel competition as an annual event in which Estonian high schoolers have the interactive opportunity to challenge themselves and compete against peers in integrated STEAM and home economics content. As per the findings, it is difficult to unite all STEAM disciplines into one competition, whereas the scientific aspect of the acronym is mostly presented. Cristensen (2019) noticed a similar phenomenon. We thereby centred the sciences and arts at the contest.

Kringel complements curricular content, highlighting food-related processes often based on scientific principles for which students must integrate knowledge of various disciplines to understand and make sense of given problem-solving tasks. Thereby, Kringel focuses on transferring knowledge by combining the two sides stated by Taar and Palojoki (2022): theoretical knowledge and practical skills.

Kringel aims to support students' subject-specific interests and knowledge and to support all 4Cs. The tasks are planned to support students' critical thinking and creativity, while teamwork expects collaboration and communication skills. Students participate in the competition as a three-student team from one school. Participating in teams has several advantages. Working in teams allows the complementing of each other's knowledge and experiences to bridge the gaps one might face alone. The findings illustrate that students enjoy engaging in competition with peers. In addition, Stinger et al. (2020) indicate that peer influence correlates with interest in future STEM careers.

As reflected in the competitions, we hope that Kringel's content will attract students and enhance their interest in home economics and STEAM areas. The desired impact could be students' ability to notice science in their daily lives. We are not aiming for the level of international competitions; rather, we hope that Kringel demonstrates that science-based subjects can be comprehensible and engaging to all students. Therefore, for wider engagement, the competition has been divided into two stages so teachers can implement the competition into their learning.

In the first stage, students solve tasks in an online form. Several food-related questions and tasks guide students in combining their theoretical knowledge with practical experiences to work out solutions. As a practical outcome, the teams assemble a one-minute video explaining one food-related scientific process or reaction. In a well-made video, scientific terms are used to explain the processes, and calculations or formulas are included. An important aspect of the video is creativity. The 12 best teams are invited to the second stage, where students compete in the Tallinn University Science Kitchen and Physics Lab.

In the second stage, students have both theoretical and practical tasks that involve a knowledge of home economics, chemistry, physics and geography. The practical tasks expect students to use 21st-century skills when solving experimental problems in teams. As is typical of home economics education, the results are evaluated not only for correct subject knowledge but also for their aesthetic appeal.

5. Conclusion

Although subject-specific competitions evolve, they remain relevant to educational contexts. These competitions not only adapt to changing trends and educational priorities but also serve as a platform to engage and challenge students with a special interest in the subject areas, including STEAM education. For students, it is a valuable opportunity to meet like-minded peers and challenge themselves with tasks, expecting more effort to perform than in school tasks. To remain effective, student competitions should keep pace with changing times and educational expectations, support student development and provide both engagement and sufficient challenges for young learners with a special interest in particular fields. Therefore, aspects such as students' performance and experiences in the competition require further research to better prepare the tasks for the competitions.

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