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University of Ostrava

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University of Luxembourg

Comenius University Bratislava

OSTRAVSKÁ UNIVERZITA

JOHANNES KEPLER UNIVERSITÄT LINZ

UNIVERSITY OF JYVÄSKYLÄ
FINNISH INSTITUTE FOR EDUCATIONAL RESEARCH

UNIVERSITÉ DU LUXEMBOURG

COMENIUS UNIVERSITY BRATISLAVA

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Curriculum Integration: Partner Reports' Summary

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JKU JOHANNES KEPLER UNIVERSITÄT LINZ

UNIVERSITY OF JYVÄSKYLÄ
FINNISH INSTITUTE FOR EDUCATIONAL RESEARCH

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Abstract

Integrating 3D printing into STEAM education offers opportunities across subjects and educational levels. This comparative analysis synthesises the identified opportunities from Austria, Finland, Luxembourg, and the Czech Republic, exploring how 3D printing can be utilised to create learning experiences. By examining the integration of 3D printing in these countries, this report highlights the potential benefits, such as enhancing student engagement, fostering creativity, and developing practical skills in design and engineering. Furthermore, it outlines the specific subjects where 3D printing can have the most significant impact, including mathematics, biology, physics, chemistry, and art, and discusses the broader implications for digital literacy and collaborative learning.

Through a review of these opportunities, this analysis aims to inform and guide the implementation of 3D printing in educational systems, ensuring that teachers and students are well-prepared for future technological advancements.

Content of the document

Country-Specific Analysis Summary

Austria

The analysis highlights the potential of integrating 3D printing into STEAM education within the Austrian K-12 education system. Although STEAM is not officially part of the Austrian curriculum, significant opportunities exist for its incorporation, particularly in mathematics and digital literacy. This report aims to lay the groundwork for developing teacher training programs focused on integrating 3D printing into STEAM education at primary and secondary school levels, evaluating how 3D printing technology can align with and enhance current STEAM curricula.

In Austria, the school system consists of preschool, primary school, lower secondary school, and various forms of upper secondary education. Preschool is compulsory for 5-year-olds, followed by four years of primary education and four years of lower secondary education. After this, students can choose between a pre-vocational year or various types of secondary schools, either general or vocational. The Austrian Ministry of Education provides guidelines encouraging the incorporation of digital tools and technologies in teaching, with recent reforms emphasising digital literacy. This creates an environment conducive to integrating 3D printing, even though STEAM as a unified approach is not formally included in the curriculum.

The use of traditional teaching materials such as textbooks, pen and paper, and blackboards is widespread in Austrian schools, but there is a growing trend towards integrating digital resources and computers, especially in lower secondary education. The COVID-19 pandemic has accelerated this shift, highlighting the need for more interactive and engaging teaching methods. In this context, 3D printing offers a unique opportunity to enhance student engagement and motivation through hands-on projects. For example, in mathematics, 3D printing can be used to create tangible models for geometry, helping students understand abstract concepts. Similarly, in digital literacy courses, 3D printing can be incorporated to teach 3D modelling and the basics of robotics.

Despite the potential benefits, there are challenges associated with integrating 3D printing into the curriculum. Many teachers lack the technical knowledge to use 3D printers effectively, and schools often face difficulties acquiring and maintaining the necessary equipment. Additionally, aligning 3D printing projects with the existing curriculum can be challenging due to time constraints and the need to meet specific educational standards. To address these challenges, it is essential to develop and distribute detailed teaching materials and exercises that align with the current curriculum. Encouraging project-based learning approaches can naturally incorporate 3D printing into various subjects, making learning more interactive and engaging.

Implementing comprehensive training programs for both pre-service and in-service teachers is crucial to build their technical skills and confidence in using 3D printing technology. In Austrian teacher training, there are existing courses such as "3DMP for Beginners/Advanced," "Technology-Supported Geometry," and "Technology in Mathematics Education," which provide a solid foundation in 3D modelling and printing. However, these courses must be expanded to include primary and lower-secondary teachers. In-service training, often project-based with workshops focusing on digital literacy and 3D printing technologies, should also be enhanced to provide officially recognised courses that count towards mandatory professional development hours.

Integrating 3D printing into teacher training programs can significantly enhance the quality and effectiveness of STEAM education in Austria. By providing continuous professional development opportunities and technical support, teachers can stay updated with the latest advancements in 3D

printing and its applications in education. This approach aligns with Austria's broader goals of integrating 3D printing into existing subjects and leveraging project-based learning to enhance STEAM education. A similar analysis will be conducted for the Czech Republic to further understand the integration of 3D printing in their educational system and teacher training programs.

Czech Republic

The analysis of the integration of 3D printing into STEAM education within the Czech Republic highlights both the potential and challenges faced by the education system. The focus is on the teacher training programs at the University of Ostrava, encompassing pre-service and in-service training.

In the Czech Republic, the Ministry of Education, Youth, and Sports (MŠMT ČR) oversees the education of future teachers, setting standards and requirements for teacher training programs. Teacher education is provided by universities, with accreditation granted by the National Accreditation Office for Higher Education. The University of Ostrava (UO) holds institutional accreditation, allowing it to design and implement its own study programs. Prospective teachers typically complete a Master's follow-up study in the Teacher Education program, with separate tracks for primary and secondary education. This structure ensures a comprehensive preparation process, aiming to produce qualified and competent teachers.

The current state of 3D printing in teacher training at the University of Ostrava reveals a growing interest and incorporation of this technology. Existing courses such as "Digital Technologies and CAD Systems for School Practice" and "3D Printing in Education" introduce students to the principles and applications of 3D printing. These courses cover various topics, from the basics of 3D modelling and printing to the pedagogical methods for integrating these technologies into teaching practices. This comprehensive approach helps future teachers develop the necessary skills and knowledge to effectively use 3D printing in their classrooms.

Despite these advancements, challenges remain. Many teachers lack the technical knowledge required to fully leverage 3D printing in their teaching. This gap is particularly evident among in-service teachers, who may not have had access to such technologies during their initial training. Additionally, the availability of 3D printing equipment and resources varies widely across schools, limiting the consistent integration of this technology. To address these issues, it is essential to provide targeted professional development opportunities that build technical skills and confidence among teachers. This includes offering workshops, online courses, and collaborative learning communities where teachers can share experiences and best practices.

The integration of 3D printing into the curriculum offers several benefits. It enhances student engagement through hands-on projects, fosters creativity and innovation, and develops practical skills in design and engineering. For example, in geometry courses, 3D-printed models can help students visualise complex shapes and understand spatial relationships. In technical education, demonstrations of mechanical parts and engineering systems using 3D printing can make abstract concepts more concrete and relatable for students. These applications highlight the potential of 3D printing to enrich the learning experience and improve educational outcomes.

Moving forward, it is crucial to develop and implement strategic approaches to support the effective integration of 3D printing into teacher education. This includes creating a centralised repository of 3D printing lesson plans, project ideas, and resources teachers can access. Additionally, fostering partnerships with industry, such as the collaboration with Prusa, a major Czech manufacturer of 3D printers, can provide schools with the necessary support and materials to implement 3D printing

effectively. Such collaborations can also offer professional training and discounts on equipment, making the technology more accessible to schools.

In conclusion, while there are challenges in integrating 3D printing into STEAM education in the Czech Republic, the potential benefits are substantial. By addressing the technical knowledge gap among teachers and providing the necessary resources and support, 3D printing can become a valuable tool in enhancing STEAM education. The experiences and initiatives at the University of Ostrava serve as a model for other institutions, highlighting the importance of strategic planning and collaboration in successfully integrating innovative technologies into education. Next, we will proceed with the analysis for Finland to explore the integration of 3D printing in their educational system and teacher training programs further.

Slovakia

In Slovakia, curriculum integration strategies related to 3D printing and broader digital fabrication tools are not centrally imposed but are instead developed at the level of individual schools. The national framework curriculum allows for flexibility in how schools interpret and implement content and competencies, particularly in technology and computer science education.

Schools that integrate 3D printing typically do so within the subjects Technology and Computer science, where open-ended tasks, project-based learning and creative problem solving are encouraged. Integration is often supported by external funding (e.g., EU-funded Erasmus+ projects), regional educational centers, and NGO initiatives, rather than through top-down curriculum mandates.

Curricular innovation in this area is also to be supported by teacher enthusiasm and school leadership, though systematic teacher training in 3D printing is still emerging and mostly optional. Consequently, the depth and scope of integration vary significantly across schools. While some pilot institutions implement 3D printing as part of interdisciplinary STEAM projects, others lack the resources or know-how to do so effectively.

The Slovak case reflects a decentralised and autonomy-based model, where national curricula provide space for innovation, but implementation is highly dependent on local initiative and external support.

Finland

The Finnish education system offers a comprehensive and integrative approach to STEAM education, with significant potential for incorporating 3D printing technology. This analysis explores the integration of 3D printing at the K-12 levels, highlighting the structure, opportunities, challenges, and recommendations for effective implementation.

In Finland, the education system is designed to ensure equal opportunities for all students, with a strong emphasis on individual talent development, positive pedagogy, and student well-being. The Finnish National Core Curriculum, developed by the Finnish National Board of Education, serves as a guideline for local curricula, ensuring consistency while allowing for regional adjustments. Basic education covers grades 1-9, with primary education focusing on foundational skills and lower secondary education deepening subject knowledge and preparing students for further education.

STEAM education in Finland is integrated through a multidisciplinary approach that emphasises the interconnectedness of various subjects. The curriculum includes mandatory multidisciplinary learning modules that combine multiple subjects, providing a holistic learning experience. These modules can

be implemented through various strategies, such as parallel study of themes across subjects, sequencing related topics, and organising theme days, events, or school camps. Each student's studies must include at least one multidisciplinary learning module annually, ensuring continuous engagement with integrated learning.

Reviewing the Finnish National Core Curriculum reveals that STEAM subjects are well-supported through guidelines that promote active learning, critical thinking, and problem-solving. Teachers are encouraged to collaborate in planning and implementing multidisciplinary modules, with support from professional development opportunities. The curriculum also emphasises using technology, with guidelines for incorporating ICT into teaching and learning processes. This includes using digital tools like 3D modelling software and 3D printers to enhance learning experiences across various subjects.

Integrating 3D printing into K-12 education presents numerous opportunities. 3D printing can help students visualise complex geometrical shapes in mathematics, making abstract concepts more tangible. It can be used in science to create models for experiments and demonstrations, facilitating a deeper understanding of scientific principles. These applications of 3D printing foster hands-on, inquiry-based learning, enhancing student engagement and promoting creativity and innovation.

Despite the strengths of the Finnish curriculum, challenges exist in integrating 3D printing into K-12 education. Teachers need ongoing training to develop the technical skills to effectively use 3D printers. Moreover, maintaining and supporting the technology can be resource-intensive, posing financial and logistical challenges for schools. Addressing these challenges requires comprehensive teacher training programs that cover both the technical and pedagogical aspects of 3D printing. This will equip teachers with the skills and confidence to integrate 3D printing into their teaching practices.

To support in-service teachers, Finland offers various professional development opportunities, including workshops, online courses, and collaborative learning communities. These programs help teachers acquire and refine their technical skills and provide opportunities to share best practices and resources. The availability of continuous professional development ensures that teachers remain updated with the latest advancements in 3D printing technology and pedagogical methods.

Integrating 3D printing into K-12 education and teacher training in Finland offers significant benefits. It enhances student engagement through hands-on projects, promotes creativity and innovation, and helps develop practical skills in design and engineering. For example, in geometry, 3D printing can help students visualise complex shapes, while in technical education, it can be used to create models for mechanical parts and engineering systems. These applications make learning more interactive and relatable, improving educational outcomes.

Moving forward, it is crucial to continue developing and refining strategies for integrating 3D printing into the Finnish education system. This includes expanding training programs for pre-service and in-service teachers, ensuring access to the latest technological resources and pedagogical methods. Fostering partnerships with industry can provide schools with the necessary support and materials to implement 3D printing effectively. These efforts will help ensure that 3D printing becomes a valuable tool in enhancing STEAM education in Finland, preparing students for the challenges and opportunities of the 21st century.

In conclusion, while challenges remain in integrating 3D printing into STEAM education in Finland, the potential benefits are substantial. By addressing the technical knowledge gap among teachers and providing the necessary resources and support, 3D printing can become an integral part of the Finnish educational experience. The next section will explore the integration of 3D printing in Luxembourg to provide further comparative insights.

Luxembourg

The Luxembourgish education system provides a comprehensive framework for integrating 3D printing into STEAM education, focusing on both K-12 levels and teacher training programs. This analysis explores the structure, opportunities, challenges, and recommendations for effectively implementing 3D printing technology in Luxembourg's educational landscape.

In Luxembourg, elementary education encompasses the first nine years of schooling, subdivided into four learning cycles. Cycle 1 includes pre-primary education for children aged 3 to 5, which is compulsory from age 4. Cycles 2 to 4 each span two years and correspond to primary education. At the end of each cycle, students must acquire defined learning objectives and essential skills to progress to the next cycle and eventually to secondary education. Pre-primary education focuses on social experiences and language acquisition, while primary education emphasises literacy, mathematics, science, arts, physical education, and social values.

Secondary education in Luxembourg is divided into classical secondary education and general secondary education. Classical secondary education aims to provide a broad range of general knowledge and skills, preparing students for higher education. General secondary education prepares students for professional life while offering pathways to higher education. Additionally, pre-vocational education, lasting three years, is structured along modular lines, allowing students to progress at their own pace. This system includes subjects such as French, mathematics, German/Luxembourgish, general knowledge, optional classes, and physical education.

STEAM education in Luxembourg is not formally integrated into the national curriculum but is promoted through various thematic projects and activities in some schools. Pre-primary education often uses a transdisciplinary approach to STEAM, integrating arts into STEM disciplines through project weeks on topics like colours in nature or robotics. This approach helps children connect content and process skills to real-world situations. In elementary education, teachers have the freedom to incorporate STEAM activities into their weekly schedules on a voluntary basis, focusing on practical and skill-based learning. In secondary pre-vocational education, teachers can collaborate to develop innovative transdisciplinary pedagogies, enhancing creative and collaborative STEAM teaching and learning.

The University of Luxembourg (UL) plays a significant role in teacher training, focusing on pre-service elementary and secondary pre-vocational teachers. The Institute for Teaching and Learning at UL works across various content areas, including mathematics, sciences, computational thinking, and STEAM education. UL aims to assist pre-service teachers in planning and conducting teaching activities with 3D modelling through a STEAM-based transdisciplinary approach. The National Education Training Institute (IFEN) provides ongoing professional training to all in-service teachers and theoretical training to pre-service secondary teachers.

Despite the potential benefits, integrating 3D printing into the curriculum poses challenges. Teachers must recognise the pedagogical advantages of 3D printing and be willing to invest additional time in related activities. Overcoming anxieties about technology and providing adequate technical training are crucial for successful implementation. Furthermore, maintaining and supporting 3D printing equipment can be resource-intensive.

The benefits of integrating 3D printing into STEAM education are manifold. It enhances student engagement through hands-on projects, fosters creativity and innovation, and helps develop practical skills in design and engineering. For instance, students in mathematics can use 3D printing to visualise

complex geometrical shapes, while in science, they can create models for experiments and demonstrations, making abstract concepts more tangible. These applications promote interactive and relatable learning experiences, ultimately improving educational outcomes.

Moving forward, it is essential to develop strategic approaches to support the effective integration of 3D printing into Luxembourg's education system. This includes expanding training programs for pre-service and in-service teachers, ensuring access to the latest technological resources and pedagogical methods. Also, fostering industry partnerships can provide schools with the necessary support and materials to implement 3D printing effectively. These efforts will ensure that 3D printing becomes a valuable tool in enhancing STEAM education in Luxembourg, preparing students for future challenges and opportunities.

In conclusion, while there are challenges in integrating 3D printing into STEAM education in Luxembourg, the potential benefits are significant. By addressing the technical knowledge gap among teachers and providing the necessary resources and support, 3D printing can become an integral part of the educational experience.

Comparative Analysis: Identifying Commonalities and Differences Across Countries

This comparative analysis examines the integration of 3D printing in STEAM education across Austria, Finland, Luxembourg, and the Czech Republic. It identifies commonalities and differences, highlights best practices, and draws lessons learned from the implementation experiences in these countries.

Common issues

Emphasis on Multidisciplinary Learning	All partner countries emphasise a multidisciplinary approach to education, integrating 3D printing into various subjects such as mathematics, science, and arts. This integration fosters a holistic understanding of concepts and enhances hands-on learning experiences.
Challenges in Teacher Training	A common challenge identified is the need for comprehensive teacher training. Teachers in all countries require ongoing professional development to acquire the technical skills and pedagogical strategies necessary for effective 3D printing integration. This includes both pre-service and in-service training programs.
Resource and Equipment Constraints	Schools in all partner countries face challenges related to resource constraints. The cost of 3D printers and materials, as well as the maintenance and technical support required, are significant barriers to widespread adoption. Ensuring equitable access to these technologies is a common concern.
Enhanced Student Engagement	3D printing has been consistently reported to enhance student engagement and motivation. Hands-on projects involving 3D printing encourage

	creativity, critical thinking, and problem-solving skills. These projects make abstract concepts tangible, thereby improving understanding and retention.

Differences in Implementation

Curriculum Integration Strategies

Austria	Focuses on integrating 3D printing within existing subjects like mathematics and digital literacy through project-based learning approaches. The Austrian curriculum allows schools to emphasise certain subjects more heavily, facilitating informal STEAM integration.
Finland	Utilises a mandatory multidisciplinary learning module approach, ensuring that students engage with integrated learning experiences annually. Finland's curriculum supports collaborative planning and implementation of these modules.
Luxembourg	STEAM education is promoted through thematic projects and activities, especially in pre-primary and primary education. Luxembourg emphasises practical, skill-based learning with opportunities for 3D printing integration during project weeks.
Czech Republic	Teacher training programs include specific courses on 3D printing, focusing on practical applications and pedagogical methods. This approach supports both pre-service and in-service teachers in incorporating 3D printing into their teaching practices.
Slovakia	Teacher training in 3D printing remains optional and largely project-based. However, some pedagogical faculties and teacher training institutions have started offering workshops and modules in digital fabrication. The potential for 3D printing to support problem/project-based learning, creativity, and interdisciplinary STEAM activities is recognised, but still underutilised due to limited resources and lack of systemic support.

Support and Professional Development

Austria	Emphasises the need for structured, comprehensive training programs for both pre-service and in-service teachers to build technical skills and confidence in using 3D printing technology.
Finland	Offers various professional development opportunities, including workshops, online courses, and collaborative learning communities, to support continuous teacher training.
Luxembourg	Focuses on developing skills through STEAM-based approaches and provides ongoing professional training through the National Education Training Institute (IFEN).
Czech Republic	Provides practical experience and pedagogical support, encouraging collaboration with industry to give teachers hands-on experience with the latest technologies.
Slovakia	Support is mainly provided through externally funded projects (e.g. Erasmus+, Horizon Europe) and NGOs, which organise workshops and training sessions for

	teachers. These often take the form of hands-on events focused on practical applications of 3D modelling and printing within STEM/STEAM contexts. Teacher training institutions (e.g. National Institution of Education and Youth) have begun to incorporate topics related to digital technologies and 3D modelling into their courses, thematic seminars.

Best Practices

Structured Professional Development

Effective integration of 3D printing requires structured professional development programs that combine technical training with pedagogical strategies. Hands-on workshops and continuous support build teachers' confidence and competence.

Collaborative and Project-Based Learning

Encouraging collaborative projects and interdisciplinary learning modules helps students connect knowledge from different subjects and apply it in practical ways. Project-based learning enhances student engagement and fosters a deeper understanding of STEAM concepts.

Resource Allocation and Support

Allocating resources for purchasing and maintaining 3D printers and providing technical support is essential. Partnerships with industry can provide additional support and materials, making technology more accessible to schools.

Curriculum Flexibility

Allowing flexibility within the curriculum to incorporate new technologies like 3D printing can facilitate smoother integration. Countries that support thematic and project-based approaches tend to have more success in integrating 3D printing into education.

Fostering a Culture of Innovation

Creating a culture that embraces new technologies and innovative teaching methods is key. This involves training teachers and encouraging them to experiment and share their experiences with colleagues.

While each country has unique approaches to integrating 3D printing into STEAM education, common themes such as the need for comprehensive teacher training, resource allocation, and fostering student engagement are evident. By sharing best practices and addressing common challenges, partner countries can enhance educational strategies and better prepare students for future technological advancements. The next section will provide specific recommendations based on the insights gained from this comparative analysis.

Opportunities for 3D Printing Integration

Integrating 3D printing into STEAM education offers numerous opportunities across different subjects and educational levels. This analysis synthesises the opportunities identified from Austria, Finland, Luxembourg, and the Czech and Slovak Republics into a list, with detailed explanations of how 3D printing can be utilised to create learning experiences.

Enhancing Geometry and Mathematics Education

3D printing provides a powerful tool for visualising complex geometric shapes and concepts. By allowing students to design and print three-dimensional models, they can better understand spatial relationships, properties of shapes, and geometric theorems. This hands-on approach makes abstract mathematical concepts tangible, improving comprehension and retention.

Improving Understanding of Biological Structures in Science

In biology, 3D printing can create detailed models of cells, organs, and other biological structures. These models allow students to examine and manipulate representations of microscopic entities, facilitating a deeper understanding of biological processes and anatomy. This hands-on interaction can enhance engagement and make learning more interactive and memorable.

Facilitating Learning in Physics and Engineering

3D printing enables the creation of mechanical models and components, which can be used to study principles of mechanics, dynamics, and engineering. Students can print parts for experiments, build simple machines, and explore the properties of materials. This practical application helps bridge the gap between theoretical knowledge and real-world engineering practices, making learning more relevant and applied.

Supporting Chemistry Education with Molecular Models

In Chemistry, 3D printing can produce molecular models that aid in understanding chemical bonding, molecular geometry, and reactions. By constructing physical models of molecules, students can visualise how atoms interact and form compounds. This tangible representation of molecular structures helps clarify complex concepts and supports more effective learning.

Promoting Creativity and Innovation in Art and Design

Integrating 3D printing into art and design education encourages creativity and innovation. Students can design and print their own artistic creations, exploring the intersection of technology and art. This process not only fosters artistic skills but also introduces students to digital design tools and techniques, preparing them for careers in creative industries.

Enhancing Digital Literacy and Technological Competence

3D printing can be integrated into digital literacy curricula to teach students about 3D modelling software, design principles, and the operation of 3D printers. This knowledge is increasingly important in a technology-driven world, and students who develop these skills will be better prepared for future careers in STEM fields. The practical experience designing and printing objects also reinforces problem-solving and critical thinking skills.

Encouraging Collaborative and Project-Based Learning

3D printing projects often require collaboration, making them ideal for group work and project-based learning. Students can work together to design, print, and assemble complex projects, fostering teamwork and communication skills. These collaborative projects help students see the connections between different subjects and apply their knowledge in comprehensive, multidisciplinary ways.

Providing Real-World Applications and Prototyping Experience

3D printing allows students to create prototypes for engineering and design projects. This real-world application of theoretical knowledge helps students understand the practical implications of their studies. Students can engage in iterative problem-solving by designing and testing prototypes, and improving their designs based on feedback and experimentation.

Summary

In conclusion, integrating 3D printing into STEAM education in Austria, Finland, Luxembourg, and the Czech Republic highlights a collective effort to enhance learning through innovative technology. This report has detailed the opportunities and challenges of incorporating 3D printing into various subjects, emphasising the need for comprehensive teacher training and resource allocation. By adopting the best practices and recommendations provided, educational institutions can effectively use 3D printing to foster creativity, critical thinking, and practical skills in students. These efforts are essential in preparing students for a technology-driven future, ensuring they have the necessary skills and knowledge to succeed.

Following this analysis, we encourage readers to explore the extensive documents provided by each partner for detailed insights and specific implementations. Or chat with our project-personalised GPT to engage in a talk about our project. Additionally, the bibliography generated by each university offers resources for further research and development in the field of 3D printing in education.

Chat with our documents

https://chatgpt.com/g/g-VCYN66ZLI-3d-steam-companion

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