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Integrating Robotics Across the Primary School Curriculum

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Abstract

Ireland's Digital Skills Strategy 2015-2020 aims to further embed technology and digital learning tools in primary and post-primary schools where all stakeholders work together to support the integration of ICT in every classroom in a systematic and focused way.

This research paper reports on the design, development and implementation of a weeklong Robotics Summer Course for In-service Primary School Teachers. The design of the course was a collaborative endeavour between academics in Initial Teacher Education in STEM, employees from the technology industry, primary school and post-primary teachers and the Professional Development Services for Teachers in Ireland. The course focused on the potential of integration ICT across the primary school curriculum by embedding a constructivist pedagogical orientation, showing teachers how to facilitate activities whereby learners can exercise creative, problem-solving, critical thinking, project work and team-working skills using robotics in the classroom.

This paper will present findings from the teachers' evaluation of the course, reporting on their opinions on: their confidence, knowledge, ability and overall competencies in how to integrate robotics into their classroom; the design of future robotics summer courses and; the use of robotics in their future teaching. The findings can be used to inform future policy in STEM education and development of STEM courses for pre-service and in-service primary teachers and development of Corporate Social Responsibility (CSR) activities run by Technology Companies.

Keywords: Robotics, Primary, STEM Education, Professional Development

STEM Education

21st century skills require young people to have questioning and inquiring minds with effective problem solving, creativity and communications skills. The ability to memorise facts and procedures is not enough, they must also be able to apply their creativity, knowledge and skills within and across disciplines and in real life situations. Governments and industry are highlighting the importance and need for a highly capable STEM (Science, Technology, Engineering and Mathematics) workforce and a population with the above, mentioned skills to ensure economic, social and cultural prosperity [1, 2].

STEM is at the heart of a technological revolution which is transforming the way we live and the way we work.Therefore the emergence of STEM is now at centre stage in the education reform movement [3]. There is a need to integrate STEM right across the education system and the need to prepare students with twenty-first-century skills through STEM-related teaching, especially at the grassroots at primary level.

Over the past decade there have been a plethora of prioirity statements, implementations plans and policies in the promotion of 21st Century skills including STEM skills within the Irish education system [4,5,6,7,8,9]. This concentrated effort to enhance the quality of Science and Technology, Visual Arts, Literacy and Numeracy in education have often all been in isolation to one another.

Most recently Ireland's STEM Education Policy Statement 2017-2026, aims to encourag and inspire more of our young people, particularly more females, to specialise in Science, Technology, Engineering and Mathematics during their education and training so as to open the doors to exciting and fulfilling jobs, careers and life opportunities.This requires our teachers to have sufficient pedagogical content knowledge, and expertise in STEM teaching, learning and assessment, to enable them to design and enact high-quality learning experiences.

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'STEM education is an interdisciplinary approach to learning that removes the traditional barriers separating the four disciplines of science, technology, engineering and mathematics and integrates them into real-world, rigorous and relevant learning experiences for students' [10].

Jolly (2007) sets out seven compelling reasons to involve students in STEM:

1. STEM lessons help students go deeper in their understanding of important science and methematical concepts
2. Students become innovative critical thibkers and are able to amke good decisions
3. Students understand how to approach and solve problems
4. Students develop a sense of ethics and a social conscience
5. Students develop good collaboration skills
6. Students become more tecgnologically literate
7. Students understand how theior STEM course work opens the doors to future careers

Integrating STEM education across the curriculum with Robotics

Technology has the potential to support transformation in teaching, learning and assessment practices in schools and it can connect educational policy with economic and social development [12]. The "T and E" of STEM Education appears to be an obstacle to producing a meaningful STEM experiences. Integrating Robotics into the classroom is a very effective means of gluing the STEM and even STEAM (Science, Technology, Engineering and Art and Mathematics) together in classrooms. Engineering: is the glue that integrates science, maths and technology and forces them towards workable solutions. STEM uses engineering design process (EDP) as a systematic, orderly, open-ended way of approaching problems and designing solutions for those problems [11].

The domain of robotics represents a multidisciplinary and highly innovative field encompassing physics, maths, informatics, coding, programming, and even industrial design as well as social sciences. Robotics can also help in the practice and use of science process skills, the engineering design process and problem-solving approaches incorporating observation, estimation, manipulation and social interaction/teamwork skills [13, 14] and therefore in the delivery of STEM education in our schools

Methodology

This section of the paper will report on the design, development and implementation of a weeklong Robotics Summer Course for In-service Primary School Teachers (N= 17) (7 Male and 10 Female). The design of the course was a collaborative endeavour between academics in Initial Teacher Education in STEM, employees from the technology industry (DELL EMC), primary school and post-primary teachers and the Professional Development Services for Teachers in Ireland.

Course Aims

The course focused on using robotics to support an enquiry process and enable their students to work on solving complex real-world problems by engaging in collaborative project-based learning activities that go beyond the classroom.

Learning Methodologies

Throughout the course, the teachers engaged in a variety of participant-led, teacher-led and practice-based learning opportunities, working both in an individual and group capacity**:**

- Interactive hands on workshops based on constructivist, inquiry based approaches to teaching and learning.
- Team-building activities promoting collaborative, group work and dialogue in the classroom.
- Design and carry out of inquiry based activities, investigations and problem solving challenges.
- Hands-on learning activities engaging and focusing on the engineering.
- Design and make which focus on the development of scientific process skills (observation, questioning, discussion, prediction, analysis, exploration, investigation, and experimentation).
- Learning activities providing opportunities for building, programming, and designing robots.

Course activities

The teachers were provided with the opportunity to plan, design and practice teaching methodologies that integrate robotics into lessons focused on developing children's literacy and numeracy, science and creative and artistic skills.

Inquiry based robotics activities incorporated:

- The constructivist approach to teaching show teachers how to empower pupils to think critically, make deep connections through questioning, exploring, thinking, experimentation and reflecting and applying this understanding in a productive way into actionable knowledge. All of which are carried out through exploratory talk, dialogue, reading and writing.
- The practice and development of problem solving, inquiry based scientific process skills in robotics in contributing to developing the child's language, communication and literacy skills and also their mathematical and numeracy skills.
- Scientific process skills: Observation (looking at the evidence), Predicting, Recording data, Higher order thinking, Analysing the information, recognising and interpreting patterns), Student and teacher questioning, Collaboration (dialogue), Arriving at conclusions, Measuring and Estimating and Experimentation.
- Team building activities
- Open ended challenges,
- Demonstrations and presentation activities

Feedback from teachers

This section reports on a selection of some of the feedback form the tecahers after they had completed the week long summer course.

Please tick the appropriate boxes	Greatly improved	Improved	Stayed the same
Your knowledge of how to integrate Robotics into the curriculum	70	30	
Programming skills	47	41	12
Your ability to user robots in the classroom	65	35	
Your confidence to use robotics in the classroom	41	59	
Your practice of the Design Process	41	59	

Table 1. Feedback from teachers on Robotics Summer Course (% of N= 17)

The teachers were asked to comment on the greatest success of the course. Their comments mentioned:

- Completing the robot; Understanding how robots are used in our lives; improving their knowledge about robotics and in particular coding; the nature of the lessons (flexible and adjustable approach to the lessons) and; Fun and practical aspect of the course.

Some of their comments included:

"The facility to have the speed of the 'instructions' slowed down so everyone could process at his/her own speed"
"The insight it gave in how to integrate and use robotics in the classroom."
"My knowledge of sensors and programming them improved hugely."
"A new and complex topic taught in a simple and effective way."
"How accessible and attainable robotics in the classroom now seem."
"My confidence has hugely improved particularly in the area of assembling robots and programming robots."
"The hands on nature of it."
"We encountered every imaginable problem which was no harm. So we had to solve every imaginable problem."

The teachers were asked to comment on the greatest challenge of the course. Their comments mentioned:

"Understanding programming and understanding theory"
"Having confidence in teaching programming"
"The programming was the most difficult challenge for me"

All of the teachers stated they will now use robotics in their future teaching. use of robotics in their future teaching.

Conclusions

Schools and early years settings must continually evolve, improve and learn from best practice in relation to STEM education. Teachers are now required to change their approaches to STEM teaching, learning and assessment. The teachers need a significant amount of assistance and support in this area.

The week long summer course allowed the teachers time and space to try things out and reflect on STEM and how it can be integrated across the primary curiculum. This project was also very successful as it involved many stake holders with a variety of experiences to share ideas, knowledge and practices.

References

[1] SFI (2015) Science in Ireland Barometer. An analysis of the Irish public's perceptions
[2] and awareness of STEM in society. http://www.sfi.ie/resources/SFI-Science-in-Ireland-Barometer.pdf
[3] National Research Council. (2011). Successful STEM Education: A Workshop Summary. A. Beatty, Rapporteur. Committee on Highly Successful Schools or Programs for K-12 STEM Education, Board on Science Education and Board on Testing and Assessment. Division of Behavioral and Social Sciences and Education
[4] Koehler, C., Binns, I. C., Bloom, M. A. (2015). The emergence of STEM. In Johnson, C. C., Peters-Burton, E. E., Moore, T. J. (Eds.), STEM road map: A framework for integrated STEM education (pp. 13-22). New York, NY: Routledge.
[5] Department of Education & Skills (DES) (2015) Digital Strategy for Schools 2015-2020. DES: Dublin. Available at https://www.education.ie/en/Publications/Policy-Reports/Digital-Strategy-for-Schools-2015-2020.pdf
[6] https://www.education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Department-of-Education-and-Skills-Strategy- Statement-2016-2019.pdf
[7] https://www.education.ie/en/Publications/Corporate-Reports/Strategy-Statement/Action-Plan-for-Education-2017.pdf
[8] Ireland's National Skills Strategy 2025; https://www.education.ie/en/Publications/Policy-Reports/pub_national_skills_strategy_2025.pdf
[9] https://www.education.ie/en/Publications/Policy-Reports/Arts-In-Education-Charter.pdf
[10] National Strategy: Literacy and Numeracy for Learning and Life; https://www.education.ie/en/Publications/Policy-Reports/lit_num_strategy_full.pdf
[11] Vasquez, J.A. Comer, M. & Sneider, C. (2013) STEM Lesson Essentials, Grades 3-8. Integrating Science, Technology, Engineering, and Mathematics. New York: Heinemann.
[12] Jolly, A. (2007). STEM by design. Strategies and activities for grades 4-8. New York: Routledge.
[13] Benitti, F.B.V. (2012). Exploring the Educational Potential of Robotics in Schools: A Systematic Review. *Computers & Education, 58*(3), 978-988.
[14] Scaradozzi, David & Sorbi, Laura & Pedale, Anna & Valzano, Mariantonietta & Vergine, Cinzia. (2015). Teaching Robotics at the Primary School: An Innovative Approach. Procedia - Social and Behavioral Sciences. 174. 3838-3846.