A STEM FAMILY E-LEARNING FRAMEWORK TO INCREASE FAMILY ENGAGEMENT IN DISADVANTAGED COMMUNITIES

Kate Darmody[1], Julie Booth[1], Fergal O'Toole[1], Alexandra Alcala[1], Josephine Bleach (PhD)[1], Paul Stynes (PhD)[1] and Pramod Pathak (PhD)[2]

[1]*National College of Ireland Mayor Street, IFSC, Dublin 1, Ireland*

[2]*Technological University Dublin, Grangegorman, Dublin 7, Ireland*

ABSTRACT

STEM family e-learning involves increasing the engagement in STEM home learning activities. STEM home learning activities range from exploring subjects such as science technology, engineering, and maths through a fun play based K-6 STEM curriculum. The family are trained to act as teachers, mentors, and coaches to the K-6 members. Families from educational disadvantaged areas are typically early school leavers and having the STEM capacity to support their children is a challenge. This research proposes a STEM Family e-Learning framework to increase family engagement in supporting the K-6 members engaged in STEM learning activities. The proposed framework combines training for volunteers and STEM learning activities provided to families. Training for volunteers focuses on how to work with families in disadvantaged communities. STEM learning activities involve providing the family with STEM programmes such as Virtual Robotic Coding Clubs, Card Challenges, e-Learning Programme, STEM Play and Learn, STEM Workshops, Showcases and Events. Parent and child evaluation data indicate that the activities stimulated interest in STEM for both children and their parents and increased confidence in STEM subjects. This research can potentially enhance the mainstreaming and extension of STEM e-learning to disadvantaged communities.

KEYWORDS

STEM, e-Learning, Family Engagement, Disadvantage, Action Research.

1. INTRODUCTION

Research consistently highlights early learning as the foundation for all subsequent learning (Heckman, 2006) and the importance of Science, Technology, Engineering and Mathematics (STEM) as an indicator of future academic success. Competence in STEM is essential for functioning in everyday life, and for success in our modern technological workplace. Children today will be applying for jobs in STEM areas such as advanced robotics, autonomous transport, artificial intelligence, and biotechnology. Student achievement in STEM education is attributed to a complex interrelationship of socioeconomic factors, home influences, and home-school relationships (Duch & Gennetian, 2018). Families in educationally disadvantaged communities do not have the knowledge or skills required to encourage or help young people with STEM subjects (ELI, 2012; Gunning, Marrero and Morell, 2016), and student engagement has been found to be lower in schools in disadvantaged communities (Bray et al., 2021; Devitt et al., 2020). In the context of e-learning, Bray and colleagues found that the primary barriers teachers noted in student engagement online were lack of student interest and a lack of support at home. These social and motivation barriers had greater significance in disadvantaged community settings (Bray et al., 2021).

Parental attitudes and involvement influence their children's interest, motivation and sense of personal efficacy (Bandura, 1997) and reinforce outcomes in a positive or negative feedback loop. For students in disadvantaged communities, it has an impact on their choice of and persistence in a STEM career. Parents involvement in their children's STEM education may accelerate achievement of learning or mitigate risk factors that threaten it (Henderson & Mapp, 2002). Families' feedback is a critical element in developing opportunities for STEM learning (Henríquez, 2018).

Recognizing agency of the participants (Bandura, 2001) and individual home learning context is important. Gunning, Marrero & Morell (2016) provided the opportunity for low-income families to do science and engineering activities together. Their findings indicate that the opportunity successfully altered the families' view and practice of science outside of school. It is claimed that learning educational robotics can be a gateway for children's engagement with scientific concepts and mathematical thinking as well as developing their understanding of technology (Elkind, 2008). Individualized, active, explorative and child-directed learning (Casad & Jawaharlal 2012) is important to giving young children positive STEM experiences in order to maintain their interest. High-quality long-term integrated science experiences build a critical foundation to support future science knowledge and interest (Gerde, Schachter, & Wasik, 2013; Patrick, Mantzicopoulos, Samarapungavan & French, 2008).

STEM programmes with disadvantaged communities have been running since 2008 in the Early Learning Initiative (ELI, 2012) in Dublin's Inner-City. An initial survey of need (Dartington Social Research Unit, 2006) found that while local parents had high educational aspirations for their children, they did not understand their pivotal role and were not confident that they had the skills to support their children's learning. With support for parents as the primary educators of their children a priority, involving local people as co-constructors of programmes and in the decision-making processes is perceived as key to educational change and student achievement (Bleach, 2013). These programmes were initially delivered in-person through schools and services or integrated within home visiting and parent engagement programmes. In 2020 the STEM K-6 programmes transitioned to e-Learning delivery in response to the COVID19 emergency restrictions. The present study investigated the impact of introducing K-6 e-learning activities on family engagement in a disadvantaged community. The major contribution of this research is a novel STEM Family e-Learning Framework that combines family engagement, training and activities in order to promote family and community engagement with e-learning. Engagement is defined as the combination of three dimensions namely, participation, confidence and interest.

2. STEM FAMILY E-LEARNING FRAMEWORK

ELI designed multiple holistic family interventions ranging from workshops and events on STEM subjects to Virtual Robotic Coding Clubs through K-6 e-learning programmes. Community Action Research (Bleach, 2016) is used to design, implement, and evaluate the multi-faceted e-learning programme. Time to plan, engage, implement and evaluate is a central component of the process. The STEM Family e-Learning Framework is shown in figure 1. The framework combines three components, family engagement, training, and activities each of which are detailed below.

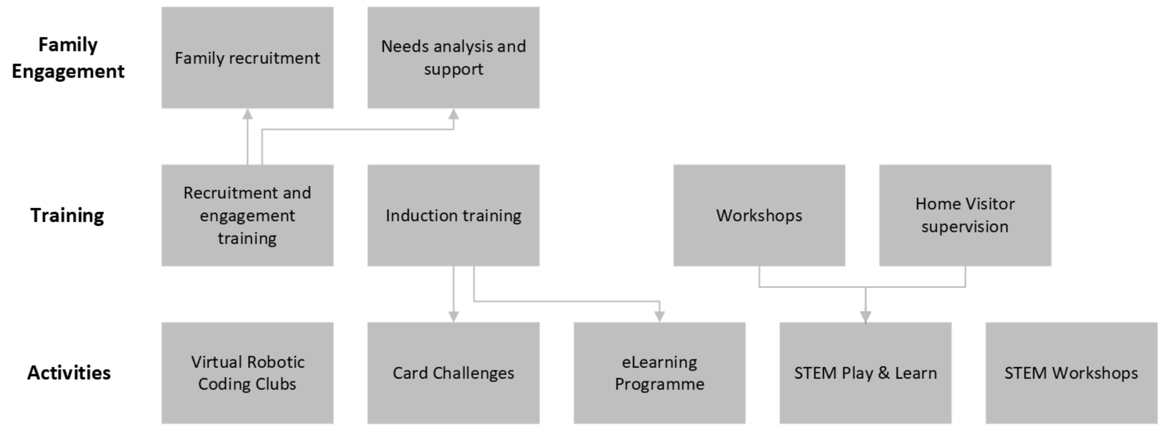

Figure 1. STEM family e-Learning framework

Family engagement consists of family recruitment and family needs analysis and support. Family recruitment uses multiple methods to recruit participants namely, referral from ELI's home visiting, family engagement programmes, along with local schools and services. Families may also self-refer hearing of programmes through social media, and word of mouth. Family needs analysis and support involves first identifying the barriers individual families might face to engagement. A family's access to technology, digital literacy, proficiency in English and confidence to engage in STEM are all taken into consideration. The level of support is then determined based on these needs. Engaging directly one-to-one with families may be important with support to access the technology and materials provided in advance of an activity. The number of participants should be kept low to address the cognitive and affective difficulties of mastering STEM concepts and enable more intense engagement and support. Discussions around on-screen etiquette along with allaying concerns around internet safety requires continuous conversations and check-ins throughout the programme. Ongoing support should be provided to discuss any difficulties families are having with e-learning, and so parents have a voice in the development of the programme, ensuring it is family-friendly and fit for purpose.

Training involves building staff capacity to recruit and engage families which feeds back into the family recruitment, needs analysis and support processes. Induction training for volunteers, workshops for volunteers and Home Visitors (staff delivering one-to-one programmes) are provided prior to beginning activities and, finally, Home Visitor supervision is provided for STEM Play & Learn. These training components enable best practice and to ensure professionals are supported. Staff are trained in how to engage with families, this can be individualized depending on the needs of the family. Guidance on content development is provided and experienced staff model STEM activities for the one-to-one sessions, explaining the benefits of the activities and resources for a child's development. One-to-one introduction meetings are arranged for each family with their Home Visitor or volunteer. In keeping with best practice from the Home Visiting Model ongoing programme support is provided to Home Visitors and volunteers through supervision and programme reviews.

The STEM family e-Learning activities, detailed below, are designed to appeal to a range of age groups. The Virtual Robotic Coding Club (8-12 years) aims for children to learn about basic robotics, programming and electronics with mbots and micro bits which they program using Makeblock software. The activities re-enforce children's coding skills over the 6-week programme, culminating in a competition event where children can participate in a coding challenge.

Card Challenges (8-12 years) aims to raise awareness of the role that the family and community can play in improving and promoting literacy and numeracy with fun activities and building parents' confidence in participating in learning activities with their children. Families were paired with a corporate volunteer to play card games each week for 4 weeks with a virtual card challenge competition at the end.

The aim of the e-Learning Programme (5-12 years) is to raise parent's awareness of STEM educational and career expectations and to increase parental educational capital facilitating their ongoing involvement in their child's education and learning. This 4-lesson program is developed with a focus on the environment, through four subtopics: food, water, energy, and climate, and activity packs are provided for each topic. Creating a Google platform of engagement provides a space for peer learning and discussion amongst families.

The STEM Play & Learn programme (4-6 years) aims to upskill parents as home educators to have the confidence, understanding, skills and knowledge to continue to support their children's education in this new everchanging situation. This 6-week programme supports children's early literacy, numeracy, language, and social/emotional development, in fun and interactive way. The blended learning approach through phone/video contact; e-Learning programmes and resources; home learning packs including books and toys to explore STEM concepts suitable for this age.

STEM workshops (5-11 years) are one off opportunities for families to engage in fun learning educational activities to explore STEM. The workshops are delivered in collaboration with other organizations and professionals with a STEM background.

3. METHODOLOGY

The development of the activities, framework and their evaluation follow a community action research approach (Bleach 2016). This research was approved by the Ethics Committee. Informed consent was sought prior to participation.

Prior to beginning the programme parents are asked to complete an intake form. Information provided in the form along with conversations with the programme coordinator form the basis of the family's needs analysis. In the case of STEM Play & Learn, parents completed a short pre-programme survey identifying the frequency to which the family engage in home learning activities.

167 children and 167 parents participated in the e-learning activities from August 2020 to December 2021. All families were from an area of socio-economic disadvantage in Dublin's Inner City. All e-learning activities were delivered online in the family home. Children's and parents' attendance were collected in order to measure participation.

Parents and children were invited to complete online post-programme surveys designed by ELI to evaluate the engagement of the family based on examining children's and parents' interest and confidence in STEM. Participants were asked to rate their levels of confidence and interest on a five-point scale in a number of questions. For example, parents were asked to rate the level to which participating in the STEM activity increased their confidence in their ability to support their child's learning in STEM and their involvement in their child's STEM learning. Children were asked to rate the level to which their confidence in STEM skills increased and if participating increased their interest in STEM. 68 parents and 64 children responded. Parents participating in the STEM Play & Learn also completed the same home learning environment questions that were asked at pre-programme.

4. RESULTS AND DISCUSSION

This section examines the findings and discusses key components to measuring successful family engagement as well as the challenges. Data were analysed in Microsoft Excel. Average percentage of attendance in e-learning activities used to measure participation. Interest and confidence in STEM were measured by frequency of children and parents rating 4 or 5 on a 5-point scale. Qualitative data was analysed by identifying recurring themes in children and parents' responses.

Children participated online from their homes accompanied by their parents. The average percentage participation of both children and their parents in the programmes are outlined in Table 1.

Table 1. Average percentage participation of parents and children in each activity of STEM Family e-Learning Framework

Programme	Parent avg. % attendance	Child avg. % attendance
Virtual Robotic Coding - 6 weeks	26%	68%
Card Challenges - 4 weeks	92%	92%
STEM Play & Learn - 6 weeks	54%	54%
STEM Workshops - 1 session	92%	100%

From child and parents' attendance in Virtual Robotic Coding Clubs it is evident that engaging with children and parents directly for this virtual robotic coding club had a positive impact on parental participation with 26% of parents participating compared to previous years when 0-4.9% engaged in person (ELI, 2018, 2019). Participation, however, was a challenge with the self-directed e-Learning module due to parental capacity, time and digital literacy issues. As is indicated in the results presented above, programmes that are parent directed and involve one-to-one attention to families such as the Card Challenges and STEM Play & Learn result in high levels of participation and engagement, particularly regarding parents.

Parents and children highlighted the relationships and connection, with professionals and peers as a beneficial aspect for engaging in the programmes, and for some parents was their sole contact outside the home. For one child the favourite part was *"[been] online with familiar faces, learning new things in a fun way"*. Participation in the programmes coupled with the connection with staff also encouraged engagement in further programmes: *"Thank you for thinking of my child for coding club, he really enjoyed the STEM event back in August. He has his experiment on show in his bedroom, he even brought his experiments into school for science week to show what he has done."* Finally, parents noted that the resources provided also encouraged engagement in their children.

Survey data indicated that the e-learning activities stimulated both children's and parents' interest in STEM. On being involved in helping their child learn about STEM after the activities parents participating in Virtual Coding Club (95%, n=18), Card Challenges (100%, n=7), and the STEM workshops (96%, n=27) reported an increased interest. Furthermore, data from STEM Play & Learn indicates parents engaging in home learning activities daily increased by 16-38%. Children's interest in STEM was also stimulated through the activities with children or parents reporting a greater interest in their learning STEM after Virtual Coding Club (94%, n=17), Card Challenges (100%, n=7), and the STEM workshops (66%, n=27). As the STEM workshops are individual events and not over multiple sessions it may have resulted in the lower rate of interest. It must also be noted that this was reported by parents and not by the children directly. In relation to their child's increased interest, one parent noted *"it was a new area of learning for my child. He didn't know anything about microscopes but the event really got him thinking and sparked his interest."*

Confidence in STEM was measured in children in the Virtual Robotic Coding Club. 67% (n=12) of children reported high levels of confidence in their coding skills after participating and 61% (n=11) in their computer skills. 94% (n=17) of the children also indicated that both their coding and computer skills had improved while participating in the activities. Parents also noted children's enhanced confidence and ability in qualitative responses across activities. One parent commented that their *"5 year old has had huge enjoyment from it, and his confidence to create things on his own has soared as a result of the initiative."* Parents' own confidence in supporting their child to learn STEM was also enhanced through engagement in the e-learning activities. Parents noted high levels of confidence after Virtual Coding Club (84%, n=16), e-Learning Programme (100%, n=2) and STEM Play & Learn (93%, n=14). Increasing parents' confidence and involvement through these activities can develop opportunities for children's future STEM learning (Henríquez, 2018) and potentially accelerate children's learning (Henderson & Mapp, 2002).

This study has some limitations. Firstly, as mentioned previously, ELI has been engaging with the community since 2008. Prior relationships have been established with some of the families in the study and this prior engagement may have previously influenced children and parents' interest and confidence in STEM. Additionally, these prior relationships coupled with the self-report nature of the surveys may have led to response bias.

5. CONCLUSION AND FUTURE WORK

This research investigated the impact of a novel, holistic STEM Family e-Learning Framework to promote family engagement with STEM e-learning. Results demonstrate that creating fun and enjoyable e-learning activities for children to engage in STEM increases interest and confidence, with children's skills in coding (94%) and interest in STEM (66% in workshops and 94% in Virtual Coding Club) improving. It is evident that building children's self-efficacy of STEM through these e-learning activities stimulates their engagement and desire to further participate in STEM (Bandura, 1997), with parents noting their children continuing the STEM activities and increased creativity, for example one parent noted *"it is a very good programme and my child is continuing what she learnt by having a weekend card game with her cousins… It is great fun for them and a great way of learning."* Upskilling parents as coaches and co-participants built their capacity as educators and increased family interest, confidence and participation in STEM. It offered rich K-6 STEM family learning opportunities through the application of skills in context but also through an apprenticeship-like enculturation into the language and norms of a particular domain. Furthermore, it is evident that engaging in an e-learning approach increases parent participation in their child's STEM learning, as can be seen in the 21% increase in parental engagement in Coding Clubs since the programme was last delivered in person. Research has shown that the teaching approach in online learning can impact on student engagement (Keane, 2013). The delivery and relationship with staff were noted in the qualitative data as factors of engagement in the e-learning activities. One parent whose child has delayed speech stated their Home Visitor *"was brilliant with working with X. She held X's attention through the virtual calls so well… He absolutely loved her and as a result of the good connection we heard more words."* This research can potentially enhance the mainstreaming and extension of STEM e-learning to disadvantaged communities. This work can be improved by exploring how territorial development action research process (Karlson and Larrea, 2014) combined with threshold theory can change STEM cultural cognitive frameworks within educationally disadvantaged communities.

ACKNOWLEDGEMENT

This work was supported by grant 20-DP-8252 from the Science Foundation of Ireland.

REFERENCES

Bandura, A., (1997). *Self-Efficacy: The Exercise of Control.* W. H. Freeman and Company.

Bandura, A., (2001) Social Cognitive Theory: An Agentic Perspective. *Annual Review of Psychology, 52*, 1-26. https://doi.org/10.1146/annurev.psych.52.1.1

Bleach, J., (2013). Improving Educational Aspirations and Outcomes through Community Action Research, *Educational Action Research Journal*, *21*(2), 253-266.

Bleach, J., (2016). Community Action Research in Ireland: Improving Educational Outcomes through Collaboration in the Dublin Docklands. In L. Rowell, C. Bruce, J. Shosh, & M. Riel, (Eds.), *Palgrave International Handbook of Action Research* (pp. 177-188). Palgrave Macmillan.

Bray, A., Banks, J., Devitt, A. and Ní Chorcora, E., (2021). Connection before content: using multiple perspectives to examine student engagement during Covid-19 school closures in Ireland. *Irish Educational Studies*, *40*(2), 431-441.

Casad, B. J., & Jawaharlal, M., (2012). *Learning through guided discovery: an engaging approach to K-12 STEM education.* [Conference paper]. ASEE Annual Conference, San Antonio, Texas. https://peer.asee.org/21643.

Dartington Social Research Unit, (2006). *National College of Ireland Early Learning for Children in North Docklands: Report of Findings.* [Unpublished Report]. National College of Ireland.

Devitt, A., A. Bray, J. Banks, and & E. Ní Chorcora, (2020). *Teaching and Learning During School Closures: Lessons Learned. Irish Second-Level Teacher Perspectives*. Trinity College Dublin. http://hdl.handle.net/2262/92883

Duch, H. and Gennetian, L.A. (2018). Using a behavioral economics perspective to boost family engagement in the getting ready for school preschool intervention. In Caspe, M., Woods, T. A., & Kennedy, J. (Eds.). *Promising practices for engaging families in STEM learning* (pp.65-80). Information Age.

Early Learning Initiative (ELI), (2012). *Submission to the Joint Committee on Jobs, Social Protection and Education on Educational Disadvantage.* [Unpublished Report]. National College of Ireland.

Early Learning Initiative (ELI), (2018). *End of Year Report 2017/18.* National College of Ireland. https://www.ncirl.ie/Portals/0/ELI/ELI%20End%20of%20Year%20Report%202017-2018_Final.pdf?ver=2019-06-26-091433-083

Early Learning Initiative (ELI), (2019). *End of Year Report 2018/19.* National College of Ireland. https://www.ncirl.ie/Portals/0/ELI/Final%20End%20of%20Year%20Report%202018-19%20-%20Updated.pdf

Elkind, D., (2008). Forward In Bers, M.U. *Block to Robots*, Teachers College Press.

Gerde, H.K., Schachter, R.E. and Wasik, B.A., (2013). Using the scientific method to guide learning: An integrated approach to early childhood curriculum. *Early childhood education journal*, *41*(5), 315-323. https://doi.org/10.1007/s10643-013-0579-4

Gunning, A.M., Marrero, M.E. and Morell, Z., (2016). Family learning opportunities in engineering and science. *The Electronic Journal for Research in Science & Mathematics Education*, *20*(7). https://files.eric.ed.gov/fulltext/EJ1188035.pdf

Heckman, J. J., (2006). Skill Formation and the Economics of Investing in Disadvantaged Children, *Science, 312* (5782), 1900-1902. https://doi/10.1126/science.1128898.

Henderson, A.T. and Mapp, K.L., (2002). *A New Wave of Evidence: The Impact of School, Family, and Community Connections on Student Achievement. Annual Synthesis 2002*. National Center for Family & Community Connections with Schools. https://sedl.org/connections/resources/evidence.pdf

Henríquez, A. (2018). NYSCI neighbors: creating locally-driven authentic opportunities for immigrant parents in s STEM ecosystem. In Caspe, M., Woods, T. A., & Kennedy, J. (Eds.). *Promising practices for engaging families in STEM learning* (pp. 137-146). Information Age.

Karlson, K. and Larrea M., (2014) *Territorial Development and Action Research Innovation Through Dialogue*. Routledge

Keane, E., (2013). *Widening Participation in Higher Education in the Republic of Ireland*. HEFCE (Higher Education Funding Council for England).

Patrick, H., Mantzicopoulos, P, Samarapungavan, A. and French, B.F. (2008). Patterns of young children's motivation for science and teacher-child relationships. *The Journal of Experimental Education*, *76*(2), pp. 121-144. https://doi.org/10.3200/JEXE.76.2.121-144