STEM Education in Northern Ireland: Is it an example of systemic failure?

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Abstract
Five years have now passed since the last government review of STEM (Science, Technology, Engineering and Mathematics) education in Northern Ireland (Perry and Irwin, 2015). This small-scale qualitative study set out to analyse the progress made and challenges faced within STEM education in Northern Ireland, and to draw out implications for education and teacher education. Individual filmed interviews were carried out with a range of education professionals and representatives from industry and politics (n=11), followed by small group interviews with pupils finishing the junior phase of their schooling (n=13). Findings reveal high levels of pupil engagement but also, and in contrast to many other countries, the study highlights frustration among STEM professionals at a lack of investment in STEM education at all levels. The study also identifies additional challenges in promoting inquiry-based learning approaches to STEM education in the current high-stakes assessment environment. Conclusions are drawn for education and teacher education.

Keywords
STEM education; Northern Ireland; inquiry-based learning; teacher education; curriculum.

Introduction
STEM (Science, Technology, Engineering and Mathematics) Education has been promoted by governments around the world since the early 2000s, but recent studies have highlighted mixed success. For instance, in an analysis of data from 30 European countries, Kearney (2016) found that most countries consider STEM education to be a major educational priority and that STEM education policies and initiatives have continued to receive political and financial support. Kearney (2016) also noted a range of initiatives to promote STEM across the 30 countries including the promotion of inquiry-based learning, initiatives to address current shortages of STEM teachers in schools (particularly at secondary level) and improvement of initial and/or in-service STEM teacher education. Despite this investment, however, Kearney's study revealed high levels of underachievement in STEM subjects and a lack of student interest in choosing STEM subjects and related careers.

In a wider consideration, Freeman et al. (2015) compared STEM investment in South-East Asia with that in Western European countries and Canada. They highlighted that the South Korean government had focused upon STEM investment since the 1960s to support the Korean economy, and that China's Ministry of Education had emphasised proactive collaborative partnerships between higher education, industry and research groups. In contrast, the strategies in the United Kingdom, Canada, Germany, France and the Netherlands had been to design STEM policy in response to workforce needs. Freeman et al. (2015:1) pointed out that, 'There is no contemporary nation with an economy both vigorous and well-integrated that is not also strong in STEM', but also that, 'Research in many countries shows there is a pattern of declining interest in STEM in the middle secondary years' (Freeman et al., 2015:4).

Furthermore, in her critical review of 237 international studies, McDonald (2016) identified three key factors that impact upon pupil engagement in STEM education: first, the need to maintain a focus

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upon student engagement with STEM education, with the junior secondary phase of education identified as a critical stage; second, that educational practice had to be developed to more fully engage and more successfully equip students; and third, that the standard of teaching would need to be high to enthuse and inspire students to pursue STEM related endeavours.

Despite extensive international investment in STEM education, there is still uncertainty around the precise meaning of STEM education (Bybee, 2010), and confusion remains surrounding its effective implementation, as evidenced in the observations of Ritz and Fan (2015) and the proposals of Wang et al. (2011), from which emerge (at least) five possible interpretations: the 'silo' approach; the 'embedded' approach; the 'integrated' approach; the 'interdisciplinary' approach; and the 'multidisciplinary' approach. An additional challenge for STEM education has been the mechanism of assessment. Freeman et al. (2015) concluded that a move away from high-stakes accountability testing (as defined by Au, 2007) was the strategy adopted by most of the many countries they studied in order to improve pupil engagement with STEM. They reported that China, Japan, Korea and Taiwan had recorded a shift in focus to support development of creativity, problem-solving, collaboration and critical thinking, and (ibid: 12) that 'China's New Curriculum Reform involves incorporation of inquiry-based, creativity-focused, student-centred learning'. In contrast, Freeman et al (2015) reported that in the United Kingdom, high-stakes accountability testing had compromised both the standard of teaching and the quality of the learning experience.

Su et al (2017) identified instances of successful practice in STEM education in Canada and Finland. Finland outperforms most other countries in the PISA assessment (OECD, 2013), and here there is an emphasis upon teacher autonomy and trust of the teacher's judgement, with high-stakes testing disregarded for most stages of the educational experience. In Canada, a major focus is that the pupils become scientifically literate (Guven and Gurdal, 2011), with science taught using an inquiry-based, student-centred, constructivist approach. Particular value is placed upon scientific skills with 'real world' connections to technology, society, and the environment.

Kearney's (2016:5) findings from analysis of 30 European countries echo the value placed upon inquiry-based learning: 'When comparing the results of the last edition of this report published four years ago, promoting inquiry-based learning still remains the most highly ranked issue with 80% of all countries stating it is addressed as a top priority or important issue at national level'.

Therefore, despite substantial international research (Bybee, 2010; Wang et al., 2011; Ritz and Fan, 2015), there is still no agreement on the most effective approach to the promotion and delivery of STEM education. Across the world, the importance of STEM education to economic prosperity is recognised (Freeman et al. 2015), but implementation policies vary extensively. Internationally, STEM education is compromised by a shortage of sufficiently skilled teachers, limited student engagement and limited student achievement, despite large financial investments and high levels of activity in many countries (Freeman et al., 2015; Kearney, 2016). However, there is evidence from international contexts (Guven and Gurdal, 2011; Freeman et al., 2015; Kearney, 2016; Su et al, 2017) that within the best practice of STEM education, there has been a significant development of inquiry-based learning, which is in conflict with traditional mechanisms of high-stakes testing to be found elsewhere.

STEM education: The Northern Ireland position

Over a decade has passed since the Northern Ireland (NI) government first set out its vision for STEM education in the Report of the STEM Review (Department of Education & Department for Employment and Learning, 2009). Achievement of this vision was last reviewed five years ago (Perry and Irwin, 2015), so an examination of the current position for NI within an international context was considered timely, and forms the focus of this study. The 2009 Report of the STEM Review made 20 recommendations, listed under four headings (Department of Education & Department for

Employment and Learning, 2009:14): 'Business must take a lead in promoting STEM'; 'We must alleviate key constraints in the STEM artery'; 'There needs to be increased flexibility in the provision of STEM education'; and, 'Government must better coordinate its support for STEM'.

From 2009, STEM education was promoted within schools in NI and across the United Kingdom as a critical component for economic growth (Department for Employment and Learning (NI), 2011). There was concern that young people were not interested in STEM-related subjects or careers and that this could quickly lead to a significant and economically damaging skills shortage. The Report of the STEM Review identified a number of factors that were peculiar to NI, including a lack of transition planning when pupils transitioned from primary (pupils aged 4 to 11) to post-primary school (pupils aged 11 to 18), along with little professional development of serving teachers in STEM-related issues. Underachievement in STEM subjects was identified as a further concern, and careers guidance was judged to be insufficient with regard to STEM subjects. Between 10% and 18% of STEM students were dropping out of their first year in NI universities and approximately one quarter of STEM subject graduates were leaving NI at that time to live and work elsewhere.

'Success through STEM' (Department for Employment and Learning, 2011) listed actions to be taken by each of the NI government departments to meet the 20 recommendations within the 2009 Review. The report emphasised the interdependence between business sector 'demand' (ibid:8) and education sector 'supply' (ibid:10) in order to balance 'supply and demand in a growing economy' (ibid:7). It also highlighted the need for a more co-ordinated approach from NI government departments in order to meet an anticipated future increase in the demand for STEM skills. However, in November 2015, a report prepared for the NI government's Committee for Education (Perry and Irwin, 2015) itemised progress against the listed actions in the 2011 'Success through STEM' Strategy: across all recommendations, findings reflected little improvement if any, from the position in 2009. Significantly, the Perry and Irwin report isolated inquiry-based learning (IBL), Continuous Professional Development (CPD) for teachers, and Initial Teacher Education (ITE) as key elements for the success of STEM education in NI. Their findings included that primary school teachers still felt ill-equipped to deliver STEM education, with less time given to science in NI classrooms than against international comparisons, and far from achieving the 2009 goal to increase the numbers of students enrolling in STEM education courses for ITE, numbers were falling. It is notable that, despite the central role assigned to the business sector in the 2011 'Success through STEM' Strategy, along with the critical interdependence that was highlighted between the business and education sectors, the Perry and Irwin report makes no mention of the role to be played by NI business.

The purpose of this study, funded by the Royal Society for the encouragement of Arts, Manufactures and Commerce (RSA), was to examine STEM education in NI within an international context, to find out: current perceptions of STEM education in NI, from representatives in schools, universities, industry and politics; if current practice shows any improvement since 2015 to meet the initial goals of NI government policy in 2009; and views on the future for STEM education in NI, with particular regard to teacher education.

Methodology

An interpretivist research paradigm was adopted to address the central research questions, since, 'the social world can only be understood from the standpoint of the individuals who are part of the ongoing action being investigated…Social science is thus seen as a subjective rather than an objective undertaking, as a means of dealing with the direct experience of people in specific contexts' (Cohen et al., 2018:17). As this study was focused upon the perceptions held by individual representatives, along with their experiences of current practice and the views that they had formed about the future for STEM education in NI, an interpretivist paradigm was judged to be the most appropriate approach. Interviewing was subsequently selected as the primary data gathering tool within this study, as

Seidman (2013) and Peraklya and Russuvuori (2011) argue that the purpose of interviewing is to understand the experience that people have in life along with the meaning that they take out of that experience.

In order to capture representative voices, 'adult experts' (n=11) from industry, politics, schools and universities were interviewed in a one-to-one setting, thereby facilitating a triangulation of independent views. Initially, twenty adult experts were approached, chosen because the offices they held reflected their recognition in NI as experts in their respective fields. Those who agreed to participate (n=11) provided a representative sample and comprised: a senior representative from each of the two NI university colleges for initial teacher education (ITE); a principal author of the NI STEM Review of 2009; a founder and director of the NI Science Park, which supports local industry and entrepreneurs; the NI Chair of CAS (Computing At Schools); a Member of the NI Legislative Assembly (MLA) who was actively involved in NI education policy; and four teachers, one from each of four participating schools, along with one of the participating school principals. A sample of four Belfast primary schools were contacted, to equally represent experiences and views from both the 'controlled' and 'maintained' NI education sectors (being the two main school management types in NI), so that potential differences in experience could be identified between the two management types; rural school input would ideally have been included in order to examine possible variation of experience between rural and urban settings, but it would have been impracticable within the given funding.

Benson and Lunt (2011) point out that pupil voice is too often missing in research literature, when pupils may have significant insights to offer. A component part of this research was therefore to listen to what the pupils had to say about STEM education in terms of what they had experienced to date and what they would like to experience in the future. Following McDonald's (2016) identification of the junior secondary phase of education as critical to STEM engagement, this study targeted the transition between primary school and secondary school at the age of 11. Pupils (n=13) from Primary 7 classes (aged 10 and 11 years) in each of the four participating Belfast primary schools were interviewed within their school groups to remove any distraction or inhibition.

The decision was taken to employ a semi-structured interview format for all the interviews, because the questions are open-ended and consequently possess a number of advantages, as detailed by Cohen et al. (2018:513): the interviewer can pick up on responses to clarify meaning or to pursue a deeper understanding of an issue; the wording can be tailored to the different individuals; they also, 'encourage cooperation and help to establish rapport'.

In this study, the adult experts were interviewed individually, and the pupils from each school were interviewed as a focus group, so that the pupils were thus enabled to derive some peer comfort from each other's presence, while at the same time ensuring that each pupil's views were sought, and avoiding problems such as the non-participation or dominance by a few individuals that can arise in focus groups (Cohen et al., 2018).

The particular approach used within this study focused upon filming the semi-structured interviews to create an 'Academic Documentary' – simply, a filmed version of the findings and the discussion of emerging issues. This idea stemmed from a five-minute filmed summary of the lead author presenting findings and discussing issues arising from a previous research project, which was then posted on Facebook and received over 1500 views in one week. Such an approach offered two advantages. First, it could enhance the methodology, because it was anticipated that the approach of an Academic Documentary would enable anyone watching to receive not only a report of what was said, but critically also the expressions, intonations, and nuances with which the words were spoken. As noted by Cohen et al. (2018:633) 'Video material catches the non-verbal detail that audio recordings cannot'.

It was hoped that this non-verbal feature of film recording would support Glaser's post-positivist approach, whereby, with reference to data interpretation, awareness would be maintained of the limitations of certainty (Glaser, 1999). It was reasonably anticipated that the relative dynamics of group interviews described by Cohen et al. (2018) would apply to the use of film recording to at least the same degree as the more established media of audio recording and transcription.

Secondly, it was considered that compilation of film-recorded interviews would support dissemination, provided appropriate ethical provisions were secured. Ethical approval was granted by the Research and Ethics Committee of the lead author's University College. All participants were advised of the intention to compile the recorded interviews to create the Academic Documentary, and that it may be distributed on an academic network, hosted by the RSA. Data was held securely, and voluntary and informed consent was obtained for all participants, including the right to withdraw without reason, with written parental permission secured for pupil participation. The interviewer was careful to provide adequate time for the interviewees to speak and to avoid leading questions. Participating school principals, teachers and pupils were assured that only the pupils' first names would be used at any time, and advised that uniforms should not be worn, by which the school could be identified. Participating experts were given the option of being identified by title captions and credits.

The RSA funding secured the services of a professional freelance camera operator and editor of established and experienced industry (BBC and Ulster Television) standard. Once filming was complete, the data from the video footage were then open coded and analysed by constant comparison (Newby, 2010), maintaining 'subject with subject and data with emerging concepts' (Newby, 2010:492). Specifically, relevant comments from each interviewee were systematically logged and then given a code to identify the nature of each of their comments, so that by comparing all of the relevant comments across all of the interviewees, the data could be grouped into emerging themes. Over three hours of filmed interview data were ultimately grouped into four overarching themes and then edited to create linked sequences of excerpts for each theme. In total, there were 64 excerpts.

Findings and discussion

Within each of the four themes, the following sections summarise the key points made by the adult experts and pupils, and address the issues deriving from them, with regard to the research questions.

Pupils' experience of STEM education in NI

Pupils were asked what they understood by the term, 'STEM', and what STEM activities they might have completed in school. Further questions then focused upon whether they enjoyed any particular aspects of their STEM experiences and if they thought STEM would be important to their futures. Across the four schools, pupils spoke enthusiastically of various experiences and perceptions of STEM, but with significant differences between the individual school experiences. A range of STEM activities was identified, including: testing materials; building merry-go-rounds and windmills; solving problems to ensure their kites would fly; programming using 'Scratch'; a lighthouses project in Primary 2 (aged 5 and 6 years); a Science Week in Primary 6 (aged 9 and 10 years); investigating the working of boats with propellers; using science kits, such as 'Connect' and 'Lego'; visits from STEM Ambassadors from Bombardier Aircraft Company; an 'Inspiration Day' in Primary 6, where people came in to talk about their various jobs; and, a visitor from 'Medics in Primary School' to talk to the pupils about how the human body works.

It is apparent from the pupils' comments that some of them had experienced activities that required them to plan and design systems that resulted in practical outcomes. In their accounts, no significant

differences were discernible between girls and boys nor between schools, in terms of the levels of interest and enjoyment that they displayed.

> ...we get to observe and do it with our hands – it's physical and practical'
>
> (boy 1, school A).

> We've been observing and we've been discovering, and we've been planning designs, and we learn from our mistakes
>
> (girl 2, school A).

They identified these experiences as having relevance in their everyday worlds:

> It [STEM] seeps in to every job that people are doing
>
> (boy 1, school B).

> I would like to be an architect - they design buildings and plan so the engineers can build them
>
> (girl 1, school B).

> I want to be, like, an engineer – like a car engineer – they fix cars and they can make them better
>
> (boy 2, school B).

Pupils also displayed some understanding of how the four subject disciplines making up STEM were interconnected:

> Science makes up everything, Technology's going to be the future, Engineering's going to build the technology to be the future, and Maths. is going to solve it
>
> (boy 1, school C).

However, interconnection between the four STEM disciplines was not always fully grasped:

> Science is quite an obvious one, specifically if you want to be a Biological Oceanographer. Technology is good for recording what you've learned about the ocean, and then that also ties in with Mathematics, because you'd need a good sense of Mathematics to do a lot of Technology things, and then Engineering – you need to do – a lot of – am…
>
> (boy 1, school D).

An underlying enthusiasm with which the pupils engaged with STEM experiences was clear throughout. It was evident from all of the pupils, teachers and school principal, however, that the pupils' experience of STEM education was piecemeal, with very limited input from industry. No consistent curricular experience was apparent. The school principal and two of the teachers made the point that primary schools want to improve the STEM experience for the children, but are limited by resources. They additionally highlighted that the STEM experience for pupils largely depends upon whether their teacher has STEM-related qualifications. Notably, in spite of the challenges arising from resource and expertise limitations, pupils cited many examples of inquiry-based learning. However, in contrast to the pupils' enthusiasms and ambitions, teachers from all of the primary schools expressed disillusionment with an absence of political leadership or vision for the STEM experience of their pupils.

As the pupil participants were at the end of the junior phase of their school education, it was highlighted by the school principal and two of the teachers that political direction has focused upon only numeracy and literacy with regard to the critical primary/post-primary school transition at age

11. As noted by one of the teachers, 'there hasn't been a mention of STEM'. It was pointed out by the school principal that a successful working model for good practice with respect to transition planning already existed, but it had not been applied to the STEM subjects. Again, there was evident frustration from the school principal and all of the teachers about a lack of political engagement.

Despite McDonald (2016) identifying precisely this junior secondary phase of education as the critical stage to impact upon pupil engagement in STEM education, evidence from the adult experts and the pupils about their STEM education experience indicates a systemic failure to provide an effective delivery. Kearney (2016) reported that most European countries have prioritised STEM to receive political and financial support, to include improvement of initial and/or in-service STEM teacher education, but these findings indicate an absence of such prioritisation in NI. Evidence from the pupils' experience in this study points to no improvement in STEM education in NI since Perry and Irwin's report of 2015. Evidence from the adult experts indicates that a failure of political intervention to support pupils' experience of STEM education has resulted in the adult experts becoming disillusioned regarding the future for STEM education in NI. With reference to teacher education, these findings suggest that opportunities to acquire a STEM qualification would significantly impact upon the quality of educational provision that a teacher could offer to pupils, even though such opportunities within current ITE and CPD provision are limited.

Inquiry-Based Learning (IBL)

There was unanimous agreement from all of the adult experts that STEM should be compulsory, cross-curricular and inquiry-based. As articulated by one of the teachers, 'This is the future, this is where we are going; STEM should be filtering into every area of the curriculum'. It was evident from the responses of adult experts that IBL presented a 'battleground', an area of conflict between bigger issues. The Science Park director asserted that the current system of education in NI is a 'memory test', which is not preparing children well for the new world of work, whenever, 'a lot of that memory requirement is automated [digitally accessible]'. He was concerned that in the age of automation, if children were not taught how to think and develop more 'translational' skills, such as the creativity, collaboration, teamwork and resilience encouraged within an IBL experience, then these children ran the risk of becoming obsolete in the new age of work. He believed that the current model of education in NI was stuck within a 'Victorian' mind-set, which was designed to produce young people to work in factories and jobs that no longer exist, and that the NI model of education must urgently evolve to embrace approaches such as IBL. The MLA argued that much of education still appeared to be sedentary, that NI needed a balance between the academic and the practical. He believed that many people who were talented in STEM-related skills had been deemed to have failed within the more traditionally recognised academic measures of success. The ITE representatives both focused on a need for the NI curriculum to embrace different learning models, with one of them concluding that in NI society, 'the premium still rests with an academic education and the professions...we need to raise the bar for the place of STEM in our education system.'

Such arguments resonate with reported international developments. The criticism of the NI Curriculum as a 'memory test' stuck within a 'Victorian' mind-set is a clear reference to the high-stakes testing identified by Au (2007), which is now being abandoned by many countries around the world (Freeman et al., 2015), and has been concluded to compromise teaching standards and the quality of learning (ibid). The 'translational' skills such as creativity, collaboration, teamwork and resilience that were highly valued by all of the adult experts, are exactly the skills that are receiving national investment in south-east Asia (ibid), Europe (Kearney, 2016) and Canada (Su et al. 2017). With respect to IBL, there has again clearly been no improvement in NI since Perry and Irwin's report in 2015. All of the adult experts in this study expressed not only high levels of frustration over the current provision of STEM education for NI pupils, but conviction that future provision demands radical review. Such change would obviously require a political commitment that has not been in evidence since the initial

Report of the STEM Review in 2009. The argument for political investment in an IBL approach to radically change STEM provision therefore derives from both extensive international example and all of the adult experts in this study, representing industry, politics, schools and universities. The implication for teacher education, whether ITE or CPD, is that IBL should be considered a priority.

Continuous Professional Development (CPD) and Initial Teacher education (ITE)

There was recognition in the Report of the STEM Review for NI (2009) that training was needed for primary school teachers to enable them to introduce the new 'World Around Us' curriculum, which included STEM, but all of the teachers and school principal interviewed in this study reported that there was a complete absence of any CPD training for serving and experienced teachers and insufficient training for student teachers. As noted by one of the teachers, 'young teachers coming in to the profession are not fully aware of the importance of STEM*'.* It was emphasised by the CAS Chair that the future of STEM education in primary schools hinged upon having properly trained teachers. It was also unanimously agreed among the adult experts that more investment was needed in both ITE and in-service CPD to support the delivery of STEM education, but one of the ITE representatives made clear that dedicated STEM modules would be very difficult to deliver within teacher education, due to the extra funding that would be needed, and additionally due to the consequences that would ensue for the courses that are currently delivered. If elements of STEM education were to be introduced into the preparation of student teachers, then something from the existing programme of preparation would have to be sacrificed. Here, again, was evidence of need for significant change, but again, all of the adult experts agreed that the political implementation needed for such a change had not been forthcoming.

Despite the emphasis upon ITE and CPD within the Perry and Irwin report in 2015, there was no evidence in this study of any improvement in NI provision since then, with agreement from all of the adult experts that significant investment and planning for teacher education were needed for the future of STEM education. This failure of progress is in contrast to the initiatives across Europe reported by Kearney in 2016 to address shortages of STEM teachers in schools and improve initial and in-service STEM teacher education. In order to inspire students to pursue STEM related careers, MacDonald (2016) concluded that high standards of teaching are essential, which would clearly require investment in ITE and CPD for STEM teacher education. However, although such investment may be an essential component in growing a STEM economy, it is only one component, as Kearney's 2016 European study also pointed out that high levels of underachievement still persisted in STEM subjects, together with a lack of uptake in STEM related careers.

The role of business

Within the original vision of the NI STEM Review (2009), there was recognition of the value of STEM within society and to the economy. In this study, the MLA stressed that businesses can show pupils the reasons, 'why they are learning what they are learning' along with the practical applications, and 'if we want to keep the businesses we have and attract new business in to Northern Ireland, we need to provide the skills locally, and that will also be good for the prospects of the pupils'. The teachers and school principal pointed out that collaboration and industry partnerships are needed, but that engagement with business is very occasional and dependent upon goodwill and personal contacts. It was made clear that there was an absence of co-ordination or commitment, which the adult experts believed would have to come from political leadership. However, there was a warning from the CAS Chair that business engagement directly with STEM education should be cautioned, that the business sector may have expertise in subject content, but that without the pedagogical knowledge and language needed for effective education, there could be difficulties for successful integration of business or industry with schools. The CAS chair proposed that a three-way partnership should be investigated, whereby student teachers (under the supervision of their university tutors) would take the role of the 'interpreter' between business and schools, to ensure effective communication, and

thereby support an effective partnership. Such an approach would allow businesses, schools and universities to each 'play to their strengths' in focusing only upon their respective areas of expertise, with a student teacher having the opportunity within a university course to research businesses and develop appropriate resources.

The apparent inertia of NI government to progress a role for business within STEM education is consistent with the findings of Freeman et al. (2015), in their conclusion that although South-East Asian STEM policies were proactive, Western European STEM policies were typically reactive to workforce needs. Furthermore, Freeman et al. emphasised that Western European countries have pursued these policies despite clear evidence that successful economies require high levels of STEM education. It is notable within the findings of this study, that not only has there been no perceived progress in the role of business within STEM education since Perry and Irwin's report of 2015, but since business was not mentioned in that report, there has been no reported progress for the role of business since 2011. However, as identified by the CAS Chair, a successful role for business might depend upon a three-way partnership between business, university ITE students, and schools. Such a proposal reflects the interdependence that was propounded in the NI 'Success through STEM' Strategy (2011) between business, ITE/CPD, and the pupils' STEM education experience, ideally prioritising inquiry-based learning and moving away from high-stakes testing. The interdependence of these components is also reflected in Kearney's European study (2016) and in the four overarching themes of this study.

Conclusion

Evidence has been analysed from perceptions expressed by a sample of 11-year old school pupils (n=13) in Northern Ireland (NI), together with adult experts (n=11) representing schools, universities, politics and business. The evidence indicates a systemic failure in NI to provide an effective STEM (Science, Technology, Engineering and Mathematics) education. Findings reveal high levels of pupil enthusiasm for STEM education, but piecemeal experiences resulting from a lack of resources, very little business input, and a limited number of teachers possessing STEM qualifications. Despite political investment in STEM education around the world, and international recognition of the importance of STEM education for a successful modern economy, this study found no evidence of any improvement in NI STEM education provision since the last NI government report in 2015. All of the adult experts in this study expressed high levels of frustration over the current provision of STEM education for NI pupils, and a conviction that future provision demands political commitment to a radical review of curriculum and teacher education, which moves away from high-stakes testing as defined by Au (2007) and embraces inquiry-based learning (IBL). A three-way partnership was proposed between business, teacher education (pre-service and in-service), and the pupils' STEM education experience (focusing upon IBL), reflecting the interdependence and central importance of these components that were highlighted in the NI 'Success through STEM' Strategy (2011). Evidence additionally indicated that pre-service and in-service teacher education should prioritise STEM qualifications and IBL techniques in order to improve the STEM education experiences of pupils.

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