Monopolising the STEM agenda in second-level schools: exploring power relations and subject subcultures

Oliver McGarr1 · Raymond Lynch1

Accepted: 15 September 2015/Published online: 22 September 2015 © Springer Science+Business Media Dordrecht 2015

Abstract The ubiquitous and often pervasive expansion of the science, technology, engineering and mathematics (STEM) agenda across global education systems has largely gone uncontested. Strategic efforts to build on perceived natural subject synergies across the separate STEM disciplines are promoted as central to supporting the growth of economies through the development of human capital and by ensuring the supply of suitably trained individuals for vocational roles in these areas. However, these efforts are predicated on the assumption that such perceived natural subject synergies can easily support pedagogical complimentary and in so doing, often fail to acknowledge the social histories of the subjects involved. In this paper the authors examine the divergence in treatment of STEM subjects within the Irish second-level context through the lenses of subject hierarchies and social class. The cultural capital associated with studying each of the respective STEM subjects in school is considered and the objectives of the STEM agenda are problematised.

Keywords STEM education · Technology education · Subject subcultures · Cultural capital

Introduction

Increased interest in science, technology, engineering and mathematics (STEM) education, largely driven by concerns about economic competitiveness, assumes ‘natural’ synergies within the disciplines of STEM. While there are considerable overlaps in relation to their content and complimentary elements to their focus, attempts to present STEM education as a unified entity plays down the significant differences in the status, subcultures and
historical origins of these subjects within the Irish second-level education system. Through an examination of the development of STEM education in the Irish context, this paper aims to explore the extent to which the new STEM agenda is a genuine attempt to increase participation in STEM subjects, and subsequent careers amongst students studying all of the STEM disciplines, or whether traditional subject hierarchies and class-based divisions highlight the true intention of the STEM agenda—namely another mechanism through which ‘privileged groups adjust their strategy in the light of changing circumstances’ (Whelan and Hannan 1999, p. 286). To explore this issue this paper firstly outlines the increasing international interest in STEM education before then moving on to examine the provision of STEM subjects in the Irish second-level educational system. Following this analysis, the paper then attempts to examine some of the disparities in provision of the various STEM subjects through the lenses of subject hierarchies and social class.

The STEM agenda: an international perspective

Concerns about economic competitiveness have, for several decades, focused attention on the uptake and quality of graduates in STEM. The recent economic crisis has, according to Williams (2011, p. 31), spurred on this emphasis with the aim of better equipping, ‘a workforce for dealing with the contemporary nature of business and industry, and encourage more school leavers to seek further training and employment in areas of engineering and science’. Within this technicist-vocational paradigm the ‘crisis’ discourse stresses the need for technologically skilled graduates to fuel economic growth and enable the state to ‘stay ahead of the curve’ by harnessing the potential of new and emerging technologies. This concern has not been limited to higher education. Second-level schooling is also subject to this doctrine and has witnessed policy changes encouraging and incentivising the uptake of mathematics and science subjects. In effect schools have, as Lynch (2012) argues, become subservient to global capitalism.

Pitt (2009) however reminds us that STEM as an educational concept is problematic since there is limited consensus as to what it is, how it can be taught and how it can be assessed. Central to this debate is the extent to which STEM is the study of any of the related areas (science, engineering, technology and mathematics) or whether it involves the linking of different aspects of STEM in order for it to be considered STEM education. Yet despite these concerns the STEM acronym has quickly gained recognition within the education field as a ‘catch all’ term encompassing all technological and scientific activities within the educational system.

At one level the integration of these subjects as a logical coherent group reverses the traditional fragmentation of these areas on the curriculum to better reflect the inter-relatedness of these subjects in industry. However, such grouping does not recognise the existing subject hierarchies and inequalities in provision and participation amongst STEM. As Sanders (2009, p. 21) cautions, ‘for a century, STEM education have established and steadfastly defended their sovereign territories. It will take a lot more than a four-letter word to bring them together’. In an examination of the conceptualisation of what STEM entails, Breiner et al. (2012) found that such conceptions vary significantly across stakeholders. They also found that while there is an acceptance amongst stakeholders that a focus on STEM is important in order to support the global competitiveness of the United States, there is “no common operational definition or conceptualisation of STEM”. As a consequence of this ambiguity, Breiner et al. (2012, 9) conclude that there is a challenge in
“changing the paradigm from compartmentalising academic disciplines to the integration of these disciplines as advocated by many through the STEM movement”. This challenge to the integration of the STEM disciplines within education systems is reflected internationally. While research (see Berker and Park 2011) has demonstrated potential educational benefits to integrative approaches to STEM education for students’ holistic development, as demonstrated by Wang et al. (2011, p. 1), differing and often contradictory beliefs and perceptions amongst educators about STEM has led to divergent classroom practices that militate against the successful integration of disciplines. Despite arguments by Clark and Ernst (2006, p. 24) that within STEM “technology education has the means of becoming the catalyst for integrated curricula”, technology education continues to be overlooked or excluded from many STEM initiatives (Kuenzi et al. 2006). As highlighted by Brown et al. (2011, 5) the appeal of the rising STEM agenda, which promises to elevate the status and profile of all involved, has encouraged many in the field of Technology and Engineering education to “either integrate more math and science into their courses or highlight the ways in which those concepts were already being integrated”. However, there is little if any gravity placed on a reciprocal requirement for Mathematics or Science to integrate more technology or engineering into their curricula. The successful integration of STEM is “hindered by compartmentalised education” (Clark and Ernst 2006, p. 26) and these territorial battles over content and subject matter. Such battles and struggles for subject recognition against the backdrop of a rising STEM agenda in education, are also reflected at a national level.

STEM education in second-level schools: the Irish context

Goodson (1983) highlights the importance of examining the social histories of school subjects when exploring curriculum development. From an Irish perspective the history and status of the subjects STEM varies considerably within the second-level educational setting. The study of Science and Mathematics has its origins within the classical humanist tradition of the mid-nineteenth century secondary school. As highlighted by Carr (1998, p. 327), classical humanism is concerned with preparing ‘an intellectual elite for the task of preserving their society’s cultural heritage’. This is often concealed and legitimised by placing emphasis on ‘the academic pursuit of knowledge’ perceived as relevant to society (Gleeson 2010, 34). The ‘academic’ relevance of both Mathematics and Science as second level subjects has been reinforced by the Irish matriculation system. Despite Irish as a subject being the only compulsory subject at senior cycle in Ireland, Mathematics is often taken by more students each year due to third-level universities and colleges requiring Mathematics at some level for entry to the majority of their programmes (Hyland 2011). As highlighted by Young (1975) the selection of second-level subjects is directly linked to University programmes and areas of research. As a consequence, Science as a subject has also historically enjoyed high status in schools. Unlike the second-level subjects of Engineering and Technology, Science is a prerequisite for entry onto many third-level programmes.

Bernstein (2000, p. 5) argues that the development of subjects involves power relation that ‘create boundaries, legitimise boundaries, reproduce boundaries’ and subjects with clearer boundaries enjoy higher status in the curriculum. In Ireland, both Science and Mathematics as second level subjects have had time to create and legitimise clear boundaries over the long history of the subjects’ development. The second-level subjects of
Engineering and Technology have not had the same timeframe to create such clear boundaries. For example Engineering was not introduced as a senior cycle subject in Ireland until 1969 and was first examined in 1971 (Trant et al. 1999), while Technology as a senior cycle subject was not introduced until 2007. Therefore, these subjects are in many ways still at the stage of creating boundaries (and arguably within a more ‘crowded’ curriculum). During this process of boundary formation there is a requirement to remain relatively porous so that as much content as possible can be incorporated within these boundaries. Science underwent a similar process in Ireland where, prior to 1969, students could study Physics and General Science at senior cycle as part of the science curriculum, but these two subjects have since been replaced with Physics, Chemistry, Biology and Agricultural Science as senior cycle subject options (CSO2000). This further stratification of the science curriculum into the four mentioned senior cycle subjects could arguably be recognised as an attempt to clarify and reinforce boundaries since it was a deliberate move away from a ‘general’ view of science towards a more specifically framed and narrowly defined curriculum.

The subjects of Engineering and Technology share a very different history to those of Mathematics and Science. They emerged as part of the separate vocational school system after the 1930 Vocational Educational Act where vocational education was formalised through the establishment of local vocational schools to provide vocational training and pre-employment preparation (Coolahan 1981). The establishment of these schools, as separate from the existing secondary schools, created a bi-partite system where the status of the traditional secondary schools was considerably higher than their vocational counterparts. As a consequence, vocational and technical education in Ireland has traditionally held a lesser position and lower social status within the second level education system (Dowling 1968). Whelan and Hannan (1999, p. 298) describe the socially divided nature of this system of provision noting that, ‘by the mid-1960s the majority of urban and rural communities were effectively provided for by this bipolar system. Middle-class children went to the local fee-paying schools or to boarding schools; while the local vocational school catered for children from local working class or small farmer families’. Prior to 1966 students of vocational schools in Ireland were only eligible to sit the Day Vocational Certificate Examination which was completed after the end of 2 years of study and did not permit students to go on to third-level education (Coolahan 1981). While changes to the provision of second-level education in the late 1960s led to the erosion of such differences between the vocational and secondary school system, the traditional vocational subjects, which now found their way into the secondary school system, carried with them their low status. However, this under-valuing of vocational education is not unique to Ireland. Clarke (2012), for example, notes that although vocational education systems fulfilled a critical role, the sector was consistently undervalued. Similarly, in describing the UK system, Paechter (1993, p. 350) notes that technology-based subjects in UK schools were seen as, ‘a group of subjects which had a history of being of low status, non-academic, and mainly aimed at working-class and ‘less able’ students’.

Lynch (2012, p. 9) notes that since the 1960s in Ireland, ‘educating students for employment, especially in science, engineering and technology became the primary focus of government policy’. The overtly classical-humanist orientation of Irish education, deeply embedded in what O’Sullivan (2006, p. 93) terms a ‘theocratic’ approach, was deemed to be unsustainable economically and replaced with a market-led system. Despite the inclusion of Technology and Engineering within STEM and their historical origins in vocational education, the extent to which they are seen as important within the second-level system is questionable. Recent concerns regarding the uptake of STEM subjects in
third-level education has focused exclusively on the uptake of Science and Mathematics in second-level schools with no reference to the technological subjects of Engineering or Technology. For example, in recent years there have been significant changes in mathematics at second-level level. The *Report on the Project Maths implementation group*, for example, noted that;

Ireland’s future economic growth and competitiveness will increasingly depend on the extent to which it can support high value knowledge based industries. Mathematics is essential for disciplines such as science, technology, engineering and finance… In a globalised competitive economy it is important that Ireland moves beyond being “average” at mathematics towards the promotion of advanced levels of skills, creativity and innovation. (DES 2010, p. 4).

Engineers Ireland, the professional body representing the Engineering profession in Ireland, also produced a report, *Report of Taskforce on Education of Mathematics and Science at Second Level by Engineers Ireland* (Engineers Ireland 2010), examining the uptake of science and mathematics for the engineering.

From a science perspective similar reports have been developed. For example, in the *Report of the task force on physical sciences* (2001) it outlines that, ‘Ireland’s economic future depends critically on the supply of an increasing number of people qualified in science and engineering. But at the very time this demand is increasing, there has been a sharp fall-off in interest in the sciences throughout our education system’.

While concerns in relation to science and mathematics are clearly evident in current literature, there does not appear to be a comparable level of interest in the technology-related subjects at second-level level as evidenced by the lack of similar reports and taskforces related to the uptake of Technology and Engineering in second-level schools. It is also not a requirement to have studied a technology-related subject in second-level school to gain access to a third-level degree programme in Engineering or Technology but for the vast majority of degrees a level of Mathematics is essential; one is also frequently required to show that a science subject has been completed. Again, this issue does not appear to be unique to Ireland as Williams (2011, p. 29) notes:

Proposals for the STEM agenda most often overlook Technology education as a significant component. Relevant documents are replete with references to improving student achievement in Mathematics and Science, improving the quality of Mathematics and Science teachers; and even technology educators promote goals such as increasing interest, improving competence and demonstrating the usefulness of mathematics and science…

Towards and understanding of unequal status

In exploring the difference in status amongst the STEM subjects there are a number of possible explanations. This section will attempt to examine the issue from three different perspectives, namely content, subject hierarchies and social/cultural capital.

Subjects as bodies of content knowledge: the content perspective

It could be argued that the absence of Technology and Engineering from the broader STEM agenda in second-level schools relates to the largely under-resourced and out of
date subjects currently offered. The subjects of Engineering, Technology and Design and Communication Graphics (DCG) have an infrequent review cycle despite the nature of their content. For example the Leaving Certificate syllabus of Engineering has not been updated in over two decades while the Technology and DCG subjects were introduced in 2007 with no syllabus revisions in the interim. The historical origins of these subjects has maintained a focus on the development of craft and practical skills with less of an emphasis on higher order skills related to the application of mathematical and scientific concepts within an Engineering and Technology context. Divorcing the practical ‘design and make’ skills from the more theoretical and analytical capabilities, evident in the Science and Mathematics subjects, may reflect assumptions about the types of students served by these subjects, their capabilities and their career prospects. While the Science and Mathematics subjects have attempted in recent years to emphasise the practical applications of the theoretical knowledge (that have traditionally defined their subjects) there has not been as similar connection made with the theoretical underpinnings behind the more practically orientated Technology-related subjects. If STEM education is more than the convenient clustering of subjects then interaction of these subjects of STEM is crucial. Felix and Harris (2010, p. 30) for example, note that:

The use of engineering and technological design principles has been suggested as a way to increase the active engagement of students and improve students’ learning and transfer in science and maths.

With such out-of-date subjects it is perhaps understandable that they have been largely side-lined from the STEM agenda as it would be counterproductive to include subjects that do not represent the nature of careers in STEM. However, explaining the marginalisation of Technology and Engineering on the basis of their content, while relevant, fails to recognise deeper divisions that exist amongst the subjects provided on the second-level curriculum. The following section explores these divisions.

Subjects as competing social constructs: a subject hierarchies perspective

Bernstein’s (1975, 1990) classification of subjects from a sociological lens provides a useful way of framing these divisions. In attempting to make sense of the way knowledge is organised in schools, Bernstein (1975) identifies two dimensions to this organisation. These relate to the classification of the subjects and their framing. Classification refers to the porosity of a subject. If the content of the subjects is clearly defined and does not ‘share’ content with other subjects, Bernstein argues, that this is a highly classified subject. The level of classification of the subject signifies the power and status of the subject as highly classified subjects have strong rules determining what is part of the subject and what is not.

Framing refers to the level of control over what is to be learned, how the learning takes place and the order of the process. This level of framing, or control, determines the level of flexibility of the subject.

Viewing school-based subjects from these two dimensions four potential categories exist (See Fig. 1). Bernstein refers to these as four curriculum codes. Strongly classified and strongly framed subjects reside within, what he calls, the collection code whereas weakly classified and framed subjects reside within the integration code.

When viewed through the lens of curriculum codes significant differences emerge across the range of STEM subjects in Ireland. The subjects of Science and Mathematics reside within the collection code. These subjects are strongly classified. For example,
Mathematics has a long-established body of knowledge. Similarly Science subjects, whether that is Biology, Physics or Chemistry, have defined subject boundaries. While other more applied subjects may draw on related subject knowledge, the subjects themselves have maintained clear divisions between other subjects that draw on scientific content.

Both subjects are also highly framed. In Mathematics for example, the subject has been typified for decades as one that is teacher-centred and largely employing individual student tasks. The content is also incremental in its development with key topics to be addressed often in a defined order. Science is also highly framed. At a Junior Level the subject is categorised in three areas (Biology, Physics and Chemistry) and the pedagogical approaches are centred around experimental work that is tightly framed. Tormey (2011) notes that the question of classification is a question of ‘boundary maintenance’ and it could be argued that the subjects of Mathematics and Science have maintained their power (classification) and control (framing) despite the introduction of a range of subjects that draw from the content that they claim ‘ownership’ of.

The technology-related subjects reside at the opposite quadrant of Bernstein’s classification framework. These subjects tend to draw on the subject knowledge of a range of areas and are therefore not tightly classified. Technology, for example, draws on aspects of ICT, Chemistry, Physics, Mathematics, Art and Design as well as the Social Sciences. In addition, there is no universally accepted order by which these topics/areas are delivered or taught and therefore the subject could be defined as loosely framed. Considering these differences one can see that the STEM subjects differ in terms of the power and control they enjoy within the curriculum.

The hierarchal ordering of subjects often reflect the social stratification and social and educational capital available to those that choose them, for example Van de Werfhorst et al. (2003, p. 45) note that working-class children, ‘are likely to select technical subjects because of the proximity to the parents’ manual job experiences and because these fields lead to secure labour market prospects’. Subjects therefore do not simply reflect content...
areas but can be seen as an organising social framework. This final perspective is addressed in the following section.

**Subjects as cultural capital: a socio-cultural reproduction perspective**

Subjects have unique subcultures that evolve over time and as a result of historical beginnings. Goodson and Mangan (1995, p. 615) note that these subcultures consist of a, ‘general set of institutionalised practices and expectations which has grown up around a particular school subject, and which shapes the definition of that subject as both a distinct area of study and as a social construct’.

Viewing subjects as social constructs reflects their social status which as suggested by DiMaggio (1982) is often predicated on the dominant social position of their students. Within his cultural reproduction model, Bourdieu and Passeron (1990) argues that schools reward students on the basis of their cultural capital. Capital theory proposes that cultural capital is a process of transmitting social status so that it can be converted into both social and economic capital at a later stage (Georg 2004). As Highlighted by Georg (2004, 334) ‘Institutionalised cultural capital is a result of educational achievements in educational institutions with the power to define what is ‘important’ and ‘unimportant’ knowledge.’ Both the historical development of the respective STEM subjects and the current matriculation system have emphasised the importance of Scientific and Mathematical knowledge and consequently it also increases the cultural capital associated with pursuing these subjects in school. While cultural capital is socially constructed (Robbins 2005), within schools and the wider education system, it is often treated as the ‘‘natural’ aptitude of pupils’ (Georg 2004, p. 334). Therefore, the pursuit and performance of students in Technology and Engineering subjects versus Mathematics and Science subjects is viewed as reflective of student ability in, or aptitude for, these subjects. This is not unique to Ireland as it has become ubiquitous in international educational discourse. For example, the Programme for International Student Assessment (PISA), a worldwide study conducted by the Organisation for Economic Co-operation and Development (OECD), compares 15-year-old students’ performance in Mathematics, Science and Reading (OECD 2009). In comparing the school achievement of pupils in public versus private schools in America again, Corten and Dronkers (2006) compared the Mathematics, Science and Reading scores of students. This further crystallises the cultural capital associated with the subjects of Mathematics and Science. In this way the rejection of the Technology and Engineering subjects in favour of an emphasis on Mathematical and Scientific knowledge as part of the STEM agenda at second-level in Ireland is reflective of a pursuit to promote the social status for STEM and retain cultural capital and thus preserving the advantage of the ruling classes. This was clearly evident in the 2012 initiative to introduce 25 ‘bonus points’ for students who receive a grade D or greater in higher level Mathematics in the Irish Leaving Certificate examination (IUA 2012). The net effect of this initiative is that while a student will receive 100 points for achieving an A1 grade in all other higher-level subject examinations in Ireland, an equivalent grade in Mathematics will see a student earn 125 points. Therefore, Mathematics as a subject is ‘worth’ more to students under the current matriculation system, clearly adding to the socially constructed cultural capital associated with the subject. In contrast, Technology and Engineering as second-level subjects have limited cultural capital (Robbins 2005) to offer and are hence awarded less value.
Towards a more complex understanding of STEM: an issue of class and privilege?

Changes to any system can often unearth the complex architecture that underpins its present form. Having analysed the STEM subjects through the lens of Bernstein’s curriculum codes and Bourdieu’s cultural capital, deeper divisions within the cluster of STEM subjects are evident. School subjects are not ‘natural’ clusters of subject knowledge bound into coherent entities. Instead, their content and arrangement reflect the social and cultural norms prevalent at the time of their establishment. As such they are temporal phenomena containing the attitudes and ideological beliefs of the time. Looking at the case of Ireland, technology-based subjects therefore represent and symbolise as much the roles and status of technological careers at the time of their introduction as they do about their subject content. Consequently, the refinement and maintenance of subjects reflects the power relations and on-going tensions between these competing positions which often reflect deeper divisions of class and privilege. Tormey (2011, p. 54), for example, highlights that we need to move from essentialist understandings of subjects to ‘to socially and chronologically specific accounts of subjects’. Therefore from a social class perspective subjects are not bodies of knowledge but rather organisational frameworks that maintain class divisions within schools. These divisions privilege or discriminate particular social groups through the opening or foreclosing of opportunities. For example, speaking about the congruence between the Irish educational and occupational system, Whelan and Hannan (1999, 303) note, ‘the manner in which the connection between the Irish educational and occupational system has developed with a high degree of level congruence has involved the maintenance of a series of barriers to working-class achievement in a system dominated by the academic needs of college bound middle-class students’.

In essence, while they are presented as a coherent entity, the STEM subjects play very different roles in Irish post-primary schools. The vocationally-focused subjects of Technology and Engineering have traditionally served the needs of lower socio-economic groups. At one level this has been critical for enabling traditionally marginalised students engage in subjects that could improve their transition into employment, while on the other hand, they could equally be criticised as subjects that socialise young working-class people into subordinate economic roles (Banks et al. 2009).

In addressing these inequalities within the Irish schooling system and exploring a way forward several questions arise. If, as it appears from this analysis, Science and Mathematics are monopolising the STEM agenda, what is the future role of the traditional vocational subjects of Technology and Engineering? The vocational focus of these subjects, which in the past concentrated on preparing students for direct employment in cognate industries, has been eroded with the massification of third-level education. For example, Ireland has one the highest school completion rates in the OECD with 93 % of students completing upper secondary programmes (OECD 2014). Furthermore, the ‘higher education attainment rate for 30–34 year olds, at 52.6 %, is among the highest in the EU’ and the average third level participation rate for 18–20 year olds was 51 % (HEA 2014). In this context, the vocational relevance of the subjects are being replaced by a reconceptualised focus to ensure their continued relevance. They now serve as one of the many subjects available for students who wish to accrue ‘points’ for entry into third level education. However, if these subjects are to align with the more ‘higher status’ subjects of Science and Mathematics will they continue to serve the needs of the cohort of students they currently serve? Commenting on curriculum change in the area of technology in the
UK, Paechter (1993, 359) raised concerns about the decline in the relevance and suitability of the reconceptualised subjects for the original student cohort they had served. Suggesting that such changes can leave, ‘lower ability and practically-minded students with even fewer havens within the overall school curriculum’. In the context of the STEM changes will a similar situation arise in the Irish context? Will the ‘gentrification’ of the subject remove the glass ceiling for many of the working-class children that opt for such subjects or is such a move, as LaPorte (2009) warns, ‘forgetting about the unique experiences that they [the subjects] could provide’?

Considering these issues raises broader questions about the role and purpose of compulsory state education. The neo-vocational agenda evident in Irish educational discourse forecloses alternatives to the ‘stemification’ agenda and also forecloses opportunities to question the subject-focused organisation of schools. Subject choice in Irish schools also undermines the role of a broad and balanced educational experience for all students. This is particularly so in a time of the ‘portfolio career’ and when scientific and technological literacy is essential for all citizens, not just those seeking careers in the STEM area. Therefore the broader role of schools in developing critically engaged and empowered citizens, as opposed to narrow vocational alignment, must be to the fore of curriculum reforms. In this context, many of the hegemonic assumptions within the current system need to be interrogated. Should we continue to organise the schooling experience around artificial subject boundaries that replicate social class divisions? It could be argued that the hegemonic illusion of subject choice is not a mechanism to empower students but rather a hidden mechanism to reaffirm class divisions and acclimatise some students to subordinate roles.

Conclusion

In responding to the emerging opportunities arising from the increasing interest in STEM the subjects of Science and Mathematics have an advantage due to their power and privilege within the educational system. For example, while innovations in the subjects of Mathematics and Science are attempting to make the subjects more applied (to incorporate engineering and technological aspects) there does not appear to be a similar attempt at curriculum level to link the practical elements of the Technology-related subjects to the more theoretical underpinnings. From the analysis in this paper it appears that the subjects of Science and Maths are populating the traditional space of Technology while preventing a similar encroachment from the historically vocationally-based technology subjects into their space. From this perspective the STEM agenda could be seen as an adjustment by the privileged to populate and monopolise the STEM arena which it historically shunned.

Viewed from the perspectives of subject hierarchies, subject subcultures and curriculum codes, there are significant differences in the STEM cluster of subjects. The comparatively low status of technology subjects on the second-level curriculum highlights the complex subject hierarchies at play in schools and reflects wider societal values around the long-established subjects of Mathematics and Science. Looking beyond Ireland to an international perspective further research needs to be done to explore the extent to which these divisions are evident in other countries. Williams (2011), for example, looking at the global development of STEM education, notes that in talking about STEM there seems to be little clear discussion about the similarities and differences between the various subjects. This suggests that similar divisions, as outlined in this paper, may exist in other countries.
References

Banks, J., Byrne, D., McCoy, S., & Smith, E. (2009). Engaging young people? Student experiences of the leaving certificate applied programme. ESRI Research Series No. 15. Technical Report. Economic and Social Research Institute, Dublin, Ireland.

Berker, K., & Park, K. (2011). Integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students’ learning: A meta-analysis. *Journal of STEM Education: Innovations and Research, 12*(5), 23–37.

Bernstein, B. (1975). *Class, codes and control: Towards a theory of educational transmission* (Vol. III). London: Routledge.

Bernstein, B. (1990). *The structuring of pedagogic discourse: Class codes and control* (Vol. IV). London: Routledge.

Bernstein, B. (2000). *Pedagogy, symbolic control and identity: Theory, research, critique*. Oxford: Rowman & Littlefield Publishers.

Bourdieu, P., & Passeron, J. C. (1990). *Reproduction in education, society and culture*. London-Beverley Hills: Sage.

Breiner, J., Harkness, S., Johnson, C., & Koehler, C. (2012). What is STEM? A discussion about conceptions of STEM in education and partnerships. *School Science and Mathematics, 112*(1), 3–11.

Brown, R., Brown, J., Reardon, K., & Merrill, C. (2011). Understanding STEM: Current perceptions. *Technology and Engineering Teacher, 70*(6), 5–9.

Carr, W. (1998). The curriculum in and for a democratic society. *Pedagogy, Culture and Society, 6*(3), 323–340.

Clark, A., & Ernst, J. (2006). A model for the integration of science, technology, engineering, and mathematics. *The Technology Teacher, 66*(4), 24–26.

Clarke, M. (2012). The response of the Roman Catholic Church to the introduction of vocational education in Ireland 1930–1942. *History of Education: Journal of the History of Education Society, 41*(4), 477–493.

CooLahN. J. (1981). *Irish education: Its history and structure*. Dublin: Institute of Public Administration. Corten, R., & Dronkers, J. (2006). School achievement of pupils from the lower strata in public, private government-dependent and private government-independent schools: A cross-national test of the Coleman–Hoffer Thesis. *Educational Research and Evaluation, 12*(2), 179–208.

CSO. (2000). *That was then, this is now. Change in Ireland, 1949–1999: A publication to mark the 50th anniversary of the Central Statistics Office*. Dublin: Central Statistics Office.

DES. (2010). *Report of the project maths implementation support group*. Department of Education and Skills, Republic of Ireland. http://www.education.ie/en/publications/policy-reports/report-of-the-project-maths-implementation-group.pdf

DiMaggio, P. (1982). Cultural capital and school success: The impact of status culture participation on the grades of US high school students. *American Sociological Review, 47*(2), 189–201.

Dowling, J. (1968). *The hedge schools of Ireland*. Cork: The Mercier Press.

Engineers Ireland. (2010). *Report of taskforce on education of mathematics and science at second level by engineers Ireland*. http://webpages.dcu.ie/~bradysa/CASTEL_reportUploads/20100211-Mathematics_and_Science_at_Second_Level.pdf

Felix, A., & Harris, J. (2010). A project-based, STEM-integrated alternative energy team challenge for teachers. *Technology Teacher, 69*(5), 29–34.

Georg, W. (2004). Cultural capital and social inequality in the life course. *European Sociological Review, 20*(4), 333–344.

Gleeson, J. (2010). *Curriculum in context: Partnership, power and praxis in Ireland*. Oxford: Peter Lang.

Goodson, I., (1983). Subjects for study: Aspects of a social history of curriculum. *Journal of Curriculum Studies, 15*(4), 391–408.

Goodson, I. F., & Mangan, J. F. (1995). Subject cultures and the introduction of classroom computers. *British Educational Research Journal, 21*(5), 613–629.

HEA. (2014). *Consultation paper: Towards the development of a new National plan for equity of access to higher education*. Dublin: Higher Education Authority. https://static.rasset.ie/documents/news/access-consultation-paper.pdf

Hyland, Á. (2011). *Entry to higher education in Ireland in the 21st century*. Dublin: National Council for Curriculum and Assessment.

IUA. (2012). *Reform of selection and entry to university in the context of national educational policy*. Dublin: Irish University Association.
Kuenzi, J., Matthews, C., & Mangan, B. (2006). *Science, technology, engineering, and mathematics (STEM) education issues and legislative options*. Congressional Research Report. Washington, DC: Congressional Research Service.

LaPorte, J. (2009). Passing the Baton at the intersection of acronymonium and heritage roads. *Journal of Technology Education, 21*(1), 2–9.

Lynch, K. (2012). Newmanagerialism as a political project: The Irish case. In K. Lynch, B. Grummell, & D. Devine (Eds.), *New managerialism in education: Commercialisation, carelessness and gender*. London: Palgrave McMillan.

O’Sullivan, D. (2006). *Culture, politics and Irish education since the 1950s*. Dublin: Institute of Public Administration.

OECD. (2009). *PISA 2009 assessment framework—Key competencies in reading, mathematics and science*. Paris: Organization for Economic Cooperation and Development.

OECD. (2014). *Education at a Glance 2014: OECD indicators*. Paris: Organization for Economic Cooperation and Development. [http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf](http://www.oecd.org/edu/Education-at-a-Glance-2014.pdf)

Paechter, C. (1993). What happens when a school subject undergoes a sudden change of status? *Curriculum Studies, 1*(3), 349–363.

Pitt, J. (2009). Blurring the boundaries—STEM education and education for sustainable development. *Design and Technology Education: An International Journal, 14*(1), 37–48.

Robbins, D. (2005). The origins, early development and status of Bourdieu’s concept of ‘cultural capital’. *The British Journal of Sociology, 56*(1), 13–30.

Sanders, M. (2009). STEM, STEM education, STEMmania. *The Technology Teacher, 68*(4), 20–26.

Taskforce on the Physical Sciences. (2001). *Report of the task force on physical sciences*. [http://www.irlgov.ie/edu/pub.htm](http://www.irlgov.ie/edu/pub.htm)

Tormey, R. (2011). Subject disciplines, interdisciplinarity and education for sustainable development. In T. Batteson & R. Tormey (Eds.), *Teaching global perspectives: Introducing student teachers to development education* (pp. 45–57). Dublin: Lifey Press.

Trant, A., Branson, J., & Frangos, C. (1999). *Reconciling liberal and vocational education*. Dublin: CDVEC Curriculum Development Unit.

Van de Werfhorst, H. G., Sullivan, A., & Cheung, S. Y. (2003). Social class, ability and choice of subject in secondary and tertiary education in Britain. *British Educational Research Journal, 29*(1), 41–62.

Wang, H., Moore, T., Roehrig, G., & Park, M. (2011). STEM integration: Teacher perceptions and practice. *Journal of Pre-College Engineering Education Research (J-Peer), 1*(2), 1–13.

Whelan, C., & Hanman, D. (1999). Class inequalities in educational attainment among the adult population in the Republic of Ireland. *Economic and Social Review, 30*(3), 285–307.

Williams, P. (2011). STEM education: Proceed with caution. *Design and Technology Education, 16*(1), 26–35.

Young, M. (1975). An approach to the study of curricula as socially organized knowledge. In M. Golby, J. Greenwald, & R. West (Eds.), *Curriculum design* (pp. 100–127). London: The Open University.