INCLUSIVE EDUCATION AND PEDAGOGY IN POST-PRIMARY STEM CLASSROOMS

As inclusive education becomes more and more synonymous with general school life it has become increasingly important to establish both the practical meaning and effective implementation of inclusive pedagogy in our classrooms. The overarching goals of inclusive education are grounded in a desire to create more equitable and accommodating societies, but governments face many challenges when it comes to translating these ideals into reality, particularly within the field of Science, Technology, Engineering and Mathematics (STEM).

Post-primary educators in Ireland are trained in generalised differentiation strategies for the purposes of accommodating for all learners. However, it is difficult to ascertain the effectiveness of inclusive pedagogy in improving learning attainment.

The aims of this research project were two-fold: to gather and analyse findings on the general attitudes of post-primary STEM teachers in Ireland towards inclusive education and to gather and analyse findings on inclusive pedagogical practices utilised by post-primary STEM teachers in Ireland.

The overall findings found that the 54 STEM educators who participated in the study held generally positive views towards inclusive education and expressed adequate understanding of its nature and challenges. Several teaching techniques appeared throughout the meta-strategies, which suggested an interchangeability between differentiation, assessment and general inclusion in the minds of the participants. No pedagogical strategies identified in the study were STEM specific.

Keywords: STEM; Science; Inclusive education; Inclusive pedagogy; Evidence-based pedagogy.

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INTRODUCTION AND BACKGROUND

The focus of this article stems from both the researcher's lived experience of post-primary classrooms as a STEM educator and from their understanding of human sociology/psychology. Inclusive education and its learning meta-strategies are central to much of contemporary initial teacher education (Kurth and Foley, 2014). While the ideals of inclusive education are an overarching aim for education systems to strive towards, the researcher has experienced a stark difference in the realities of the classroom versus the theory of generalised classroom inclusion. Macro-level change proposals informed by education research are inclined to disregard the practical challenges of classrooms, particularly in post-primary settings. Time constraints, lack of resources, behaviour management, diversity of learning ability and a broad achievement criteria that do not always pertain to formal learning outcomes are some examples of the challenges that modern educators face (Janssen, Westbroek and Doyle, 2015).

Differentiation, and the utilisation of varying pedagogical techniques, does not solely constitute inclusive STEM education, and there appears to be a disconnect between what are desired qualities in STEM students versus what is achievable for them. Existing literature regarding the area of inclusive education proves very little in terms of its actual efficacy in improving learning attainment at a macro-level (Haug, 2017; Young, McNamara and Coughlan, 2017; Grima-Farrell, Janssen et al., 2015; Bain and McDonagh, 2011).

Currently the research literature is quite limited when analysing the links between inclusion and science education within this context. A recent bibliometric and descriptive analysis of the area concluded that while there has been a quantitative increase in the number of studies conducted in both areas, the majority of articles published relating to science and inclusive education are categorised as special education in terms of research (Waltz Comarú et al., 2021). It is evident when observing the conclusions of research into the area of STEM education that those who

experience effective inclusive practices in the classroom tend to achieve higher academically and develop scientific skills more proficiently (Nasri et al., 2021). However, given that the majority of research articles produced in relation to STEM education and inclusion are treated separately to one another, it is difficult to ascertain if these increased levels of achievement and improved learning outcomes are within the context of special education or in the broader demographics of mainstream classrooms.

The provision for special educational needs (SEN) and general inclusion within Irish education is mandated through several key pieces of legislation; The Education Act (1998), the Education for Persons with Special Educational Needs Act (EPSEN) (2004) and the Education (Admissions to Schools) Act (2018). The majority of western countries have been moving towards fully inclusive education systems over the last number of decades with the aim to improve societal equity (Kivirauma, Klemelä and Rinne, 2006).

While many educational policies have been implemented across the global community to better achieve the ideals of inclusive education, the meaningful progress made has been quite minimal in this area (Walton, 2023). The benefits of inclusive education relating to learning attainment are limited to relatively small-scale studies and common trends appear consistently with regards to the challenges as to why it is not feasible to effectively implement at a system-wide level (Janssen et al., 2015). The National Council for Special Education (NCSE) (2009) has listed the rise of behaviours of concern in young learners, socio-economic inequality and the erosion of national literacy and numeracy as being some of the barriers that have stymied the development of a truly inclusive education system in Ireland.

The importance of this research topic lies in examining effective pedagogy and educational policies that best serve learners of all backgrounds. The current approach of generalised inclusion in classrooms has not provided evidence as to whether it is truly efficacious in providing adequate supports for the learning needs of young people. Examining the realities faced by STEM teachers in schools and developing quantifiable metrics for inclusive learning strategies should be an integral part of all large-scale educational change for policy makers. The experiences of the researcher and interactions with other STEM and non-STEM educators alike would suggest there is a lack of critical analysis towards how pedagogy is deemed effective or efficient. The EPSEN Act is currently being reviewed by the Joint Committee on Disability Matters, a committee of the Oireachtas which monitors the implementation (by Ireland) of the United Nations Convention on the Rights of Persons with Disabilities, but its focus lies on the overall inadequacies of inclusive education in Ireland rather than the specifics of effective inclusive teaching (Joint Committee on Disability Matters, 2023). The provision of quality education for all students is essential to create a more equitable society and to increase the pool of potential candidates for specialised areas of research and employment which require higher levels of learning and cognitive ability.

The research questions that guided this research were:

- What general attitudes do post-primary STEM teachers in the Republic of Ireland hold towards inclusive education and the extent of these attitudes?
- What inclusive pedagogical practices are utilised by post-primary STEM teachers in the Republic of Ireland?

METHODOLOGY

A quantitative approach was taken to data collection for this small-scale study. The researcher utilised a questionnaire as the data-collection instrument. Due to practical limitations, an online questionnaire that individuals could complete in their own time was an ideal approach to gather quantitative empirical data (Wright, 2005). This type of data-collection provides an efficient mechanism to accumulate key information essential to the focus of the overall research questions of the thesis.

Cluster and convenience sampling were conducted for the purposes of data-collection for this study. The schools selected for the clusters differed in terms of educational settings and demographics. They were as follows:

- A single-sex (male) voluntary secondary school with 1100+ students and approximately 70 teaching staff.
- A mixed-sex Education and Training Board school with 1000+ students and approximately 70 teaching staff.
- A mixed-sex Education and Training Board school (Delivering Equality of Opportunity In Schools) with 700+ students and approximately 50 teaching staff.

Quantitative Methods Approach

The questionnaires were distributed digitally via email as a Google Form. Participants gave their consent in writing or through the Google Form questionnaire. The data was then collated and analysed.

The respondents from the questionnaire numbered 54. They were from a larger group of approximately 1000 post-primary STEM educators which were drawn from the Sharing Science Ireland group and a number of post-primary schools in the locality of the author.

The intention and design of the questionnaire was to gather information in relation to the participants' demographics, teaching experience, their qualifications in STEM subjects, current inclusive pedagogical practices they implement and their general views of inclusive education within the field of STEM. It was deemed important by the researcher to gather background information of participants in order to identify any trends that appeared within their views and implementation of inclusive pedagogy within the classroom.
A Likert scale (Likert, 1932) was used in the questionnaire as it allowed the participants to communicate their level of understanding and opinions on key areas within the field of inclusive education with set responses: Strongly disagree, Disagree, Neither Agree nor Disagree, Agree and Strongly Agree. This was an essential aspect of the study as it allowed for the collation of quantifiable ordinal data which was reviewed before having to apply thematic analysis for the qualitative questions.

Ethical Issues and Considerations

A research proposal for this study was submitted and approved by the Hibernia College Ethics Committee prior to commencing the study and the collection of data. This research study complied with the British Educational Research Association (2011) and Hibernia College's ethical guidelines. To summarise:

- No students or persons under the age of eighteen were used in this study.
- Participants were invited to opt in to this research on a voluntary basis.
- Participants were informed of the option to withdraw their participation from the study after eight weeks.
- Participants were informed of how their data would be stored and maintained.
- Participants were informed of their right and ability to access their own data upon request.
- No information or data was gathered that could be used as an identifier for participants.

Prior to the distribution of the online questionnaires, the Principal of each school selected as a cluster for sampling, was approached for the consent of their school to be included in the study.

Potential biases of the researcher were minimised in two ways: through the use of neutral, non-leading language in the survey design and the opting for a quantitative approach to data gathering rather than qualitative interviewing.

Data Analysis

This study's post-positivist research design meant the data gathered from the questionnaires were collated and analysed for any emerging trends with regards to background information of participants and their views/practices of inclusive education within STEM. For meaningful analysis to occur, elements of thematic analysis through categorisation were required in order to be able to better quantify open-ended responses in the survey (Vaughn and Turner, 2016).

The points of agreeability on a Likert scale, utilised for the questionnaire, were numerically metrified by assigning them values. This was carried out in order to establish a measure of validity and robustness within the study's data gathering process. The table below details the numerical values chosen for each point on the Likert scale:

Table 1: Assigned numerical values of Likert Scale Points

Point of Agreeability	Assigned Numerical Value
Strongly Disagree	-2
Disagree	-1
Neither Agree nor Disagree	0
Agree	1
Strongly Agree	2

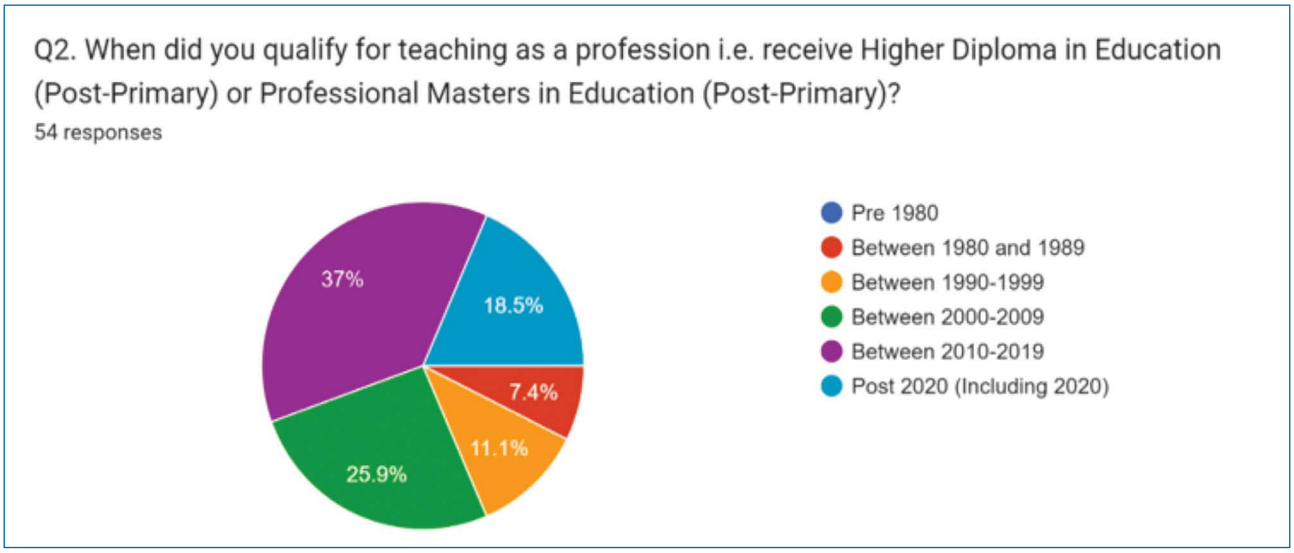
FINDINGS AND DISCUSSION

The study's data was analysed to identify factors that could affect the views and practices of post-primary STEM educators in terms of inclusive education and pedagogy. The study's findings are presented under the following three headings:

- Demographical and background information of participants.
- General views and beliefs regarding inclusive STEM education.
- Implementation of inclusive pedagogy in the STEM classroom.

Several questions within the questionnaire were designed to establish the demographical and background information relating to participants' teaching experience and when they became a qualified post-primary educator. Figure 1 below gives a percentage breakdown of the sample group in terms of when they qualified as professional post-primary teachers.

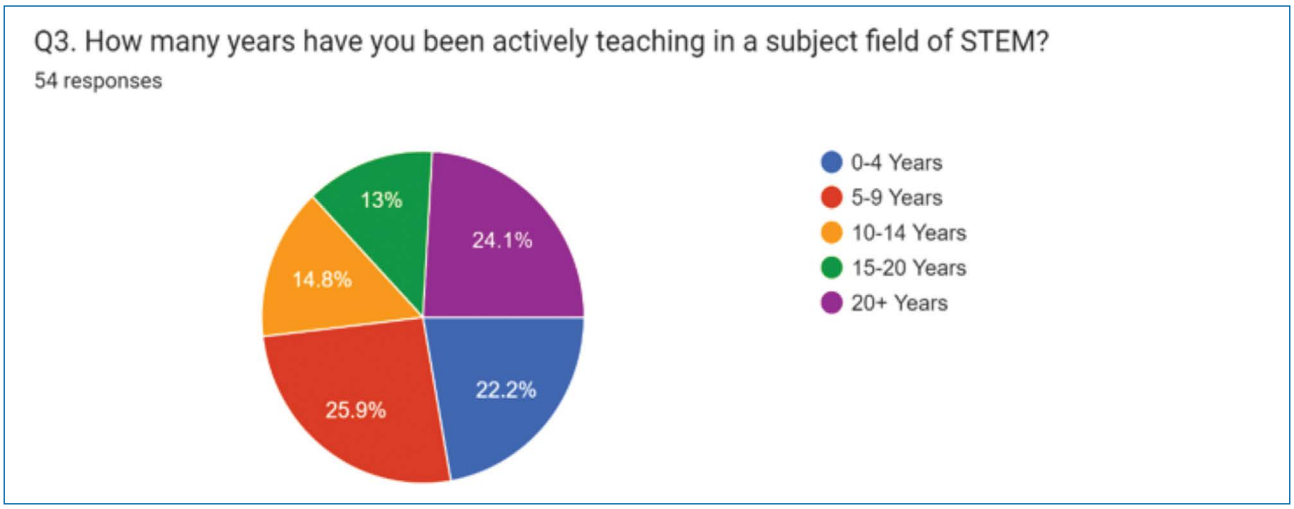
Figure 1: Era of professional teaching qualification.



The key points that were noted were:

- Approximately 20% of participants qualified after 2020.
- Approximately 40% of participants qualified between 2010 and 2019.
- Approximately 25% of participants qualified between 2000 and 2009.
- Less than 20% of participants qualified prior to 2000.
- No participants qualified prior to the year 1980.

Figure 2: Number of years of active teaching of participants in a STEM subject.



Establishing how many years participants had of active teaching in a STEM subject discipline was important, as current research literature suggests it is one of many factors that can affect the views and inclusive practices of educators (Dignat, Rimm-Kaufman, van Ewijk, and Kunter, 2022). Figure 2 displays participants' years of active teaching in a STEM subject. It was observed that approximately:

- 20% of participants had 0-4 years of active STEM teaching experience.
- 25% of participants had 5-9 years of active STEM teaching experience.
- 15% of participants had 10-14 years of active STEM teaching experience.
- 15% of participants had 15-20 years of active STEM teaching experience.
- 25% of participants had 20+ years of active STEM teaching experience.

The statistical functions of Microsoft Excel were used to calculate the mean, sample standard deviation, margin of error and percentage margin of error. Initial impressions were that participants held generally positive attitudes towards inclusion but felt they were not adequately supported to implement inclusive pedagogies effectively. The margins of error were relatively high however (for a 95% confidence interval), which suggested the validity of data may be compromised. Overall, a Mode Score was obtained for the range of the entire data sets but not within certain sub-sets due to the inability to calculate modal values for certain questions. The analysis of the data relating to the overall attitudes of participants towards inclusive education are presented in Table 2.

Table 2: Analytics of participant demographical data and attitudes.

Question	Q7	Q8	Q9	Q10	Q11	Q12
Mode Score	1	1	-1	1	1	1
Mean Score	1.25	1.22	-0.38	0.78	0.58	0.69
Sample Standard Deviation	0.67	0.74	1.01	1.03	1.05	1.08
Margin of Error	0.18	0.20	0.27	0.27	0.28	0.29
Percentage Margin of Error	17.94	19.67	26.91	27.49	27.97	28.77
Z-score	1.96					

Cawley, Hayden, and Baker-Kroczynski (2002) established that significantly high levels of interpersonal contact are established between educators and their students in science-based subjects. It is understandable that the attitudes and beliefs of post-primary teachers have the potential to impact on their students and how they also view STEM. There are also strong links in existing literature between the success of implementing inclusive educational practices and the attitudes of teachers (Varcoe and Boyle, 2013).

A strong general understanding of inclusion within the classroom was evident among the study group, based on the data gathered. Close to 97 percent of the study group indicated that they felt they understood what inclusion meant in the classroom. While it was difficult to determine the exact depth of their understanding with this question alone, it would suggest that the respondents were at least relatively informed regarding this area of education.

One factor that has been linked to poor implementation of inclusive pedagogy has been lack of teacher knowledge and training in the area (Kennedy, 2010), but the results here do not indicate that this was an issue for this sample group. The processed data showed that the sample group did not feel teachers were adequately supported to implement effective inclusive pedagogy in their classrooms (Table 2). While the value of -0.38 would suggest that the sentiment is closer to neutral than to Disagree, there are limitations with this assumption due to the nature of Likert scales. The modal value of -1 gives a better indication of the attitudes of STEM teachers to this aspect of inclusion in the classroom.

The majority of the sample group (81 percent) stated that they qualified as professional post-primary teachers post the year 2000. The statistical breakdown of active teaching experience in their respective STEM subject showed that it was a relatively even distribution of teachers among the sample group. Analysing the responses against these demographical categories showed there was a negative correlation between years of service/era of qualification and general understanding/attitudes towards inclusive education. This aligned with previous studies carried out in relation to the implementation of inclusive pedagogy found that younger, less experienced educators held generally

more positive views towards inclusion in mainstream classrooms, and as a result more effectively utilised inclusive teaching practices (Forlin et al., 2008; Male, 2011).

The analysis of the data gathered from the study group highlighted some interesting facets of the thought processes of STEM educators regarding inclusive pedagogy. The design of the questionnaire in terms of establishing the capacity of and extent to which post-primary STEM teachers employ inclusive pedagogical methods allowed for the collection of descriptive qualitative data. Several themes appeared repeatedly throughout the responses given for separate questions. Regarding methods of differentiation, AFL and general inclusion, it was evident that participants considered them with a degree of interchangeability. The broad categories of questioning, group work, scaffolding and varied learning styles emerged several times throughout the questions relating to pedagogical practices. These were also the most frequently reported techniques that the members of the sample group found most effective in their teaching.

The lack of distinction between the wider meta-strategies in the responses of the sample group harks back to difficulties in clearly defining inclusive education and its practices (Shyman, 2015; McLeskey et al., 2014; Florian, 2014). When there is commonality in techniques within each meta-strategy, it may be reasonable to conclude STEM educators do not view differentiation, AFL and general inclusion differently to any significant extent. Effective teaching in STEM has been found to revolve around the following key principles (Çimer, 2007):

- Assessing prior knowledge.
- Application of knowledge meaningfully.
- Learner engagement.
- Student inquiry.
- Co-operative learning.
- Feedback and continuous assessment.

The categories and themes that emerged from participants' responses in this study largely fall under these principles. A challenge that is inevitable when attempting to define 'effective' teaching lies in the myriad of pedagogical philosophies that dominate education across the global community. An educator's pedagogical practice is heavily influenced by their perspective of teaching and learning (Pratt, 2002). It may be possible that the interchangeability the participants exhibited in relation to differentiation, AFL and general inclusion is linked with the principles of effective STEM teaching. Jansen et al. (2015) has suggested that professional educators who execute teaching efficaciously select their pedagogy based on ease of use in a classroom setting.

CONCLUSION

While the sample group was limited in terms of population, the results did concur with the findings of existing research in the area (Young, McNamara and Coughlan, 2017). Attitudes of the post-primary STEM educators towards inclusive education followed existing trends which suggest teachers hold generally positive views on the ideals of inclusive education but can be concerned about its implementation due to practicalities of the classroom (Young, McNamara and Coughlan, 2017). There were no marked differences between the views of STEM teachers and general educators in the wider literature.

It was observed that participants generally held positive views towards inclusion in the classroom and felt they held adequate understanding of the facets and challenges of inclusive education. There was a slight negative correlation between general attitudes towards inclusive education and years of teaching service; as a teacher gained more teaching experience, they appeared to hold more negative attitudes and reduced understanding towards inclusion within the classroom. This may be explained by the likelihood that teachers who have significant lengths of service in education systems generally develop higher levels of cynicism towards developments and implementation of contemporary education policies (Sau-ching and Moses, 2016). Irish educators hold generally positive views of the ideals of inclusive education but regularly report misgivings about the pragmatics of implementing the full inclusion of students with SEN and behavioural challenges in mainstream classrooms (Young, McNamara and Coughlan, 2017).

The study raised key questions regarding areas of inclusion that schools, education systems and policy makers should aim to address. It is evident that post-primary educators believe that the overall mission of inclusive education is a worthy ideal to strive for in teaching but there is little evidence globally to show that inclusion within classrooms is both happening and having a definitive impact on learning attainment. Specific metrics need to be established for what is considered to be effective inclusive pedagogy, in order to discern what is required to meaningfully improve

educational outcomes for all students (Waltz-Comaru et al, 2021). It may be possible that an overhaul to the approach and philosophies towards inclusive education is required for it to effectively manifest in classrooms.

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