PROVISION FOR WELSH-MEDIUM STEM SUBJECTS

AN EXPLORATORY STUDY

Professor Enlli Thomas
Dr Nia Mererid Parry

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BACKGROUND

STEM, in its tradition sense, refers to Science, Technology, Engineering and Mathematics. Since teacher shortage is also present in STEM-related fields, such as computer science and various technology subjects, we use STEM in its broader sense throughout this document and refer to STEM-related subjects where necessary.

Generic issues relating to the shortage of expertise in STEM -related subjects

72% of all British businesses rely on individuals with STEM skills (CBI, 2014 ac cited in Welsh Government, 2016), yet fulfilling this needs-based demand is a challenge. The apparent shortage of STEM-related expertise within the workforce contributes one of the biggest economic problems facing the UK Government today (House of Commons, 2018). Despite Government expenditure (2007-2017) amounting to £1billion to support initiatives that encourage individuals' engagement with STEM subjects, in 2014, 53% of employers expected that they would continue to experience problems in recruiting individuals with relevant skills over the coming three years (CBI, 2014).

Schools therefore have a key role to play in delivering pupils who are proficient in these subjects who can continue with their training beyond statutory education and help meet the growing demand in the workplace.

However, in order for schools to contribute positively to this demand, it is necessary to ensure a sufficient and continuous pool of highly qualified teachers who can engage and enthuse pupils about the subjects. Attracting suitable individuals to the teaching profession with knowledge of STEM is a challenge, but attracting suitable individuals to teach STEM in Welsh-medium schools is an even greater one.

Issues and opportunities relating to the teaching of STEM in Wales

Teacher shortage

It has long been recognised that there is a shortage of qualified science and technology teachers in Wales. This issue is exacerbated further by the continuous shortfall in the number of Initial Teacher Education (ITE) students who choose to train as STEM teachers:

> *The number of post-graduate science teachers being trained has fallen short of national targets over several years (Estyn, 2017, p. 6).*

During the 2016-2017 academic year, only 86 trainees were recruited to train as science teachers throughout Wales (35 in biology, 31 in chemistry and 20 in physics), which fell significantly below the target figure of 142 (Statistics for Wales, 2017). Whilst the recruitment rate to science ITE places in Wales was therefore at 65%, in England, where there are various pathways into the teaching profession, a much higher rate of 81% was achieved (Estyn, 2017, p.33).

Tackling the shortage in qualified teachers means tackling the shortfall in ITE recruitment. However, in order to tackle the shortage in ITE recruitment, pupils need to be enthused

about science and supported by specialist teachers, so that they themselves decide to progress with STEM subjects beyond school.

This issue is of particular relevance to the Welsh-medium context, most notably in rural and western areas of Wales, where the greatest proportion of Welsh-medium provision is found:

> *Generally, there is a lack of applicants for science posts and recruiting to Welsh-medium science departments is a particular problem (Estyn, 2017, p.6).*

> *…there are not enough applicants for science teaching posts across Wales… Recruiting to Welsh-medium science departments is particularly challenging (Estyn, 2017, p.33).*

> *…schools in more remote parts of Wales experience the greatest difficulty in recruiting and retaining staff (p.33).*

However, where posts are filled, either on a short-term basis (via supply teachers), or on a more permanent basis, they are not always filled by suitable candidates:

> *Even where schools are more successful in recruiting staff, the number of high-quality applicants is low. There are fewer applicants for physics posts than for biology or chemistry. There are very few suitable applicants for advertised posts…*

> *A minority of departments visited in this survey have experienced difficulties with long-term absenteeism of staff. Supply teachers for science who can teach through the medium of Welsh, especially in rural parts of the country, are in very short supply. As a consequence, schools will often employ a non-specialist supply teacher to cover science lessons.*

> *When science staff are absent, many schools have to employ non-specialist supply teachers to cover their lessons, especially in key stage 3.*

> *(Estyn, 2017, p.33)*

Related to this, pupils in Wales continuously perform worse on the PISA science tests than their counterparts in England, Scotland and Northern Ireland (Jerrim & Hure, 2016). Despite this trend, comparing schools across Wales, pupils in Welsh-medium schools outperform pupils in English-medium schools at science, although this may be, in part, due to the lower proportions of pupils that are eligible for free school meals in Welsh-medium contexts:

> *Performance of pupils in Welsh-medium schools in science at levels 1 and 2 is better than that for pupils in English-medium schools for the last five years (Welsh Government, 2017c & 2017d). This is due in part to Welsh-medium schools having lower levels of pupils eligible for free school meals (Estyn, 2017, p.13)*

> *Performance at level 5 or above, level 6 or above and level 7 or above in science has been better in Welsh-medium schools than in English-medium schools since 2012 (Welsh Government, 2017b & 2017c). Figure 11 shows that the performance in Welsh-medium schools continues to be above that in English-medium schools in 2017 (Estyn, 2017, p.35).*

Despite these optimistic patterns within Welsh-medium schools in particular, the paucity of suitably qualified teachers is not ideal, and impacts directly on pupils' engagement with these subjects:

> *Pupils consulted during this survey expressed their concern that supply teachers are unable to help them with their work, carry out practical work or assess their work meaningfully. This impacted on their progression and enjoyment of the lessons (p.33).*

Given the complexities of the current situation, it is worth exploring different solutions to this shortfall, with a focus on identifying alternative and complimentary means of training and recruitment to these subjects within HEIs.

Curriculum reform

Education in Wales has recently undergone widespread reform. Central to this reform is the implementation of the New Curriculum for Wales: 2022 (https://hwb.gov.wales/curriculum-for-wales), which is organised around six core Areas of Learning and Experience (AoLE), underpinned by four common purposes of creating (i) ambitious, capable learners, who are (ii) enterprising and creative, (ii) ethical and informed, and (iv) healthy confident individuals. Two of the core AoLEs map onto the traditional STEM-related subjects, namely Science and Technology, and Mathematics and Numeracy. This new, interdisciplinary and dynamic approach to learning allows the learner to engaged with a subject-based curriculum, but in a more integrated and meaningful way. Under the new curriculum, traditional academic subjects are to be integrated within AoLEs rather than taught narrowly and separately in a siloed fashion. For that reason, teachers will require both subject specialism and a broader understanding of the wider AoLE in order to integrate effectively across the area. This raises the question as to whether the current siloed approach that is on offer in universities is suitable as subject training base for teachers who continue on to a PGCE, or whether universities could expand on their subject area offering in order to help create teachers who can adapt effectively to the broader subject remit of the new AoLEs. This study aimed to explore some of these possibilities.

In order to explore this issue, we surveyed the opinions of a wide range of stakeholders inclusive of school pupils, teachers, university students and university lecturers. Together, their responses provide a wealth of information that highlight a series of important implications. These, in turn, serve as the basis for a series of recommendations for enhancing the opportunities to promote the study of STEM-related subjects through the medium of Welsh and bilingually.

METHODOLOGY

Participant Samples

Pupils

76 pupils from five different schools took part in the study. These pupils came from across north Wales and represented the counties of Wrexham, Conwy and Gwynedd. Surprisingly, however, whilst 18% (n = 14) of the respondents were male, 82% (n = 62) were female. In the context of STEM education, where gender differences are often highlighted (Department for Education, 2019), this higher proportion of female respondents needs to be taken into consideration when interpreting the findings. The majority of the pupils were in Year 9 (40%, n = 30), with 30% (n = 23) of respondents in Year 10, 15% (n = 11) in Year 11, and 12% (n = 9) and 4% (n = 3) in Years 12 and 13 respectively.

Just under half of the pupils (46%, n=35) attended bilingual schools where Welsh and English were used equally. A further 33% (n=25) attended schools where Welsh was used either mostly or as the sole medium of instruction, while the remaining 21% (n=16) attended schools where the medium of instruction was 'English mostly' (see Table 1 below). In comparison, the majority of pupils (64%, n = 49) reported that they used English as a social language, either solely (7%, n=5), mostly (34%, n=26) or in conjunction with Welsh (24%, n=18). Only 36% (n=27) of pupils used Welsh mostly or solely as a language for social purposes.

Table 1: Proportion of pupils according to home language backgrounds, medium of instruction at school, and use of language in social contexts

	English only	English mostly	Welsh and English equally	Welsh mostly	Welsh only
Home language	22% (n = 17)	16% (n = 12)	20% (n = 15)	8% (n = 6)	33% (n = 25)
School language	0% (n = 0)	21% (n = 16)	46% (n = 35)	25% (n = 19)	8% (n = 6)
Social language	7% (n = 5)	34% (n = 26)	24% (n = 18)	24% (n = 18)	12% (n = 9)

The sample of pupils therefore represented a range of home language backgrounds and included pupils who used both Welsh and English to various degrees within their social circles.

Teachers

21 teachers responded to the questionnaire. A similar gender imbalance, in favour of females, was also present among the teacher respondents where only 29% (n = 6) of the informants were male, and 71% (n = 15) female. Teachers were located across the whole of north Wales, with 38% (n = 8) located in central north Wales (Conwy and Denbighshire), 19% (n = 4) located in the west (Gwynedd & Ynys Môn), and the remaining 43% (n = 9) located in the east (Flintshire/Wrexham). The majority of the teachers – 62% (n = 13) – stated that the school in which they taught was Welsh-medium, with a further 19% (n = 4) teaching in bilingual schools and the remaining 19% (n = 4) unsure of the language category of their school.

The respondents covered a breadth of STEM subjects in terms of their subject specialism, and ranged from teacher to Deputy head of Faculty, Head of Faculty, and Senior Management in terms of their current position at the school.

University Students

Seven students participated in the questionnaire. All students were female. One student was a PhD candidate, while the other students were all undergraduates at various levels of their degree that studied Biomedical Sciences, Midwifery, Medical Sciences, Mathematics or Pharmacy. Although one student studied Welsh at university, they nevertheless wished to participate in this questionnaire as they had hoped to study mathematics but felt that there were no suitable opportunities available to study mathematics in Welsh.

University lecturers

The questionnaire for lecturers was sent out to relevant departments in universities across Wales. 10 lecturers responded to the call. 60% (n = 6) were male, 30% (n = 3) were female and 10% (n = 1) did not reveal their gender. These lecturers taught in Computer Science and Electrical engineering (n = 1), Education (n = 4), Mathematics (n = 1) and Chemistry (n = 1) departments.

Data collection

Data collection tools

Questionnaires were used as a data collection method. The questionnaires explored the extent to which pupils/students were interested in pursuing Science, Technology and Mathematics subjects, any potential barriers that hindered their choices, their attitudes towards studying these subjects through the medium of Welsh and the feasibility of a combined BSc degree. The pupils' and university students' questionnaire included 23 questions, the teachers' questionnaire included 25, and the lecturers' questionnaire included 21. A variety of types of questions were used, including statements set on a Likert-scale, open questions, and multiple choice questions. Questionnaires were shared with a STEM Support Advisor for the region and a STEM Mentor for Careers Wales for feedback before the final versions were disseminated.

Procedure

All Welsh-medium schools from North Wales were invited to participate in this research, along with lecturers in universities across Wales that were involved in Science, Technology and Mathematics subjects and/or Initial Teacher Education. Students were approached from within the researchers' own institution. When invited to participate in the research, all potential participants were given an information sheet that explained what the research entailed and what would be expected from them as participants. Following an agreement to take part, they were sent a link to an online questionnaire, which enabled the participants to complete the questions at a time and location that suited them, due to Covid-19 restrictions.

In what follows, all direct quotations from open-ended questions are reported verbatim.

RESULTS

RESULTS

SCHOOL PUPILS

Choices around STEM-related subjects at school

(i)   Choice of language

Approximately half (55%, n = 37) of the participating pupils agreed that they were able to choose whether they study their Science, Technology and Mathematics subjects in Welsh, English or bilingually. Of those who were allowed to choose the medium of instruction, the majority 46% (n = 17) chose to study these subjects in Welsh, while 27% (n = 10) decided to study in English, and the remaining 27% (n = 10) were able to choose to study them bilingually.

> **Implication 1:** There is a market among Welsh-speaking students for Welsh-medium provision in STEM-related subjects, should the option be available.

While there was no significant pattern between the gender of the pupils and their choice of language, their home language had an effect on their choice (χ^2 (8, n = 45) = 30.097, p < .001). 82% (n = 9) of the pupils who spoke English at home chose to study their subjects in English, 58% (n = 7) of those who speak both Welsh and English at home chose to study their subjects bilingually while 68% (n = 15) of the pupils who speak Welsh at home chose to study the subjects through the medium of Welsh. This means that the language spoken at home does not necessarily mirror the linguistic choices pupils make in school, particularly in relation to STEM subjects, and particularly for those who speak Welsh either exclusively or alongside English in the home.

The rationale provided for their linguistic choices in relation to STEM-type subjects differed across pupils and across linguistic group. These reasons are discussed below in relation to the choice to study bilingually followed by the choice to study monolingually (in Welsh or in English). Exploring pupil voice in this way is important as it may reveal underlying issues that may be addressed without jeopardising their access to Welsh-medium of English-medium content.

Bilingual

Some who chose a bilingual route (where such provision was available) did so in order to ensure complete understanding of the content so that English supported their access to the curriculum in Welsh:

> *If I did work in two languages I would understand better*

> *So that I'm still receiving my education in Welsh but can understand everything correctly*

> *At the moment I'm using nearly only Welsh in these subjects – especially Mathematics and Science, but it's hard to do additional research without the English vocabulary, so most of the time I need to do it on my own, without help – there is no-one at home with substantial Welsh skills.*

Another pupil related their choice to study bilingually to the need to be cognisant of the requirement to be able to access the subjects in both languages (or mainly in English) at university, but needing both later on in the workplace:

> *It's important to know the subject terms in both languages for University*

> *Because I really like the variety and the ability to adapt if needs be in the general work world.*

Others focused more on the flexibility of the learning process itself:

> *Because it's easier to do some things in different languages*

> *If you don't understand a word in Welsh you can see if you know it in English*

One pupil related their choice to the known benefits of bilingualism:

> *Because being bilingual is a bonus*

Overall, then, those who chose to study bilingually often did so strategically, with a view towards maximising their learning experience and opportunities for the future.

Monolingual

Of those who chose to study STEM-related subjects monolingually, many chose to study in their native / home language:

> *"I think in the English language and speak English at home"*

> *"Welsh is my first language and it's easier to remember things and to read stuff"*

> *"My first language is Welsh, so it's easier for me to understand"*

> *"Because I speak Welsh most of the time"*

Others based their choice on their learning experiences to date, with some remarking that relearning terminology and subject-specific information in another language may impact on their academic gains:

> *"I've already studied all the subjects in Welsh so it would be difficult to learn in another language"*

> *"I understand things better in Welsh & I've done all of my education in Welsh"*

> *"Because I've already learnt the Science and Mathematics terms in English"*

> *"I've learnt everything in Welsh so far, so it would be confusing"*

> *"Because I've been learning things in Welsh"*

> *"I've studied in Welsh throughout my life"*

As was noted among those who opted to study bilingually, many pupils made a strategic linguistic choice to study monolingually, based on the language in which they felt they excelled and the progression options beyond school:

> *"It's easier for me and I'll be moving to an English college"*

> *"Because not many workplaces use only Welsh. So it will be hard having an education just in Welsh and then needing to do it in English after school"*

> *"Because there are an immense amount of opportunities to learning these subjects in English over Welsh in the long term"*

> *"I'm more comfortable in English and English is the language used in most Science jobs"*

> *"Helps with understanding and jobs in the future"*

> *"There are more opportunities in Welsh"*

> *"To get a job"*

> **Implication 2:** Welsh-medium provision in STEM-related subject does not need to be exclusively Welsh – translanguaging options should be explored within these subjects in order to draw more students to continue to study through the medium of Welsh whilst also benefitting from exposure to the equivalent terminology in English.

(ii)   Choice of subjects

Pupils in Years 12 and 13, and already pursuing their A levels, were asked whether they had chosen STEM-related subjects for their studies. From the 12 participants in those years, two (17%) had chosen biology, three (25%) had chosen chemistry, no-one had chosen computing, one had chosen design and technology (8%), three had chosen physics (25%) and four (33%) had chosen maths.

Pupils in Years 9 to 11 (Y9-11) were asked how likely they were to choose STEM-related subjects for their A levels. The results are noted in Table 2 below:

Table 2: Proportion of Y9-11 pupils likely to choose STEM-related subjects for A-level.

	Biology	Chemistry	Computing	Design & Technology	Physics	Maths
Not sure	2% (n = 1)	9% (n = 6)	10% (n = 6)	8% (n = 5)	11% (n = 7)	9% (n = 6)
Not likely	41% (n = 26)	38% (n = 24)	52% (n = 33)	41% (n = 26)	41% (n = 26)	34% (n = 22)
Small chance	17% (n = 11)	25% (n = 16)	21% (n = 13)	25% (n = 16)	17% (n = 11)	13% (n = 8)
Started considering	14% (n = 9)	9% (n = 6)	8% (n = 5)	11% (n = 7)	14% (n = 9)	19% (n = 12)
Good chance	11% (n = 7)	6% (n = 4)	6% (n = 4)	8% (n = 5)	11% (n = 7)	9% (n = 6)
Very sure that I will	16% (n = 10)	13% (n = 8)	3% (n = 2)	8% (n = 5)	6% (n = 4)	16% (n=10)

The results in Table 2 indicate that the least likely STEM-related subject to be chosen at A-level was Computing (73% not likely or small chance) followed by Design & Technology (66%), Chemistry (63%), Biology and Physics (58% per subject) and finally Maths (47%).

Compared to the other subjects on offer, Biology (n=18), Physics (n=11) Chemistry (n=11) and Maths (n=19) were among the most likely subjects students were likely to pursue, alongside History (n=13), English (n=11), and Art (n=11). (See Table 3.)

Table 3: Subjects pupils said that they were likely to choose at A-Level.

Subject	No.
Health and social care	3
Physical Education	4
Outdoor pursuits	1
Geography	7
Travel & Tourism	1
Food Technology	4
Drama	9
Religious Education	6
Graphics	1
Maths	19
Mechanics	1

Subject	No.
Computing	8
Physics	11
Biology	18
French	7
Design and Technology	8
Media studies	1
Art	11
English	11
Engineering	1
Sociology	1
Chemistry	11

Subject	No.
Childcare	1
Hair & Beauty	2
Welsh	9
History	13
Psychology	3
Business	2
Photography	1
Music	2
Law	1

Some of the reasons why pupils would choose these subjects included (i) their enjoyment of the subject, (ii) career requirements, and (iii) how easy they found the subjects.

> **Implication 3:** In line with the vision of the New Curriculum for Wales: 2022, pupils need to appreciate these subjects as cross-cutting themes that serve as a good basis for other subjects.

In relation to STEM-related subjects, pupils' home language seemed to have an effect on their choice of subjects with significances between their home language and Computing ($\chi2$ (20, n = 62) = 33.404, p < .05), Design and Technology ($\chi2$ (20, n = 63) = 44.396, p < .05) and Mathematics ($\chi2$ (20, n = 63) = 33.063, p < .05). Children from English-speaking homes seemed more inclined to choose these subjects than children raised in Welsh-speaking homes.

When asked in which language they would choose to study those subjects if they were allowed to choose between English, bilingual or Welsh, the results revealed a mixed picture (see Table 4 below).

Table 4: Proportion responses to the linguistic choices pupils would make if studying these subjects at A-Level

	Biology	Chemistry	Computing	Design & Technology	Physics	Maths
English	26% (n = 12)	27% (n = 13)	25% (n = 11)	14% (n = 6)	26% (n = 12)	19% (n = 10)
Bilingual	26% (n = 12)	29% (n = 14)	39% (n = 17)	36% (n = 15)	23% (n = 11)	38% (n = 20)
Welsh	49% (n = 23)	45% (n = 22)	36% (n = 16)	50% (n = 21)	51% (n = 24)	43% (n = 23)

Interestingly, a number of students noted that their preference would be to study STEM-related subjects in Welsh at A-level, either exclusively or alongside English (74%-86% of respondents).

While there were no significant differences between the pupils' gender and the language that they would choose if they were to study these subjects at A-level, pupils who came from English-medium homes were more likely to choose to study these subjects in English, while the pupils from Welsh-medium homes showed a preference towards studying them in Welsh.

> **Implication 4:** Home language experience seems to influence the linguistic choices pupils make, although the assumption that certain subjects require knowledge of terminology in English influences those who speak Welsh at home to seek opportunities to study bilingually.

Choosing STEM-related subjects at University

**Pupils were asked how likely they would be to consider choosing the traditional STEM-related subjects or a combination of those subjects at university.
The responses are noted in Table 5 below:**

Table 5: The likelihood of pupils opting to study a STEM-related subject, or combination of those subjects, at University

	Very unlikely	Quite unlikely	Not sure	Quite likely	Very likely
Physics	49% (n = 33)	15% (n = 10)	18% (n = 12)	12% (n = 8)	7% (n = 5)
Biology	41% (n = 28)	13% (n = 9)	16% (n = 11)	16% (n = 11)	13% (n = 9)
Chemistry	49% (n = 33)	13% (n = 9)	18% (n = 12)	10% (n = 7)	10% (n = 7)
Design and Technology	50% (n = 34)	13% (n = 9)	24% (n = 16)	7% (n = 5)	6% (n = 4)
Computer Science	55% (n = 37)	12% (n = 8)	18% (n = 12)	9% (n = 6)	6% (n = 4)
Combined Sciences	51% (n = 34)	15% (n = 10)	15% (n = 10)	13% (n = 9)	6% (n = 4)
Combined Sciences & Technology	52% (n = 35)	21% (n = 14)	16% (n = 11)	9% (n = 6)	2% (n = 1)
Combined Technologies	55% (n = 37)	15% (n = 10)	18% (n = 12)	10% (n = 7)	2% (n = 1)
Maths	41% (n = 28)	12% (n = 8)	18% (n = 12)	16% (n = 11)	13% (n = 9)
Other (e.g. Bio-Chem, Ocean Sciences etc)	43% (n = 29)	13% (n = 9)	21% (n = 14)	9% (n = 6)	13% (n = 9)
Combined Sciences and Maths	54% (n = 37)	13% (n = 9)	15% (n = 10)	10% (n = 7)	7% (n = 5)
Combined Technologies and maths	60% (n = 40)	18% (n = 12)	13% (n = 9)	5% (n = 3)	5% (n = 3)

A further 22% (n = 15) of the pupils noted that they would consider studying other subjects. These included: Medicine (n = 3), Psychology (n = 1), Veterinary Sciences (n = 1), Biochemistry (n = 3), Marine Biology (n = 3) and Biomedical Sciences (n = 1).

As can be seen in Table 5, the number of students who would consider STEM-related degrees are relatively low. The most likely subjects, in line with the most popular subjects they chose at A-Level, were Biology and Maths (29% quite or very likely in each case). The notion of a combined science degree did not seem to be any more favourable than the traditional subjects on their own.

Pupils were also asked whether they would prefer to study these subjects at university in Welsh, English or bilingually.

Table 6: Proportion responses to the linguistic choices pupils would make if studying these subjects at University

	Biology	Chemistry	Computing	Design & Technology	Physics	Maths
English	35% (n = 14)	34% (n = 11)	24% (n = 7)	15% (n = 4)	37% (n = 11)	38% (n = 15)
Bilingual	38% (n = 15)	44% (n = 14)	48% (n = 14)	54% (n = 14)	37% (n = 11)	33% (n = 13)
Welsh	28% (n = 11)	22% (n = 7)	28% (n = 8)	31% (n = 31)	27% (n = 8)	30% (n = 12)

Whilst pupils generally favoured studying these subjects in Welsh at A-level, a bilingual approach seemed to be the favoured choice at University for most subjects. Again, the trend shows that pupils that come from English-speaking homes are more likely to study these subjects at university in English while the pupils from Welsh-medium homes were more likely to opt for the Welsh-language option.

Implication 5: Pupils' preconceptions regarding the linguistic provision at university is a strong factor that influences their choices at school. Universities have a role to ensure schools are aware of the Welsh-medium provision at university, including opportunities to study through the medium of English but produce their assessments in Welsh.

Career choices

When the pupils were asked whether they had considered pursuing a career in which Science, Technology and/or Mathematics was central, 36% (n =26) stated that they had considered this while 21% (n = 15) stated that they had not. The remaining 44% (n = 32) stated that they were unsure. Of those who had noted that they had an interest in pursuing such a career the examples provided included doctor (n = 7), vet (n = 2), nurse (n = 4), surgeon (n = 1), physiotherapist (n = 2), medical research (n = 1), computer scientist (n = 1), engineering (n = 2), forensic psychologist (n = 1), psychologist (n = 1), pathologist (n = 1), zoologist (n = 1) and marine biologist (n = 1).

Pupils were asked whether being able to discuss these subjects in Welsh would be useful for those careers. 51% (n = 30) either strongly agreed or agreed somewhat that being able to discuss these subjects in Welsh would be useful, while 29% (n = 17) of the pupils were unsure of its usefulness and 21% (n = 12) questioned its usefulness.

In addition to their consideration of a STEM-related career, the questionnaire also enquired whether they had any desire to become teachers. 37% (n = 26) of the pupils noted that they had considered a career in teaching, although only 31% (n = 8) of those had considered teaching a STEM subject. Unsurprisingly, female pupils were much more likely to consider a career in teaching (44%, n = 25) as compared to male pupils (8%, n = 1) (χ2 (1, n = 70) = 5.931, p < .05) (although recall that there were any more female respondents than male respondents within the sample).

Many pupils (41%, n=28) believed that an individual's chance of obtaining a job as a STEM teacher would be higher if they were able to teach in Welsh, with a further 48% (n = 33) unsure. Much of the reasoning behind this response focused on the fact that Welsh is compulsory in some contexts aand serves as the medium of delivery, in which case knowledge of Welsh would be essential. Only 12% (n = 8) did not believe that the chance of obtaining a STEM teaching job would be higher if a person could speak Welsh.

Implication 6: Employability sessions in schools need to include reference to the usefulness of Welsh language skills, particularly for STEM-related careers.

Implication 7: Universities should create marketing resources outlining the benefits of becoming a STEM-related teacher and the benefits of being able to teach and study these subjects bilingually.

Attitudes towards Welsh-medium STEM education

In order to explore why the uptake of STEM subjects is low, and many opt to study these subjects in English rather than in Welsh, pupils were asked to provide their opinion around a series of 17 statements that were linked to learning about STEM in school through the medium of Welsh.

Table 7:   Attitudes towards Welsh-medium STEM education

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
Learning about Science, Technology and Mathematics subjects is fun	20% (n = 14)	32% (n = 23)	31% (n = 22)	7% (n = 5)	10% (n = 7)
It's a strange feeling to be learning about Science, Technology and Mathematics in Welsh	6% (n = 4)	20% (n = 14)	21% (n = 15)	21% (n = 15)	32% (n = 23)
It's easy to learn about Science, Technology and Mathematics in Welsh	23% (n = 16)	39% (n = 28)	13% (n = 9)	16% (n = 11)	10% (n = 7)
The English language is better suited to Science, Technology and Mathematical subjects than Welsh	16% (n = 11)	28% (n = 20)	34% (n = 24)	11% (n = 8)	11% (n = 8)
Being able to use Welsh for everything is important	43% (n = 30)	33% (n = 23)	11% (n = 8)	6% (n = 4)	7% (n = 5)

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
I don't care whether I learn about Science, Technology and Mathematics in Welsh or English	16% (n = 11)	22% (n = 16)	24% (n = 17)	18% (n = 13)	20% (n = 14)
I get confused when I learn about Science, Technology and Mathematics in Welsh	6% (n = 4)	29% (n = 20)	19% (n = 13)	26% (n = 18)	21% (n = 15)
I want to be able to learn about Science, Technology and Mathematics in both English and Welsh	28% (n = 20)	35% (n = 25)	24% (n = 17)	6% (n = 4)	7% (n = 5)
Things make more sense to me when I learn about them through the medium of Welsh	20% (n = 14)	27% (n = 19)	20% (n = 14)	21% (n = 15)	13% (n = 9)
I enjoy Science, Technology and Mathematics lessons because I'm able to learn about them through the medium of Welsh A10	9% (n = 6)	18% (n = 13)	38% (n = 27)	13% (n = 9)	23% (n = 16)
I understand Science, Technology and Mathematics subjects better when the content is explained to me in both English and Welsh	28% (n = 20)	27% (n = 19)	21% (n = 15)	14% (n = 10)	10% (n = 7)
I prefer to keep to the English when learning about Science, Technology and Mathematics	17% (n = 12)	17% (n = 12)	35% (n = 25)	10% (n = 7)	21% (n = 15)
I don't enjoy Science, Technology and Mathematics lessons	18% (n = 12)	16% (n = 11)	18% (n = 12)	19% (n = 13)	29% (n = 20)
I enjoy learning about things through the medium of Welsh A14	34% (n = 24)	37% (n = 26)	20% (n = 14)	6% (n = 4)	3% (n = 2)
It's important that I learn about Science, Technology and Mathematics in both Welsh and English so that I can then discuss them with my friends	25% (n = 17)	38% (n = 26)	19% (n = 13)	10% (n = 7)	7% (n = 5)
Learning about Science, Technology and Mathematics in both Welsh and English would be confusing A16	6% (n = 4)	17% (n = 12)	33% (n = 23)	26% (n = 18)	19% (n = 13)
Learning about Science, Technology and Mathematics in Welsh is ok, but we need to know the English terms in order to discover things on the internet etc	54% (n = 38)	26% (n = 18)	11% (n = 8)	3% (n = 2)	6% (n = 4)

Despite only around half of the pupils (52%, n = 37) noting that they thought that these subjects were fun, many more pupils (81%, n = 50) said that they enjoy learning about things through the medium of Welsh, which shows a more positive attitude towards the language than the subjects per se. When asked about their feelings towards using a certain language when studying these subjects, the results were mixed. When asked if things make more sense to them when they are explained in Welsh, 47% (n = 33) agreed and 34% (n = 25) disagreed. A similar pattern was observed when pupils were asked whether they cared if they learnt about the subjects in Welsh or English. 38% (n = 27) agreed and disagreed with the statement. Pupils did, however, see the importance of English in the contexts of these subjects, both in order to be able to discuss them with their friends (63%, n = 43) and to search for the terms on the internet (80%, n = 56).

Implication 8: The perception that STEM-related subjects cannot be 'accessed' in Welsh needs to be addressed.

Opinions on the combined degree

Pupils were asked to provide an opinion about the potential merits of a combined STEM-related degree, despite low interest in choosing such a degree. All responses referred to the breadth of knowledge that studying more subjects would provide and that this, in turn, would result in a greater set of skills and understanding and more opportunities after graduation. Interestingly, one pupil referred to the benefits of allowing an individual to discover which aspects they do enjoy and which aspects they do not, and felt that that would aid the individual to be flexible in their future choices and to be able to choose some aspects over others in a way that would not be possible having studied one subject in isolation.

Pupils were also asked to think about potential disadvantages of studying for a combined degree. A large proportion of the answers referred to the lack of knowledge that one would gain by trying to study many subjects rather than concentrate on one. Some pupils stated that trying to learn about many subjects could put extra pressure on the students:

> "There are many more things to study, which means much more work and a need to buy more books"

> "It's a lot of pressure, you need to learn about a lot of aspects"

> "You have to be good at every aspect"

Others raised the potential for causing confusion if studying a combined degree:

> "The subjects could turn into a mixture, which would make it hard to concentrate and understand properly"

> "Having to concentrate on more than one thing can be confusing"

Implication 9: Any attempt at combining subjects into a single degree programme would need to be designed carefully in order to address concerns around depth of knowledge and the marketing and communication piece around the programme would need to explain the benefits of the combination.

Another two students felt that it could either make it difficult to decide what career to pursue or that a combined degree may highlight weaknesses as the students may have better ability within some aspects compared to others:

> "It can be difficult to know which career to venture for because you haven't studied one specific subject. Also, the employer may want someone with specific skills to the job"

> "Maybe you're very good in one subject but not as good in other subjects, but a degree that teaches a range of subject won't show this"

Implication 10: School and universities need to engage with employers in order to market the opportunities on offer and how various subjects can lead to different employment opportunities, and the benefits of speaking Welsh and English from the employer's point of view.

Pupils were also asked whether they had any other suggestions as to how Universities could help address the shortage in Welsh-medium STEM-related subjects. Many of the responses referred to developing Welsh-medium resources:

> "They could invest on having extra online work provided in the language of Welsh."

> "More study books for Science, Maths and Technology in Welsh to help the pupils"

> "Maybe provide simple books about the subjects in Welsh so that the pupils get used to reading about the subjects in Welsh"

> "Provide more Welsh resources e.g. revision guidance, websites with Welsh information, send teachers on Welsh courses, and employ teachers who can teach through Welsh"

> "Continue to create resources like the GCSE Science booklets that are available for teachers and pupils bilingually, and revision days too. But maybe make more of them and for different levels"

> "Provide/give us work (a year's/term's worth of work) to do on the subject which is useful for the pupils to continue with the work or do 'skype calls' once a week to provide leadership"

Other pupils believed that more could be done to promote these subjects:

> "Talk more about the good things"

> "Discuss it in school and display information so that we understand"

> "Advertise more on social media websites or go around schools to talk about it"

The remaining two pupils had different ideas and noted:

> "Offer them Welsh lessons"

> "Decrease the number of credits that's needed to study to be eligible for bursaries, and offer more credits to study through Welsh"

Implication 11: Universities should liaise with schools/regional consortia to help develop resources and training in Welsh for STEM-related subjects.

SCHOOL TEACHERS

Language choices

Teachers were asked in which language they or others delivered lessons at their school in the following subjects (see Table 8):

Table 8: Language medium in which subjects are delivered

	Biology	Chemistry	Computing	Design & Technology	Physics	Maths
English only	0% (n = 0)	0% (n = 0)	5% (n = 1)	0% (n = 0)	0% (n = 0)	0% (n = 0)
More English than Welsh	10% (n = 2)	10% (n = 2)	0% (n = 0)	0% (n = 0)	10% (n = 2)	0% (n = 0)
Bilingually	14% (n = 3)	14% (n = 3)	19% (n = 4)	24% (n = 5)	14% (n = 3)	24% (n = 5)
More Welsh than English	14% (n = 3)	14% (n = 3)	14% (n = 3)	14% (n = 3)	14% (n = 3)	14% (n = 3)
Welsh only	62% (n = 13)	62% (n = 13)	62% (n = 13)	62% (n = 13)	62% (n = 13)	62% (n = 13)

Most of the lessons were delivered either in Welsh or mostly in Welsh (76%, n = 16), which is not surprising given that almost all of the teachers who participated taught in either a Welsh-medium or a bilingual school (see Methodology). 57% (n = 12) of teachers reported that pupils were given no language choice since studying these subjects through the medium of Welsh was compulsory at their school. 24% (n = 5) stated that there was some level of choice, and 19% chose 'other', which included the fat that a choice is given if they are latecomers to Welsh medium education, or that everything is in Welsh until sixth-form and then there is a choice available (two respondents stated this) or that the choice depends on the results of their assessments in primary school.

According to the teachers, pupils make linguistic choices (where available) based on the following factors: (i) their lack of confidence in one language (n=6); (ii) their lack of knowledge of terms in a given language (n=2); (ii) the availability of resources in a language (n= 4); (iv) the desire to gain two sets of terminology (n=3); and (v) the language

they would then use to study in university (n=1). 4 of the teachers selected 'other' by elaborating two factors that they believe to also be influential, namely (i) if they are latecomers to Welsh-medium education (n = 2) and (ii) the home language of the pupils (n = 2).

Implication 12: Self-perception of abilities in Welsh influences linguistic behaviour from a young age (Thomas, Lewis & Apolloni, 2012; Thomas, Apolloni & Lewis, 2014). Ensuring pupils are aware that terminology is learned in a piecemeal fashion, item by item, in English and in Welsh, may help readjust their feelings of inadequacy with the language per se.

Shortage of teachers

95% (n = 20) of the teachers agreed that there is currently a shortage of teachers in STEM-related subjects. When asked why that was so, some related the shortage to the general lack of interest in the subject:

"Less study it at University"

"There's a lack of interest in the subject"

"Science subjects are challenging"

"The number that are studying it at A-level tends to be low, so there are less with the essential qualifications and the confidence to teach it"

Other teachers stated that pupils didn't wish to become teachers and that they wish to have careers that are linked directly to the subject that they have studied rather than to teach it:

"Not many young people want a career as a teacher. Pupils choose easier subjects at University"

"When talking about my own subject, which is Biology, very little A level pupils choose to follow an University course which leads to Education. Most of them either don't choose to study biology at all or they tend to choose courses such as Medicine, Veterinary or Dental which then leads to a career in those fields."

"Education is a difficult job and a degree in Physics can lead to many more opportunities beyond Education"

The remainder of the teachers noted the following reasons:

"No emphasis is given on the subject [technology], despite it being a STEM subject, as the emphasis is on Mathematics and Science, and no mention of Engineering or Technology"

"In my opinion, there are no provision for Mathematics or Physics degrees in North Wales, so there are not enough people here with enough knowledge to teach these subjects"

"We need many specialists because these are core subjects"

"We don't have time to look for teachers to fill the jobs"

Teachers were asked what measures are currently being undertaken to try and address the need for additional teachers and how effective are those strategies in solving the issue (see Table 9):

Table 9: Current measures and their effectiveness in addressing the shortage of STEM teachers

Current measures	Effectiveness
• To get a teacher to teach in English but the notes are available in Welsh	• Less effective than a teacher to teach through Welsh but better than nothing
• Employ someone without specialism in the subjects	• It depends on how long they are employed
• Science and Design and Technology are very specialist subjects, with an intense element of health and safety. There is no way in my opinion to ask individuals who aren't qualified to teach these subjects, HSE are clear in their expectations. There will have to be a raise in status in these subjects, especially Technology, but the schools concentrate on the National targets so as a results the core subjects are given more teaching time, and of course more pupils then continue with these subjects at A-levels because of it	• I feel that the Government will have to re-evaluate their ways of assessing schools. The foundation subjects are not given a fair chance at the moment.
• Try and nurture the independence of our students. The GwE officers have increased the number of visits and levels of support. The Tanio website has been a great support.	• Everything is a help, but at the end of the day, the pupils are under raising [sic] disadvantages
• There's a need to give a higher salary to the subjects where there is a shortage. The schools appoint teachers or assistants without background in the subject to teach	• It addresses the need, but it makes the problem worse as the pupils then turn their backs on the subjects as soon as they can
• English-medium teacher, Welsh leaflets	• I'm not sure, I'd have to ask the pupils
• Teachers who are not Welsh	• Quite, but not a long-term answer
• Distance learning	• Less effective
• We have to try and persuade Welsh people to come out of retirement or come back to teaching if they have left, or get English speaking staff	• Not at all! You have to either rely on people to do you favours or the lessons will be taught through English. This can cause uncertainty to the pupils if there are many supply teachers in the meantime
• Teachers teaching beyond their speciality	• Not as effective as receiving an education who are specialist, especially beyond foundation GCSE
• Usually the school chooses a teacher who is Welsh but is a specialist in other fields	• It can affect the standard of teaching the subject
• Supply teachers or teachers from other subjects	• Not effective
• Employ teacher who teachers a similar subject	• Not as effective as having a specialist in the subject
• Use teachers that aren't qualified to teach the subject but that they can speak Welsh	• Not idea, but when there is good sustainability [sic] from the subject/line head, it can work quite well. But you have to avoid giving them exam classrooms if possible.

Importance of Welsh

Teachers were asked about how important they felt the Welsh language was in various contexts (see Table 10):

Table 10: Importance of the Welsh language in different contexts for teachers

	Very important	Quite important	Unsure	Not very important	Not important at all
Academic	33% (n = 7)	52% (n = 11)	10% (n = 2)	5% (n = 1)	0% (n = 0)
Research	10% (n = 2)	67% (n = 14)	19% (n = 4)	0% (n = 0)	5% (n = 1)
Science	14% (n = 3)	67% (n = 14)	14% (n = 3)	0% (n = 0)	5% (n = 1)
Media	57% (n = 12)	38% (n = 8)	0% (n = 0)	5% (n = 1)	0% (n = 0)
In their own work	76% (n = 16)	24% (n = 5)	0% (n = 0)	0% (n = 0)	0% (n = 0)
Industry	14% (n = 3)	48% (n = 10)	33% (n = 7)	0% (n = 0)	5% (n = 1)

Most teachers believed that being able to converse in Welsh within these contexts was important. This was especially true in their own work and in the media. However, teachers were less convinced that Welsh was important out in industry, although 48% thought it was quite important and a further 13% though it was very important.

Implication 13: Industry partners need to be consulted in order to identify where the benefits of speaking Welsh may lie, and these opportunities need to be made clear to pupils and teachers.

When asked to state why they thought that being able to use Welsh in these contexts were important, some teachers believed that it was important in order to raise the status of the subjects:

"We must give the language a status within STEM fields publicly to raise awareness of being able to use Welsh in Science successfully"

"To raise the status of Welsh within the world of work"

Other teachers believed that it was important due to our rights to be able to use the language:

"These subjects are an essential part of our lives and without being able to discuss them in Welsh, Welsh is going to disappear from being an essential part of our lives"

"To improve on the standard of the language in resources and to emphasise on Welshness and bilingualism to make it more important in Wales"

"So that we can use our first language in our work from day to day"

"Our first language!!"

"The language in which the above contexts are discussed shouldn't be confined to English"

"There must be a freedom/choice to discuss in Welsh within every aspect of life"

Conversely, another two respondents felt that being able to discuss these subjects in Welsh is not the reality out in industry:

"In the industry sector, it's not essential to be able to speak Welsh"

"Most of the communication happens in English in Universities (because most of the lecturers are English). Any communication that happens in research between centres that include at least one group from outside Wales also happens in English – the same is said about the world of work"

Implication 14: Developing healthy attitudes towards the importance of heritage language maintenance and its place in all disciplines should underpin all teaching throughout the curriculum.

Resources

Having adequate resources in the language of instruction can play an important role in delivering a subject. Teachers were asked their opinion about the current provision in terms of Welsh-medium resources (see Table 11):

Table 11: Current provision of resources

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
There are enough Welsh language educational resources available	0% (n = 0)	19% (n = 4)	0% (n = 0)	62% (n = 13)	19% (n = 4)
Welsh-medium and English-medium educational resources are of the same standard	0% (n = 0)	19% (n = 4)	0% (n = 0)	52% (n = 11)	29% (n = 6)
There are more English-medium resources available on computers	80% (n = 16)	10% (n = 2)	10% (n = 2)	0% (n = 0)	0% (n = 0)
The Welsh-medium resources that are available are adequate in ensuring high marks in examinations	5% (n = 1)	29% (n = 6)	29% (n = 6)	29% (n = 6)	10% (n = 2)
Good quality Welsh-medium resources are rare	38% (n = 8)	43% (n = 9)	5% (n = 1)	14% (n = 3)	0% (n = 0)
Welsh-medium resources tend to be direct translations from English versions	29% (n = 6)	52% (n = 11)	14% (n = 3)	5% (n = 1)	0% (n = 0)
Bilingual resources are rare	43% (n = 9)	38% (n = 8)	10% (n = 10)	10% (n = 10)	0% (n = 0)
Welsh-medium resources are often available after English-medium ones	81% (n = 17)	14% (n = 3)	5% (n = 1)	0% (n = 0)	0% (n = 0)
There is a need for more modern and attractive Welsh-medium resources	57% (n = 12)	38% (n = 8)	5% (n = 1)	0% (n = 0)	0% (n = 0)
Adapting teaching Science, Technology and Maths to Welsh-medium is easy	10% (n = 2)	19% (n = 4)	48% (n = 10)	19% (n = 4)	5% (n = 1)

Most of the teachers (81%, n = 17) didn't think that there were enough Welsh language resources available, and that those that did exist were not of the same standard as English ones (81%, n = 17), and were direct translations from the English versions (81%, n = 17). The teachers also believed that bilingual resources were rare too (81%, n = 17) and that there was a need for more attractive and modern Welsh-medium resources to be made available (96%, n = 20).

The teachers were also asked whether the resources available have an influence on pupils' choice to study Science, Technology and/or Mathematics subjects further. One was of the opinion that resources had no influence on pupils' choices at all, four believed that it had little influence, five were unsure, and 11 (52% of the teachers) thought that it had at least some, or a large influence on pupils' choices.

Teachers were invited to share any additional comments that they may have regarding resources. Some of the comments referred to specific shortages of resources:

"There's a huge shortage of resources, and again, there are more choices in the core subjects compared to the foundation subjects"

"I would like more bilingual resources for KS3, 4 and 5"

"There's a shortage of Welsh-medium resources for A-level maths"

"This is definitely true for A-level"

Others made several comments:

"Resources are produced under time pressures before final exams. The English material are produced first, and then translated to Welsh. Many times, this has meant that the English materials are ready in time for revision periods, but the Welsh ones haven't been made ready in time, so the Welsh-medium students have been under immense pressure, and their grades, possibly, have been lower than they would've had they had the correct resources"

"The worst thing about teaching through the medium of Welsh is to spend hours creating our own resources because there aren't many resources of good standard – especially online. Resources that are suitable for the lower ability GCSE levels are the worse, as WJEC resources are translated from English and the language is too formal for most pupils apart from the most able first language students, and in our area, these pupils are rare. This is also true for the resources that are aimed towards the foundation tier"

"After teaching for 11 years through the medium of English, I've struggled this year. I either use the schools' powerpoints, which are very good with many differentiations for abilities but then there's no variety in the resources or I use X's website which is the only other useful place – after that it's hit and miss to get resources of adequate quality"

"In bilingual schools the resources have to be the same. There's no problem in finding Welsh resources but because every class that I teach is bilingual, it's essential that the resources go together"

Implication 15: Investing in high quality, Welsh-medium and bilingual resources that are suitable for a wide variety of learners and developed alongside rather than being adaptations or translations of English resources should be a reality.

Training

A section of the questionnaire enquired about training opportunities. When asked whether any specific training to support teachers who teach Science, Technology or Maths through the medium of Welsh currently existed, A third of respondents (n = 7) reported that there was training available to support teachers who teach STEM subjects through the medium of Welsh, whilst the majority (57%, n = 12) were unsure and a further two reported that none existed. However, only 29% of the sample felt that there was a need for more training opportunities. 67% (n = 14) were unsure and the remaining 19% (n = 2) did not feel there to be a need in this area. Those who stated that they did see the need for additional training were invited to suggest types of training that they thought would be beneficial. Three of the responses referred to the opportunity to improve teachers' Welsh language skills:

"Training on teaching Science through Welsh to graduates who have studied Science in English and have a lack of confidence in studying for their PGCE in Welsh. This should be before the PGCE."

"Speaking training to help teachers who are Welsh learners to teach through Welsh. Also, a service for them that checks their resources for the ones who have learnt Welsh"

"Language accuracy and styles, and how to use it and model it in lessons"

Another respondent said that the current training on county level should be conducted through the medium of Welsh as it's currently done mostly in English while the last two respondents referred to training on resources:

"Bring attention to bilingual resources. The problem is that when a resource is only available in Welsh it's difficult to teach English-medium pupils at the same time, because the material is set around the same topics but there are different sources for the rest of the class"

"A consortium to share resources"

Various ideas around training were given to the teachers and they were asked to rate how useful these opportunities would be (see Table 12):

Table 12: Potential effectiveness of training possibilities

	Very useful	Quite useful	Not sure	Not very useful	Not useful at all
Training on how to deliver the subject in Welsh	38% (n = 8)	29% (n = 6)	24% (n = 5)	0% (n = 0)	10% (n = 2)
Training on bilingual delivery methods, where there is no need to be fluent in Welsh	14% (n = 3)	43% (n = 9)	24% (n = 5)	14% (n = 3)	5% (n = 1)
Language training to raise confidence in using Welsh	33% (n = 7)	38% (n = 8)	14% (n = 3)	5% (n = 1)	10% (n = 2)
Training on the importance of Welsh within these subjects	29% (n = 6)	38% (n = 8)	19% (n = 4)	14% (n = 3)	0% (n = 0)
Training in one of the above with accreditation	10% (n = 2)	33% (n = 7)	43% (n = 9)	10% (n = 2)	5% (n = 1)
Training in one of the above that would transfer to Masters-level credits	14% (n = 3)	29% (n = 6)	43% (n = 9)	5% (n = 1)	10% (n = 2)

As can be seen in Table 12, there was some enthusiasm for general language training to raise confidence in using Welsh (71% in favour), for training on how to deliver the subject in Welsh (67%), for training on the importance of Welsh within these subjects (67%), and for training on bilingual delivery (57% in favour). There was, however, less enthusiasm for accredited forms of such training (43%).

Implication 16: Teachers are in favour of Continued Professional Development in areas related to the teaching of STEM subjects through the medium of Welsh/bilingually and in the importance of Welsh within these subjects. However, such training need not be credit bearing or form part of an academic pathway.

Opinions on the degree

Only 57% (n = 12) of teachers reported that they were fully or partially aware of which Universities support the teaching of STEM-related subjects through the medium of Welsh, and share this information with their pupils. The remaining 43% were either unsure (n = 7) or unaware of which Universities supported the teaching of these subjects through the medium of Welsh (n=2). When asked about their opinions on various statements relating to the idea of a combined BSc degree that would lead to a postgraduate teaching course through the medium of Welsh, the following results emerged (see Table 13):

Table 13: Opinions on statements related to a potential combined BSc degree

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
A combined Welsh-medium BSc degree would reduce the shortage of qualified teachers	5% (n = 1)	57% (n = 12)	24% (n = 5)	14% (n = 3)	0% (n = 0)
A degree such as this would create teachers without in-depth knowledge of any of the subjects	14% (n = 3)	24% (n = 5)	43% (n = 9)	19% (n = 4)	0% (n = 0)
A BSc degree in Science or Technology would be better than a BSc degree in Science and Technology	24% (n = 5)	19% (n = 4)	52% (n = 11)	5% (n = 1)	0% (n = 0)
Some subjects are easier to combine than others	14% (n = 3)	57% (n = 12)	29% (n = 6)	0% (n = 0)	0% (n = 0)
The field is too large to include a large amount of subjects	29% (n = 6)	33% (n = 7)	38% (n = 8)	0% (n = 0)	0% (n = 0)
An experience of teaching every subject would be required as a part of the degree	24% (n = 5)	43% (n = 9)	24% (n = 5)	5% (n = 1)	5% (n = 1)
A degree such as this would be a good foundation for Secondary PGCE	5% (n = 1)	38% (n = 8)	10% (n = 10)	10% (n = 10)	10% (n = 2)
A degree such as this would be a good foundation for Primary PGCE	24% (n = 5)	48% (n = 10)	19% (n = 4)	10% (n = 2)	0% (n = 0)
It would be better to include QTS into the degree than to expect the students to do a PGCE after the degree	0% (n = 0)	24% (n = 5)	76% (n = 16)	0% (n = 0)	0% (n = 0)
Stretching the course to a 4-year course including QTS would be a better option	5% (n = 1)	33% (n = 7)	62% (n = 13)	0% (n = 0)	0% (n = 0)

62% (n = 13) of teachers agreed that a combined degree would reduce the shortage of qualified teachers, however 62% (n = 13) were of the opinion that the field was too large to combine too many subjects. The teachers thought that the degree would be much better suited as a foundation for a primary PGCE (72%, n = 15) than it would for a secondary PGCE (43%, n = 9), although only 38% felt that such a degree would create individuals without in depth knowledge of the field.

In terms of combining subjects into a single degree, there were no strong feelings towards a combined science and technology degree, with 52% undecided, although 71% were of the opinion that some subjects are easier to combine than others:

> They need a solid foundation of the principles of how Science works by researching via a variety of different methods, fair testing, interpreting, presenting information and measuring validity and strengths of conclusions. Any Scientific topics that are interesting and current can be adapted to present these

> "Physics and Maths possibly. Maths, Physics (Chemistry?) and Engineering. Biology, Chemistry and Physics. Biology, Chemistry and Food Technology"

> "Many combinations would be suitable. Maths/ Technology, Science/Technology, Science/Maths"

> "There would be a need to include all subjects but Physics, Technology and Mathematics are a natural combination"

> "KS3 – Science and Technology in terms of the Curriculum for Wales"

> "Science and Technology "x3

> "Mathematics and Science" x2

> "The three Sciences" x2

> "Maths and Physics" x2

However, some of the answers highlighted a strong reluctance to combining subjects at all:

> "I don't feel that subjects should be combined at all, the field is very extensive as it's shown in Donaldson's research – I don't support the idea for Secondary, especially at A-levels

> I strongly agree that these fields are to extensive to develop confidence and a solid understanding in each one"

> "I wouldn't combine the subjects"

In commenting freely about the idea of a combined degree, two of the respondents felt that the degree would be unsuitable for Secondary education:

> "Not suitable for Secondary level. Technology is five subjects, textiles, graphics, food, resistant materials and electronics, then Science is three, biology, chemistry and physics and mathematics is two so it's not suitable to combine them as the field is too big. There would be a big, big worry about the standards of the pupils' health and safety with an individual who has only had a superficial course in each field, and it must be remembered that HSE requirements must be met when teaching these subjects"

> "A combined degree wouldn't be adequate to teach beyond GCSEs, even foundation GCSEs perhaps. Certainly not A level"

However, three of the teachers were more enthusiastic about the idea:

> "It's a great idea to fire an interest in Scientists to consider a degree in Education. Many degree courses require high grades which eliminate good learners with average A level grades. This would be a good chance to keep Welsh scientists in the field"

> "It sounds very appropriate for the new Curriculum for Wales"

> "It sounds like a good idea"

Teachers were also asked whether they believed that there was anything else that Universities could do to rectify the shortage. The ideas that were suggested were:

> "Offer more courses in the North"

> "Offer more money for studying the course in Welsh"

> "Tempt Welsh pupils to stay in Wales to study"

> "Create a combined degree but with an opportunity for the students to specialise in a subject e.g. Biology which leads to specialism and confident to teach A level in the chosen subject"

> "Promote the importance of the subjects. Activities for KS3, this is when there's a need to capture the interest of the pupils. Show the possibilities, what courses are available, experiences."

> "Courses in the Universities to make a connection between the school pupils and the University so that they see the University and a Welsh course as an option to them"

> "Use their influences to improve on the workload in the schools to encourage more student to go into teaching"

> "Not cut courses such as a Chemistry through Welsh like they have already!!!!!"

> "Encourage the Government to decrease the workload on teachers and lessen the strain on them"

At the end of the questionnaire teachers were given an opportunity to provide any additional comments. The comments provided questioned the extent to which STEM subjects are supported through the medium of Welsh at university:

> "Universities in Wales must continue to support the language in the academic world by offering courses through Welsh. The Sciences are certainly considered to be English subjects – with many Welsh schools teaching A levels through English for years after the qualification became available in Welsh. It's essential that Welsh Universities support Welsh in these subjects on an academic level rather than seeing the language as something that's only suitable for poems and poets only!"

> "Are the Universities in Wales that offer Mathematics, Science and Technology degrees offering them through the medium of Welsh?"

Implication 17: Not all teachers are aware of what universities have on offer with regards to Welsh-medium teaching for STEM-related courses. There is a clear need to expand on what is currently on offer, and to better support the provision that exists currently.

UNIVERSITY STUDENTS

Background information

Seven students participated in the questionnaire for students. These informants were studying Science, Technology or Mathematics as subjects at University. All students were female, and had studied the following A-levels:

Subject	Number of pupils	Percentage
Maths	n = 7	100%
Physics	n = 2	29%
Chemistry	n = 5	71%
Biology	n = 4	57%
Geography	n = 1	14%
Design and Technology	n = 1	14%
Welsh Baccalaureate	n = 4	57%
Welsh	n = 1	14%
Religious Studies	n = 3	43%
Health and Social Care	n = 1	14%
Art	n = 1	14%
Medical Sciences level 3	n = 1	14%

Only one of the students had studied their A-levels in English. Two had studied them in Welsh, and four had studied some subjects in Welsh and some in English. Five of the students were happy with the language(s) they chose to study their A-level subjects, for the following reasons:

"There were no revision books available in Welsh"

"I was happy to learn through my home language"

"I'm used to studying through Welsh and that's what's easiest for me"

"Welsh is my first language so it's easier for me"

The two remaining students would have preferred to study in a different language (in Welsh), and explained why they ultimately chose to study in English:

"I would've preferred to do all of my subjects through the medium of Welsh, but after a discussion with the teachers, there were more books etc available in English"

"There were more resources available through the medium of English and the teachers were more confident to communicate and teach the subjects in English because they'd studied the subjects in English themselves at University/Secondary School"

Implication 18: Student preference is often influenced by teacher bias and this can influence future engagement with Welsh in relation to STEM-related study/work.

University choices

All students, bar the one studying Welsh, were studying their subjects either mostly or entirely through the medium of English although two were writing their assignments in both languages. Only two noted that there were some opportunities to study their subjects in Welsh.

Attitudes

As was the case with the school pupils,, the students were asked to provide their opinion on a series of 17 statements that were linked to learning about STEM subjects through the medium of Welsh. Their results are shown in Table 14.

Table 14: Attitudes towards statements relating to STEM and the Welsh language

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
Learning about Science, Technology and Mathematics subjects is fun	57% (n = 4)	43% (n = 3)	0% (n = 0)	0% (n = 0)	0% (n = 0)
It's a strange feeling to be learning about Science, Technology and Mathematics in Welsh	0% (n = 0)	14% (n = 1)	0% (n = 0)	29% (n = 2)	57% (n = 4)
It's easy to learn about Science, Technology and Mathematics in Welsh	29% (n = 2)	71% (n = 5)	0% (n = 0)	0% (n = 0)	0% (n = 0)
The English language is better suited to Science, Technology and Mathematical subjects than Welsh	0% (n = 0)	57% (n = 4)	14% (n = 1)	14% (n = 1)	14% (n = 1)
Being able to use Welsh for everything is important	71% (n = 5)	29% (n = 2)	0% (n = 0)	0% (n = 0)	0% (n = 0)
I don't care whether I learn about Science, Technology and Mathematics in Welsh or English	29% (n = 2)	29% (n = 2)	14% (n = 1)	14% (n = 1)	14% (n = 1)
I get confused when I learn about Science, Technology and Mathematics in Welsh	0% (n = 0)	29% (n = 2)	29% (n = 2)	0% (n = 0)	43% (n = 3)
I want to be able to learn about Science, Technology and Mathematics in both English and Welsh	86% (n = 6)	14% (n = 1)	0% (n = 0)	0% (n = 0)	0% (n = 0)
Things make more sense to me when I learn about them through the medium of Welsh	43% (n = 3)	43% (n = 3)	14% (n = 1)	0% (n = 0)	0% (n = 0)
I enjoy Science, Technology and Mathematics lessons because I'm able to learn about them through the medium of Welsh	14% (n = 1)	14% (n = 1)	57% (n = 4)	14% (n = 1)	0% (n = 0)
I understand Science, Technology and Mathematics subjects better when the content is explained to me in both English and Welsh	57% (n = 4)	14% (n = 1)	29% (n = 2)	0% (n = 0)	0% (n = 0)
I prefer to keep to the English when learning about Science, Technology and Mathematics	0% (n = 0)	14% (n = 1)	29% (n = 2)	14% (n = 1)	43% (n = 3)
I don't enjoy Science, Technology and Mathematics lessons	0% (n = 0)	0% (n = 0)	14% (n = 1)	29% (n = 2)	57% (n = 4)
I enjoy learning about things through the medium of Welsh	86% (n = 6)	14% (n = 1)	0% (n = 0)	0% (n = 0)	0% (n = 0)
It's important that I learn about Science, Technology and Mathematics in both Welsh and English so that I can then discuss them with my friends	57% (n = 4)	29% (n = 2)	0% (n = 0)	0% (n = 0)	14% (n = 1)
Learning about Science, Technology and Mathematics in both Welsh and English would be confusing	0% (n = 0)	29% (n = 2)	29% (n = 2)	14% (n = 1)	29% (n = 2)
Learning about Science, Technology and Mathematics in Welsh is ok, but we need to know the English terms in order to discover things on the internet etc	71% (n = 5)	29% (n = 2)	0% (n = 0)	0% (n = 0)	0% (n = 0)

Despite all students thinking that learning STEM subjects in Welsh is both easy and fun, 86% thinking that things make more sense when STEM is taught in Welsh, and all students thinking that being able to use Welsh for everything is important, there was an equally strong belief regarding the importance of being able to learn about STEM in both English and Welsh. 86% felt that a bilingual approach was important in order that they are able to converse with their friends about the subjects, 71% felt that they understand STEM subjects better when they are explained to them in both English and Welsh, and all students felt that supplementing Welsh-medium learning with English terminology is important for internet searches. Only one student preferred to stick to English when learning about STEM subjects. Despite these positive beliefs, responses were mixed in relation to their beliefs about whether juggling two linguistic mediums would be confusing or not.

Implication 19: Being able to access knowledge in both languages is a clear consideration for students. Combining the languages in delivery would benefit students whilst allowing them to study in the main in their preferred language.
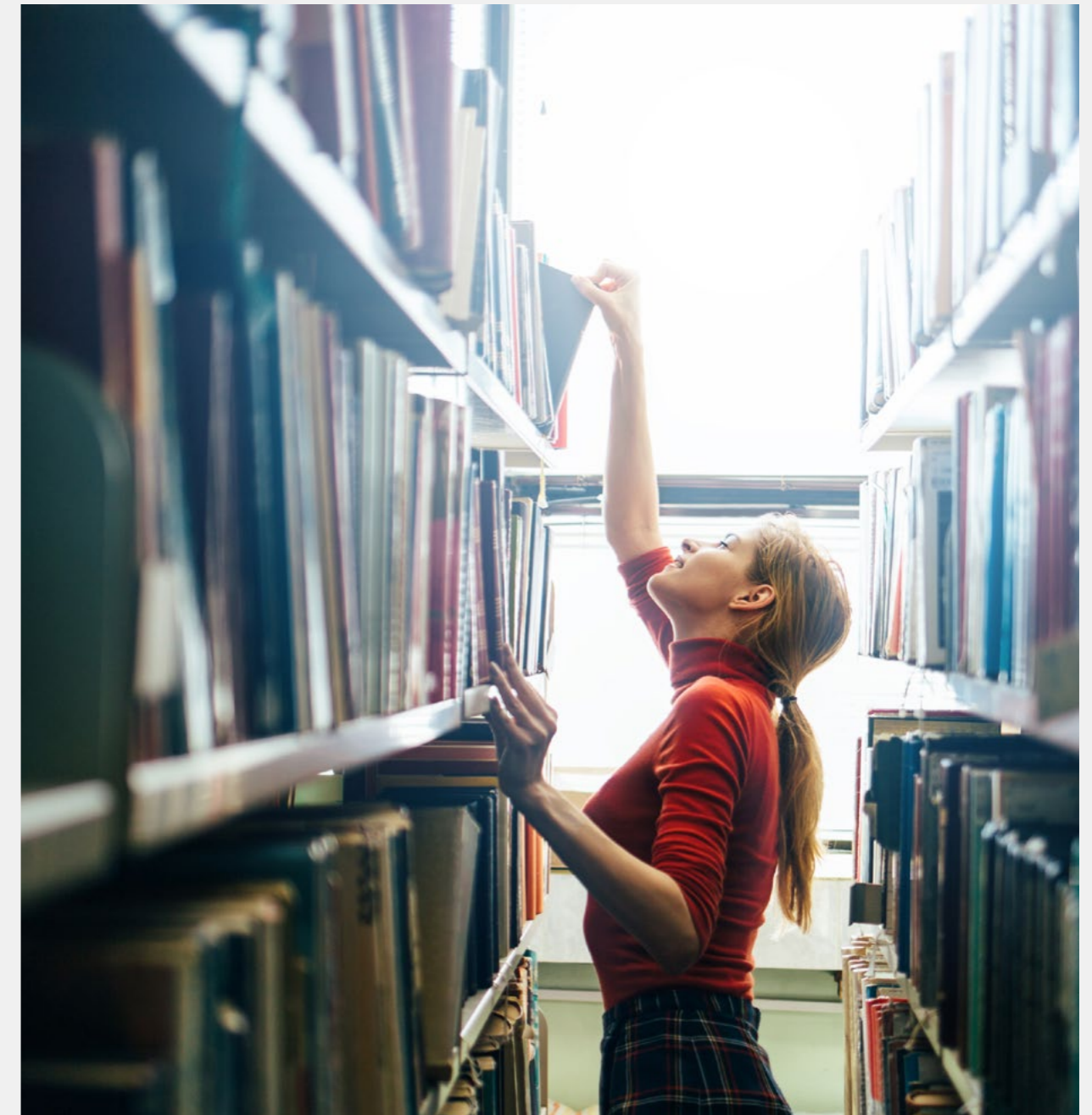
Career choices

All students were set on careers that were directly related to the subjects they were learning. When asked whether they had considered a career in teaching, 71% (n = 5) answered that they had while the remaining 29% (n = 2) stated that they had not. The students were also asked whether they would feel confident to teach through the medium of Welsh. While one student was unsure, 86% (n = 6) felt that they would be quite or very confident. When asked to list the subjects that they would feel confident teaching, they provided the following combinations, which suggests that their A-level subjects and/or degree programmes provide scope for potential 'generic' teachers:

Engineering, Technology and Science

Biology, Chemistry and Mathematics

Mathematics and Technology

Mathematics (two respondents)

Mathematics and Biology

The students were also required to answer whether they believed that having teachers who were able to teach a range of STEM-related subjects would be beneficial. One student was unsure, however the remaining 86% (n = 6) believed that it would be useful and provided the following reasons as to why:

"They could demonstrate the relationship between the subjects"

"More opportunities to get a job"

"Because these subjects are all somehow connected to each other, it's important to understand so much for each one"

All students agreed that being able to speak Welsh would put a teacher in better stead of getting a job.

Implication 20: Students often consider teaching as a next step after graduation. There is potential here to convert more students into the profession with careful marketing, and Welsh-speaking students are often confident and ready to pursue a PGCE course in Welsh.

Combined degree

The students were asked, if they were to consider their University choices again, how likely would they be to consider the combinations outlined in Table 15:

Table 15: Likeliness of choosing the following subjects at University

	Very likely	Quite likely	Not sure	Quite unlikely	Very unlikely
Combined Sciences	71% (n = 5)	0% (n = 0)	0% (n = 0)	29% (n = 2)	0% (n = 0)
Combined Technology	14% (n = 1)	0% (n = 0)	14% (n = 1)	29% (n = 2)	43% (n = 3)
Combined Sciences and Maths	86% (n = 6)	0% (n = 0)	14% (n = 1)	0% (n = 0)	0% (n = 0)
Combined Sciences and Technology	14% (n = 1)	14% (n = 1)	14%1 (n = 1)	4% (n = 1)	43% (n = 3)
Combined Technology and Maths	29% (n = 2)	0% (n = 0)	14%1 (n = 1)	14% (n = 1)	43% (n = 3)
Combined Sciences, Technologies and Maths	29% (n = 2)	29% (n = 2)	0% (n = 0)	29% (n = 2)	14% (n = 1)

The students were much more likely to consider a combined Sciences with or without Mathematics degrees (71%, n = 5 for the combined Sciences and 86%, = 6 for the combined Sciences and Maths degrees) than they were to consider a combination involving Technology subjects. This however should be expected, as nearly all the participants were studying either Science subjects or Mathematics at University. Had there been response from Technology students, the percentages may have been different as the students have bias towards their chosen fields.

The students were asked what they thought would be the benefits of a combined degree. Two of the responses noted that it would lead to more opportunities:

"A better range of jobs after graduating"

"It provides more opportunities and variety"

While the other two students stated:

"It enables you to teach more than one teaching job, and it also means that individuals who enjoy more than one of these subjects can continue to expand on their knowledge and learn about more than one subject"

"It can show how these subjects can be used in different aspects"

The students were also asked about any disadvantages that may come with a combined degree. Similar to the responses provided by teachers, three of the students highlighted that a teacher may not have the same depth of knowledge in a subject, while another response refers to the possibility that a specialised teacher may have a better chance of getting a job in one particular subject:

"Less expertise in one subject"

"Can't focus/specialise in one subject"

"It could be a disadvantage having to study a range of subject in terms of detail – it's hard to study each subject in detail within 3 years"

"People who have concentrated on one subject could have a better chance of getting a job in that subject maybe"

The students also had some ideas about other avenues that could be explored in terms of what Universities could do to help to address the problem of a shortage of Welsh-medium teachers in this field. These suggestions included:

"Offer whole courses through the medium of Welsh"

"Offer an educational Post-graduate course (similarly to the BSc that is described at the beginning of this questionnaire) to combine the subjects"

"Offer Mathematics as a degree at X University. I would've loved to study this course as a joint-honours degree with Welsh and I know of many more that would've been interested in Mathematics in X"

"There's a lack of recruiting within Secondary education. When I was researching into University courses, the people recruiting would talk of the benefits of studying a Science degree and the funding to do the degree tempted me quite easily"

At the end of the questionnaire, the students were offered to contribute any further comments. Two of the students decided to do so and said:

"When I was thinking about University choices I saw that I could only do about 22% of the Mathematics course through the medium of Welsh so I decided to do it all in English because it was less confusing to do it in one language"

"Because of circumstances, I had to follow a single-honours Welsh degree in X, but the option to do a joint Welsh and Mathematics course would've really allured me"

Implication 21: In developing any form of a combined degree, issues relating to depth vs breadth needs to be explored.

Implication 22: Opportunities to combine science and technology with the arts and humanities should also be explored in order to create Welsh-speaking students with the potential to teach some science through the medium of Welsh.

UNIVERSITY LECTURERS

Background information

The questionnaire for lecturers was sent out to relevant departments in Universities across Wales. 10 lecturers responded to the call. 60% (n = 6) were male, 30% (n = 3) were female and 10% (n = 1) didn't reveal their gender. These lecturers were based in Computer Science and Electrical engineering, Education, Mathematics and Chemistry departments.

Language choices

Just around a third (30%, n = 3) of the lecturers reported that their students can choose to study through the medium of Welsh or English with no exceptions. A further 40% (n = 4) noted that their students are given some freedom to choose, and one noted that everything is delivered bilingually. Another lecturer noted that 'If they have qualifications in Welsh or a pass a Welsh proficiency test they can study in Welsh.' Only one lecturer noted that students haven't got a choice and that everything is provided in English only.

In terms of the actual linguistic provision on offer within their departments, two of the respondents noted provision was available in both Welsh and English, two reported that delivery was bilingual and one reported that delivery was in English only. Another stated that whilst both Welsh and English were used, English was used more so, due to English being student's preferred language in most cases. Another reported that it was mostly English, but a few Welsh medium modules were offered. The remaining lecturer reported that it was English mostly, but they would offer some Welsh modules when staff capacity allowed.

When asked which of a series of factors they believed to influence students' linguistic decisions relating to their chosen medium of study, confidence was noted by five lecturers, resources and the need to learn two sets of vocabulary was noted by three, the lack of knowledge

of Welsh terminology was notes by one, and the need to continue in the same language as their school language was noted by two. Six lecturers also chose 'other', and provided the following additional factors:

"To be given access to teaching jobs through the medium of Welsh"

"Sometimes, they have no interest in continuing to learn through Welsh"

"There aren't enough modules available to be eligible for the CCC bursary"

"It's hard to say. Every student makes the choice for different reasons. I can think of students who choose based on each of the above choices. I think that the language choice comes second to the students who come to study Science. It's an interest in Science they have, and the language comes second to this"

"How comfortable and confident they are. We often suggest that they follow a module through their weakest language so that they develop that personally"

> **Implication 23:** Lecturers are aware of the variety of reasons why students opt to study in Welsh, English or bilingually. Addressing these factors directly in Open Days is essential to help reassure students where Welsh-medium and/or bilingual provision is available and provides additive experiences.

Shortage of teachers

All lecturers reported that they had experienced a shortage of Welsh-speaking students that progressed onto a QTS course in STEM-related subjects. When asked which subjects struggled the most, all subjects were mentioned in one way or another:

"Physics & Chemistry"

"There is a shortage in every Science subject by now"

"There is certainly a shortage within D&T"

"They all have an equal shortage"

"I'm not sure, but there is a big shortage in Mathematics, with some schools that don't have an expert at all apparently"

"I am only familiar with Chemistry. I know quite a few WM teachers and they are all very well-qualified. So I'm not sure that Chemistry is too bad"

When asked what they believed was responsible for the shortage, the responses included issues relating to language abilities and generic issues relating to how the profession is viewed currently:

"Not many students have been educated or have language skills to a sufficient level"

"The numbers that train now are very low – this could be as a result of policies and the Government requirements but the number who are to be teachers across all ages, subjects and language has dropped significantly. This year, only one physics teacher training through the medium of Welsh (in [our university])"

"This is the £64,000 question! A job as a teacher doesn't appeal as it did. There are grants available to study in England. Less students are doing the subject at A-level"

> **Implication 24:** University lecturers are aware of the issues relating to the shortage of Welsh-speaking teachers who can teach STEM-related subject. There is room to market teaching as a viable exit pathway, at Open Days and throughout the 3 years of the degree. At the same time, highlighting the benefits of teaching in Welsh and in English, and sharing information about the language support that is often available at universities, could help alleviate some of students' fears around pursuing STEM subjects in Welsh.

Importance of Welsh

The lecturers were asked about how important they felt the Welsh language was in the following contexts:

Table 16: The importance of the Welsh language in various contexts for lecturers

	Very important	Quite important	Unsure	Not very important	Not important at all
Academic	40% (n = 4)	50% (n = 5)	10% (n = 1)	0% (n = 0)	0% (n = 0)
Research	30% (n = 3)	20% (n = 2)	10% (n = 1)	30% (n = 3)	10% (n = 1)
Science	50% (n = 5)	0% (n = 0)	40% (n = 4)	0% (n = 0)	10% (n = 1)
Media	70% (n = 7)	20% (n = 2)	0% (n = 0)	10% (n = 1)	0% (n = 0)
In their own work	40% (n = 4)	40% (n = 4)	10% (n = 1)	0% (n = 0)	10% (n = 1)
Industry	40% (n = 4)	40% (n = 4)	10% (n = 1)	10% (n = 1)	0% (n = 0)

Welsh was clearly seen as important in all context, particularly in the media, in their own work, and out in industry, but less strongly felt in relation to research. This may be due to the English bias in academic writing, particularly within STEM-related disciplines. In fact, two lecturers stated that academic journals are mostly in English, which has an effect on the language choice in research and academia:

"Unfortunately, English is the language for the most of the journals that are published. But when conversing with industry and others outside the University, it's essential that we are able to do that in Welsh"

"In the research world in the UK, the 'REF' is the most important thing and it's the English-medium journals that survive."

Another lecturer commented on the importance of English for professional dialogue:

"From my perspective, the importance stops past the start of Higher Education. It is important early on in education to allow students to feel comfortable in Welsh if that is what they speak at home. No point in introducing another hurdle. Thus, it is important in the media. But once "out in the real world" students who cannot converse professionally in English are at a disadvantage"

The remaining respondents were supportive of the Welsh language and felt that it was important for students to be able to study in their first/main/stronger language and to ensure that the language is kept current and relevant in all domains:

"It's essential, in my opinion, that elements are available in Welsh, however, that is not our seniors' priority"

"This is how we keep the language current, or what's the use of having Welsh?"

"It is important to retain identity whilst communicating these aspects outside of Wales"

"Welsh is still a first choice language for many"

Implication 25: There is a general acceptance that there is an English bias in science. This bias needs to be addressed early on in school, and schools could introduce A-level students to scientific research articles written in Welsh for Gwerddon and help develop scientific writing styles in Welsh.

Implication 26: Need to ensure students and pupils are given the opportunity to talk about their subjects in English, whilst continuing to study in Welsh. Translanguaging is one model that has been shown to be effective in humanities subjects, but tends to be used far less in science (see Implication 28).

Resources

In line with the views of the teachers, the lecturers were also asked about their experience with resources. Their responses are noted in Table 17 below:

Table 17: Current provision of resources

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
There are enough Welsh language educational resources available	0% (n = 0)	20% (n = 2)	30% (n = 3)	50% (n = 5)	0% (n = 0)
Welsh-medium and English-medium educational resources are of the same standard	0% (n = 0)	20% (n = 2)	30% (n = 3)	40% (n = 4)	10% (n = 1)
There are more English-medium resources available on computers	50% (n = 5)	40% (n = 4)	10% (n = 1)	0% (n = 0)	0% (n = 0)
The Welsh-medium resources that are available are adequate in ensuring high marks in examinations	20% (n = 2)	30% (n = 3)	10% (n = 1)	30% (n = 3)	10% (n = 1)
Good quality Welsh-medium resources are rare	10% (n = 1)	60% (n = 6)	10% (n = 1)	20% (n = 2)	0% (n = 0)
Welsh-medium resources tend to be direct translations from English versions	20% (n = 2)	50% (n = 5)	30% (n = 3)	0% (n = 0)	0% (n = 0)
Bilingual resources are rare	20% (n = 2)	50% (n = 5)	20% (n = 2)	10% (n = 1)	0% (n = 0)
Welsh-medium resources are often available after English-medium ones	50% (n = 5)	50% (n = 5)	0% (n = 0)	0% (n = 0)	0% (n = 0)
There is a need for more modern and attractive Welsh-medium resources	30% (n = 3)	70% (n = 7)	0% (n = 0)	0% (n = 0)	0% (n = 0)
It's easy to adapt to teach these subjects through the medium of Welsh	10% (n = 1)	50% (n = 5)	10% (n = 1)	20% (n = 2)	10% (n = 1)

These results show that the lecturers believe that there is a shortage of Welsh-language resources (70%, n = 7), and that those that do exist are often direct translations from English (70%, n = 7) and are taking longer to be produced compared to the English ones (100%, n = 10). 100% (n = 10) of the lecturers believed that there is a need for more attractive and modern Welsh-language resources.

The lecturers were then asked to what extent they believed that resources influenced the students to study Science, Technology and Mathematical subjects through the medium of English. 10% (n = 1) of the lecturers reported that they believed that it influenced the students to a great extent, 40% (n = 4) believed it was to some extent, 20% (n

= 2) were unsure and 30% (n = 3) didn't believe that it had an influence to a great extent. Given that 50% (n = 5) of the lecturers believe that resources may have an influence on the students' language choice and Welsh-medium resources are rare, more needs to be done in addressing these concerns.

> **Implication 27:** There is a shortage of high quality, current Welsh-medium and bilingual resources. Universities could work collaboratively with schools and regional consortia to help develop such resources.

Some of the lecturers wished to write additional comments on the subject of resources:

> *"The resources that do exist are of a high standard, but with English being a more international language there is more choice of resources in English"*

> *"I don't tell students that there are enough resource materials through the medium of Welsh, because I, and they, know that there are not. Instead, I try and put a positive light on the shortage – tell the students that that's what it's like in the 'real world' (work world), and it's a valuable practice for them to translanguage and translate while they are in University because the employer looks for these skills. We are bilingual and translanguage/translate naturally all the time anyway, so this is a practice for another life skill. But, I appreciate that the shortage in Welsh materials effect on the willingness of the ones who are less confident in Welsh to study their work in the language of heaven."*

> *"Science teachers use translanguaging but they don't believe that it's good practice – this is what needs to change"*

> **Implication 28:** The skill of translanguaging is not often promoted in STEM teaching. Schools and Universities need to consider translanguaging pedagogies.

Training

40% (n = 4) of the lecturers were of the opinion that there was a need for further training opportunities in how to teach STEM-related subjects in Welsh, with the majority unsure (50%, n = 5) (only one did not think further training was necessary). Ideas for further training included:

> *"Training on pedagogy and teaching through the medium of Welsh for Science teachers"*

> *"Resource development due to the lack of current resources available nationally"*

> *"More in the teacher-training"*

In terms of how ITE courses prepare students for teaching STEM-related subjects through the medium of Welsh, three of the lecturers (presumably those from a School of Education) provided the following:

> *"There is a dedicated Welsh language specialist and sessions available in Welsh medium only. All resources are bilingual."*

> *"School based practice in Welsh medium schools, university sessions and resources available bilingually"*

> *"Not half as much as what we did some time ago which was to look at teaching through the medium of Welsh within the subject. With the cuts to our hours that has long gone and now we have more general lectures."*

Thinking about existing teachers out in the profession, 70% (n = 7) of the lecturers were of the opinion that the way we currently train existing teachers who are maybe not confident to teach through the medium of Welsh could be developed further and 90% felt that developing teachers' awareness of bilingual teaching methods could raise their willingness to use of Welsh without the need to teach solely through the medium of Welsh.

> **Implication 29:** Lecturers see the importance of bilingual teaching, and of supporting individuals who are less confident in using Welsh to embrace opportunities to increase their Welsh language abilities in order to contribute to the teaching of STEM-related subjects in Welsh.

Marketing opportunities

80% (n = 8) of the lecturers felt that they ensured schools were completely or quite aware of Welsh-medium provision and opportunities at university. This doesn't reflect the opinion of the teachers in schools where only 57% (n = 12) stated that they were fully or partially aware of which Universities support the teaching of STEM-related subjects through the medium of Welsh. Of those who did not think that they shared this information effectively with schools, one was unsure and the other noted that they were currently unable to teach their subject through the medium of Welsh due to capacity issues.

> **Implication 30:** Welsh-speaking lecturers are clearly active in sharing information about the linguistic opportunities afforded to students at university. However, given that schoolteachers felt relatively ill-informed about the provision, particularly in relation to STEM-related subjects, more could be done to ensure that the message is reaching appropriate individuals within the Secondary school sector in particular.

Opinions on the degree

Lecturers responded to a series of statements regarding the idea fo a combined BSc degree (see Table 18):

Table 18: Opinions on the possibility of a combined BSc degree

	Strongly agree	Agree somewhat	No opinion	Disagree somewhat	Strongly disagree
A combined Welsh-medium BSc degree would reduce the shortage of qualified teachers	0% (n =0)	30% (n = 3)	30% (n = 3)	30% (n = 3)	10% (n = 1)
A degree such as this would create teachers without in-depth knowledge of any of the subjects	20% (n = 2)	40% (n = 4)	10% (n = 1)	30% (n = 3)	0% (n = 0)
A BSc degree in Science or Technology would be better than a BSc degree in Science and Technology	10% (n = 1)	50% (n = 5)	20% (n = 2)	20% (n = 2)	0% (n = 0)
Some subjects are easier to combine than others	30% (n = 3)	30% (n = 3)	0% (n = 0)	20% (n = 2)	20% (n = 2)
The field is too large to include a large amount of subjects	60% (n = 6)	10% (n = 1)	10% (n = 1)	10% (n = 1)	10% (n = 1)
An experience of teaching every subject would be required as a part of the degree	40% (n = 4)	40% (n = 4)	10% (n = 1)	10% (n = 1)	0% (n = 0)
A degree such as this would be a good foundation for Secondary PGCE	20% (n = 2)	20% (n = 2)	10% (n = 1)	30% (n = 3)	20% (n = 2)
A degree such as this would be a good foundation for Primary PGCE	50% (n = 5)	40% (n = 4)	0% (n = 0)	10% (n = 1)	0% (n = 0)
It would be better to include QTS into the degree than to expect the students to do a PGCE after the degree	0% (n = 0)	50% (n = 5)	30% (n = 3)	10% (n = 1)	10% (n = 1)
Stretching the course to a 4-year course including QTS would be a better option	20% (n = 2)	30% (n = 3)	50% (n = 5)	0% (n = 0)	0% (n = 0)

As mentioned elsewhere in this report, lecturers were concerned that a combined degree would create teachers without in-depth knowledge of any of the constituent subjects (80% strongly agree or agree), and that STEM is too broad to include too many individual subjects (70% strongly agree or agree) and 60% felt that single honour degrees were better than combined degrees (60% strongly agree or agree) and were very mixed with regards to whether some subjects were easier to combine than others. Two of the respondents believed that no subjects should be combined:

"None. Students with a degree need a good Foundation which precludes combining. It would only be suitable for primary school. In which case, all could be done but it wouldn't be deep enough to allow employment in a STEM area outside of Primary teaching"

"None- shocking idea as you need to be a master of your subject to be able to teach!"

Despite this, when asked whether having teachers who are qualified to teach a range of Science, Technology and Mathematics subjects would be useful, 40% (n = 4) of the lecturers stated that it would be very useful, and 60% agreed that it would be quite useful.

Another lecturer suggested that the core subjects in schools up to A-levels could be combined, while others suggested the following subjects together:

"The sciences, Computer science"

"Biology, Chemistry and Physics go together but then Mathematics is very different, and Technology too despite being with the Sciences in the new curriculum. However, having said that, it would be possible to just concentrate on these if needs be."

"In groups such as 1. Natural Sciences 2. Technology and Engineering"

"Design and Technology should be kept apart from the Sciences"

"Physics and Maths"

If such a degree existed, lecturers felt that students would require experience of teaching each of the subject (80% strongly agree or agree), and that a combined degree would be more suitable as a prerequisite degree for the Primary rather than the Secondary PGCE route (90% in favour of Primary; mixed result across the board for Secondary). Opinion was divided with respect to whether a combined degree would reduce the shortage of qualified teachers or whether a 4-year course to include QTS would suffice. Nevertheless, some lecturers felt that a new, combined course leading to a PGCE was a better solution to the shortage than the current solution of using teachers who were unqualified, and that it would suit the new curriculum which uses a combined approach:

"Useful for the school because of the flexibility, but harder for the individual perhaps!"

"In regards to the question that it's too broad and maybe not enough depth, there's a danger of that happening; however, despite that, there are teachers that are teaching in fields now where they don't have a qualification at all, so surely this won't be too much of a problem."

"It is a good fit with the new Four Purposes curriculum"

Others were concerned, however, about students not gaining an in-depth knowledge of the subject, as noted above:

"Too much information would need to be taught within the same amount of time. Design and Technology is very different to the Science subjects. This is highlighted in terms of specific subject skills and pedagogy often. The Sciences will obviously be given priority within any undergraduate courses (because it's a core subject and the schools are measured on the pupils' results). There's a danger that D&T would be pushed to the edge."

"It's one thing having a gift in numeracy or mathematics in terms of being able to calculate and following methods, but there's a need for a good mathematician (and in turn, a good mathematics teacher) to have a good grasp on the subject and the careful way of thinking. This would be difficult to achieve through a STEM degree, but not impossible."

"I would be worried about the validity of a teacher with a general degree in the eyes of the pupils"

Another lecturer felt that being a part of many subjects in the University would affect the students' feeling of 'belonging':

"It would be hard to create a feeling of belonging. In semi-general degrees in English, this is the main problem for the students. They don't feel a part of any specific group, not in terms of subject or organisation. They are essentially homeless (academically)."

The remaining two lecturers suggested other ideas:

"It depends on what level they would be teaching at. It would be more appropriate for primary"

"It would be far more beneficial to have more degrees taught in Welsh than a combined degree"

The lecturers also asked whether they believed that Universities could do anything else to address the shortage of qualified Welsh-medium teachers in Science, Technology and Mathematics subjects. Two of the lecturers stated the need for additional support:

"There's a need for financial support from the Government first I think"

"I'd love to offer lots but we need the support."

One lecturer had an idea for a taster teaching course, while another thought that PGCE students could be used to work collaboratively with schools:

"Taster courses - short placements without the long term commitment for potential teachers to trial at a cheaper cost"

"Training/courses, resources, projects with schools using PGCE students."

The remaining two lecturers stated:

"It needs to be lower down in primary and secondary schools"

"Offer more Welsh-medium modules in their Baccalaureate programmes"

Implication 31: There is a strong preference for developing combined degrees within a Primary sector pathway rather than a Secondary pathway.

RECOMMENDATIONS

Summary of the findings

This study sought to investigate some of the issues relating to the current shortage of Welsh-speaking STEM-related teachers in Wales, with a view towards exploring the potential role of universities in addressing this gap. To that end, the study explored the perceptions of pupils, teachers, university lecturers and university students on the feasibility of a combined science and technology degree, in line with the science and technology AoLE, as proposed in the new Curriculum for Wales, as a potential vehicle to help grow the market in terms of Welsh-speaking professionals who are able to teach a variety of STEM-related subjects in Welsh. The feasibility of such a degree was set within a wider exploration of the barriers to Welsh-medium study within these subjects, and the desirability of such degrees from the pupil/student perspective and the employer perspective (in this case, schools).

The main findings to emerge from the questionnaires to school pupils, teachers, university lecturers, and university students are summarised below:

> Teachers and lecturers were aware of the gap in the market in terms of the paucity of teachers able to teach STEM-related subjects through the medium of Welsh.

> Where Welsh-medium options are available for STEM-related subjects, many pupils – particularly those from Welsh-speaking background and/or those who have already followed most of their education through the medium of Welsh – are likely to study STEM-related subjects in Welsh or bilingually, should they be interested in those subjects.

> However, language choice does seem to be strategic, and takes into consideration pupils' beliefs around the usefulness of Welsh vs. English within these subjects out in the workplace.

> In general, pupils from Welsh-speaking backgrounds tend to be less likely to study STEM-related subjects than those from non-Welsh-speaking backgrounds, although it is not clear from this report whether the opportunity to study these subjects through the medium of Welsh (or the ability to include some Welsh whilst studying in English) is a factor in this trend.

> Students, and pupils from non-Welsh-speaking backgrounds attending Welsh-medium schools, are more likely to consider the benefits of bilingual study rather than Welsh-medium study, in order to ensure that they are able to engage with STEM-related subjects in English. Currently, many such pupils/students opt for English-medium study where the alternative is Welsh-medium.

> Participants felt that there is a clear role for universities to play in supporting schools to grow the capacity for teachers in the future. However, whilst there was some support for the notion of creating Welsh-medium degree programmes that would cover a breadth of STEM-related content, there were significant reservations in terms of how effective these would be in practice.

> The main reservation in relation to combined degrees was around the focus on breadth at the expense of depth.

> Alternatively, there were suggestions that pupils and students need to be able to integrate both Welsh and English into their studies, and that teachers and pupils/students could benefit from language support training in dealing with STEM-related subjects in Welsh.

> Teachers felt that there was a role for universities to provide training for teachers on Welsh-medium and bilingual teaching strategies and to help develop Welsh-medium and bilingual resources.

> Whilst universities felt that they do communicate their Welsh-medium provision opportunities to schools, teachers (and, consequently, the pupils) were often unaware of these opportunities.

> It was felt that universities could do more in exploring the wider benefits of Welsh-medium study in STEM-related subjects for employment and career pathways, including in teaching.

Implications

Implications of the findings have been highlighted throughout the results section. The complete list of implications is presented together below:

Implication 1: There is a market among Welsh-speaking students for Welsh-medium provision in STEM-related subjects, should the option be available.

Implication 2: Welsh-medium provision in STEM-related subject does not need to be exclusively Welsh – translanguaging options should be explored within these subjects in order to draw more students to continue to study through the medium of Welsh whilst also benefitting from exposure to the equivalent terminology in English.

Implication 3: In line with the vision of the New Curriculum for Wales: 2022, pupils need to appreciate these subjects as cross-cutting themes that serve as a good basis for other subjects

Implication 4: Home language experience seems to influence the linguistic choices pupils make, although the assumption that certain subjects require knowledge of terminology in English influences those who speak Welsh at home to seek opportunities to study bilingually.

Implication 5: Pupils' preconceptions regarding the linguistic provision at university is a strong factor that influences their choices at school. Universities have a role to ensure schools are aware of Welsh-medium provision at university, including opportunities to study through the medium of English but produce their assessment in Welsh.

Implication 6: Employability sessions in schools need to include reference to the usefulness of Welsh language skills, particularly for STEM-related careers.

Implication 7: Universities should create marketing resources outlining the benefits of becoming a STEM-related teacher and the benefits of being able to teach and study these subjects bilingually.

Implication 8: The perception that STEM-related subjects cannot be 'accessed' in Welsh needs to be addressed.

Implication 9: Any attempt at combining subjects into a single degree programme would need to be designed carefully in order to address concerns around depth of knowledge and the marketing and communication piece around the programme would need to explain the benefits of the combination.

Implication 10: School and universities need to engage with employers in order to market the opportunities on offer and how various subjects can lead to different employment opportunities, and the benefits of speaking Welsh and English from the employer's point of view.

Implication 11: Universities should liaise with schools/regional consortia to help develop resources and training in Welsh for STEM-related subjects.

Implication 12: Self-perception of abilities in Welsh influences linguistic behaviour from a young age (Thomas, Lewis & Apolloni, 2012; Thomas, Apolloni & Lewis, 2014). Ensuring pupils are aware that terminology is learned in a piecemeal fashion, item by item, in English and in Welsh, may help readjust their feelings of inadequacy with the language per se.

Implication 13: Industry partners need to be consulted in order to identify where the benefits of speaking Welsh may lie, and these opportunities need to be made clear to pupils and teachers.

Implication 14: Developing healthy attitudes towards the importance of heritage language maintenance and its place in all disciplines should underpin all teaching throughout the curriculum.

Implication 15: Investing in high quality, Welsh-medium and bilingual resources that are suitable for a wide variety of learners and developed alongside rather than being adaptations or translations of English resources should be a priority.

Implication 16: Teachers are in favour of Continued Professional Development in areas related to the teaching of STEM subjects through the medium of Welsh/bilingually and in the importance of Welsh within these subjects. However, such training need not be credit bearing or form part of an academic pathway.

Implication 17: Not all teachers are aware of what universities have on offer with regards to Welsh-medium teaching for STEM-related courses. There is a clear need to expand on what is currently on offer, and to better support the provision that exists currently.

Implication 18: Student preference is often influenced by teacher bias, and this can influence future engagement with Welsh in relation to STEM-related study/work.

Implication 19: Being able to access knowledge in both languages is a clear consideration for students. Combining the languages in delivery would benefit students whilst allowing them to study in the main in their preferred language.

Implication 20: Students often consider teaching as a next step after graduation. There is potential here to convert more students into the profession with careful marketing, and Welsh-speaking students are often confident and ready to pursue a PGCE course in Welsh.

Implication 21: In developing any form of a combined degree, issues relating to depth vs breadth needs to be explored.

Implication 22: Opportunities to combine science and technology with the arts and humanities should also be explored in order to create Welsh-speaking students with the potential to teach some science through the medium of Welsh.

Implication 23: Lecturers are aware of the variety of reasons why students opt to study in Welsh, English or bilingually. Addressing these factors directly in Open Days is essential to help reassure students where Welsh-medium and/or bilingual provision is available and provides additive experiences.

Implication 24: University lecturers are aware of the issues relating to the shortage of Welsh-speaking teachers who can teach STEM-related subject. There is room to market teaching as a viable exit pathway, at Open Days and throughout the 3 years of the degree. At the same time, highlighting the benefits of teaching in Welsh and in English, and sharing information about the language support that is often available at universities, could help alleviate some of students' fears around pursuing STEM subjects in Welsh.

Implication 25: There is a general acceptance that there is an English bias in science. This bias needs to be addressed early on in school, and schools could introduce A-level students to scientific research articles written in Welsh for Gwerddon and help develop scientific writing styles in Welsh.

Implication 26: Need to ensure students and pupils are given the opportunity to talk about their subjects in English, whilst continuing to study in Welsh. Translanguaging is one model that has been shown to be effective in humanities subjects, but tends to be used far less in science (see Implication 28).

Implication 27: There is a shortage of high quality, current, Welsh-medium and bilingual resources. Universities could work collaboratively with schools and regional consortia to help develop such resources.

Implication 28: The skill of translanguaging is not often promoted in STEM teaching. Schools and Universities need to consider translanguaging pedagogies.

Implication 29: Lecturers see the importance of bilingual teaching, and of supporting individuals who are less confident in using Welsh to embrace opportunities to increase their Welsh language abilities in order to contribute to the teaching of STEM-related subjects in Welsh.

Implication 30: Welsh-speaking lecturers are clearly active in sharing information about the linguistic opportunities afforded to students at university. However, given that schoolteachers felt relatively ill-informed about the provision, particularly in relation to STEM-related subjects, more could be done to ensure that the message is reaching appropriate individuals within the Secondary school sector in particular.

Implication 31: There is a strong preference for developing combined degrees within a Primary sector pathway rather than a Secondary pathway.

Recommendations

Based on the implications highlighted above, the following recommendations are made:

RECOMMENDATION 1

Universities and schools need to work collaboratively in addressing issues relating to

i.   the paucity of Welsh-speaking teachers in STEM-related subjects,

ii. the need for appropriate training for teaching STEM-related subjects in Welsh/bilingually,

iii. ways of enticing Welsh-speaking students to study STEM-related subjects at school and beyond,

iv. the need for continuity of messaging regarding opportunities to study STEM-related subjects in Welsh/bilingually beyond school and the benefits of a Welsh-speaking workforce for STEM-related employers, and

v.   the need to create high quality Welsh and bilingual STEM-related resources.

A dedicated network of STEM-related lecturers with an interest in Welsh-medium issues (some who are possibly already members of STEM-related subject panels for the Coleg Cymraeg Cenedlaethol) is recommended to take this forward.

Related Implication: 1, 11, 16, 25, 27

RECOMMENDATION 2

Universities need to seek new marketing opportunities and develop new marketing resources that highlight the possibilities to study through the medium of Welsh and bilingually in STEM-related subjects at university, and the benefits of being biliterate and able to use both Welsh and English in STEM-related careers. These materials need to be produced with school pupils and prospective students in mind. Ensuring that prospective students are aware of the continuity of Welsh-medium provision into HE is important.

Related Implication: 5, 6, 7, 8, 10, 13, 17, 18, 20, 23, 24, 30

RECOMMENDATION 3

Pupils and students are clearly in favour of studying through the medium of Welsh, where available, particularly if they are from Welsh-speaking backgrounds and/or have received the majority of their education through the medium of Welsh. However, for STEM-related subjects, the ability to study bilingually or to be able to concurrently engage with those subjects in English and in Welsh seems to be a preference for some.

In developing a desirable curriculum that will recruit Welsh-speaking students, universities are recommended to build into their STEM-related degree programmes credited options that focus on students' bilingual competence in the subject in addition to subject-specific modules that are delivered through the medium of Welsh. Welsh-speaking students who may be studying most of the subject content through the medium of English, in the same way as Welsh-speaking students who are studying all or most of their subjects through the medium of Welsh, require opportunities to use and develop their bilingual skills, in order to

i.   develop appropriate terminology, in both languages, to be able to discuss the subject confidently in both Welsh and English with various types of audiences,

ii. learn how to write scientifically in the subject, both for academic and informal purposes, in both Welsh and English, and

iii. to be able to maximise their employability through engaging positively with their bilingualism.

Where the capacity to deliver subject content through the medium of Welsh is stretched or unavailable in a given School/Department, creating a collaborative model where closely related disciplines co-design these type pf modular options is recommended.

Related Implication: 4, 12, 14, 25

RECOMMENDATION 4

In relation to Recommendation 3, discussions should be had with the Coleg Cymraeg Cenedlaethol to see whether offering 40 credits Welsh-medium modules per year that focus on bilingual aspects of the subject would be eligible for the Coleg Cymraeg Cenedlaethol Studentship incentive.

Related Implication: 4, 12, 14, 25

RECOMMENDATION 5

In designing an attractive and fit-for-purpose curriculum, universities are recommended to explore opportunities to offer teaching-related modules to provide students who are studying STEM-related (and other) courses the opportunity to explore teaching as a potential career pathway during their degree. We recommend that the following considerations are addressed when designing this type of opportunity:

i.   it is recommended that these types of modules are available in Years 1, 2 and 3 and at Master's level, where possible, with the option to take only one or more than one of these modules (across various years);

ii. it is recommended that these types of modules are available in Welsh and in English, or, at the very least bilingually; and

iii. these types of modules may or may not include placement opportunities, depending on recruitment figures to these modules and school availability, but it is highly recommended that placement opportunities should be explored.

It is recommended that universities think creatively about ways of integrating the PGCE option into a 'career pathway' for STEM-related students when advertising their degrees, including the offer of a fee reduction to the PGCE year (or an equivalent Welsh-medium STEM financial incentive) in order to retain students at the institution and to draw them into the teaching profession.

Related Implication: 4, 12, 14, 25

RECOMMENDATION 6

Whilst STEM-related subjects are studied bilingually in some contexts, in the main pupils tend to study STEM-related subjects either wholly in English or wholly in Welsh. Even in contexts where pupils study STEM-related subjects in Welsh or in English, either through choice or because of the medium of instruction at the school, it is possible to ensure pupils are aware of the Welsh and English terminology and scientific phrasing through engaging with the pedagogical method of translanguaging, which '...alternates the use of Welsh and English for input and output in the same lesson' (Cenoz & Gorter, 2017, p. 311). Through the exchange of meaning relations across languages, translanguaging leads pupils to process information at a deeper level. This process enriches their language development, develops their verbal communication and literacy skills in their weaker language, and helps integrate L1 and L2 speakers within the same learning environment. A further advantage is that it offers the opportunity for monolingual parents to discuss and contribute to their child's schoolwork when that work occurs in a language they do not understand, as translanguaging leads to the processing and communication of information between languages. However, whilst there are numerous benefits to translanguaging, this method has tended to occur in relation to humanities subjects rather than STEM (Thomas, Apolloni & Parry, 2018, p. 9).

It is recommended that universities offer training to teachers, pupils and STEM-related lecturers on the benefits of translanguaging and help schools develop and evaluate their own translanguaging methods in relation to STEM-related subjects. This could include training on raising language awareness and the benefits of bilingualism.

Related Implication: 2, 4, 8, 12, 14, 19, 26, 28, 29

RECOMMENDATION 7

In order that the recommendations presented in this report are achievable, universities must plan effectively in order to be able to support these recommendations financially where necessary.

Related Implication: 17

RECOMMENDATION 8

There was minimal appetite for a combined Science and Technology degree or various combinations of other STEM-related degrees that could function as a broad foundation to follow onto a PGCE.

However, related to Recommendations 3 and 5, it is recommended that universities explore the possibilities of broadening students' abilities to gain confidence in two or more STEM-related subjects without diluting their main subject specialism, possibly through subject pathways within their degree amounting to 40 credits per year or through alternative experiences such as on-line provision that is made available for students from disparate degree programmes. It is also recommended that universities explore the possibility of offering STEM subjects as options for those studying the arts, humanities and social sciences who may be considering a career in teaching. It is recommended that these options are available bilingually.

Related Implication: 3, 9, 21, 22, 31

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PROVISION FOR WELSH-MEDIUM STEM SUBJECTS

AN EXPLORATORY STUDY

Professor Enlli Thomas | Dr Nia Mererid Parry