TALENT BANK

An Innovative STEM Intervention to Develop the Next Generation of Life Science Talent in the South-West Region of Wales

Advancing an understanding of whether a STEM experiential learning intervention can facilitate the development of further education talent, increasing awareness and interest in potential careers in the life sciences?

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Introducing TALENT BANK – An Innovative STEM Intervention to Develop the Next Generation of Life Science Talent in the South West Region of Wales

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Abstract

The rationale for the qualitative study was initiated from recommendations of the Life Science Skills for Life (2014) regional study, identifying the need for a talent pool to support the region's life science sector. A literature review identified further research needs of experiential learning design in integrated STEM interventions, particularly in further education contexts. The study explores stakeholder perspectives from employers, educators and student participants aged 16-19 years. The study was conducted over three action cycles between 2014 and 2018 iteratively identifying the talent requirements, intervention design and implementation. The intervention utilised an experiential education pedagogy in the course design with a set of features including masterclasses, industry challenges, mentoring, company visits, work experience and a set of skills strands as the main experiential learning opportunities. The aim of Talent Bank was to increase student interest and awareness of the life science sector and its STEM career opportunities in the south west region of Wales. Five collection instruments were used to collect the data and thematic analysis revealed the following findings: The Talent Bank model raised awareness and understanding of the life science sector and its career opportunities; stakeholders from the life science ecosystem willingly supported the delivery of the programme to ensure a dynamic, relevant and authentic learning experience; most participants indicated they would consider future employment in the life sciences or STEM related sectors having improved their reflexive practice habits, skills and individual profiles; the action research identified the perceptions of three stakeholder groups that could influence curricula development practice. The Talent Bank model represents an approach to developing a pipeline of the next generation of talent to serve the evolving needs of the life science sector. The researcher developed her own professional practice and craft as an action researcher in the development of the Talent Bank model.

Word Count: (300 - Abstract) (88,794 including Appendices and References) **Key words:** Action Research, Talent, Stakeholders, Further Education, Integrated STEM Education Intervention, Curriculum Development Praxis, Life Sciences Sector, Eco-system, South West Region of Wales, Careers

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STATEMENT 1: This work has not previously been accepted in substance for any degree and is not being concurrently submitted in candidature for any degree.

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STATEMENT 2: This thesis is the result of my own investigation, except where otherwise stated and that other sources are acknowledged giving explicit references and that a bibliography is appended. Where correction services have been used, the extent and nature of the correction is clearly marked in a footnote(s).

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“Is nothing but judicious imitation. The most original writers borrowed from one another. The instruction we find in books is like fire. We fetch it from our neighbours, kindle it at home, communicate it with others and it becomes the property of all.”

Francois Voltaire n.d.

A great deal has happened over the last seven years as I pursued this most challenging of journeys in my life. I will always be indebted to my first supervisor, Professor Marc Clement for his belief in the true and tangible value of my work. I am also grateful for the guidance and encouragement provided by current and past members of the Scientia research group founded by Professor Clement for their combined intellectual generosity as well as the posing of questions and queries which have played a central role in developing and shaping my thinking and writing. I am indebted to the great council of its members who have all donated their time, support and encouragement to keep me sane through the trials and tribulations of my research journey.

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“The experience of each day shapes us a little into the person we become tomorrow”.

Dedication

Dedicated to my parents and family, particularly my daughter Tilly for the loss of mother-daughter time together as I moved to the United Arab Emirates to get the ‘peace and quiet’ needed to complete the final write up; and to Baloo and Yogi our family Labradors who provided the impetus for many hours spent on long walks, providing the opportunity for quiet time to think, generate ideas and reflect. I am indebted to my UAE ‘family’ for keeping me sane through the last year of writing up and encouraging me to keep moving forward, as we navigated through the changes to our lives because of the Covid-19 pandemic through 2020/2021.

Dedicated also to my students who participated as innovators in their own development journey; I wish you all success in your chosen careers and hope our paths cross again sometime in the future. You leave a valuable legacy for the region as I hope you become part of the next generation of scientists, health practitioners and medical pioneers from your involvement in the Talent Bank study. Thank you again for sharing your perspectives and I wish you all the absolute best of luck in the future!

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Abbreviations

AR	Action Research
ABMU HB	Abertawe Bro Morgannwg University Health Board now Swansea University Health Board
ARCH	A Regional Collaboration for Health
EU	European Union
FE(I)	Further Education (Institution)
GCS	Gower College Swansea
HE	Higher Education
ILS	Institute of Life Science
LMI	Labour Market Intelligence
LS	Life Science/Life Sciences
NHS	National Health Service
OECD	Organisation for Economic Co-Operation and Development
REF	Research Excellence Framework
RLSP	Regional Learning & Skills Partnership, South West & Mid Wales
SPFP	Sector Priorities Fund Programme
SSC	Sector Skills Council
STEM	Science, Technology, Engineering and Mathematics
UTC	University Technical College
WG	Welsh Government

Key Terms

Action Plan	A detailed plan outlining actions to achieve one or more outcomes of a new prototype or service or to bring about change.
Action Research	A philosophy and methodology of research generally applied in the social sciences. It is a knowledge-based enquiry that seeks transformative change in practical settings through the simultaneous process of combining action with research which are linked together by critical reflection and which can also lead to professional development or growth.
ADDIE Model	An instructional systems design framework that is often used to create and design learning programmes and units of study. The name is an acronym for the 5 key phases it defines for building training solutions.
Co-Creation	Can refer to any action of combined creativity, i.e. creativity that is the input shared by two or more people to construct a product or service.
Ecosystem (specific to this study)	A complex network of interconnected community stakeholders that interact with each other in a specific regional environment. This study draws upon the stakeholders from the life sciences community in Wales specifically in the south west region to utilise expertise and resources.
Experiential Learning	Is a process of learning through the transformation of experience followed by a reflection on that experience. Part of a larger category of active learning, such as hand on activities which directly involves participants in the process of their own learning.
Gower College Swansea	A further education college of post-compulsory education and training located in Swansea, south west Wales. The host institution for the study and employer of the researcher-practitioner.
Human Capital Theory in Education	Emphasises how education can be seen as an instrument, significantly contributing to meeting the skill-demand needs and thereby improving the capacity of a nation's economic growth and development.
Integrated STEM Education	An educational approach that combines science, technology, engineering and mathematics into an interdisciplinary programme or class that is based on connections between the disciplines and real-world problems.
Intervention	An experiential intervention design created to address a specific issue or gap to establish whether any changes have the desired impact.
Life Sciences	Refers to the application of biology and technology to health improvement and impact on powering lifesaving and life-changing treatments, including biosciences, pharmaceuticals, medical technology, genomics, bio-diagnostics and digital health.

Life Science Industry (specific to this study)	Refers to organisations operating at the forefront of medical advancements in fields of pharmaceuticals, bio-technology, medical devices, bio-medical technologies, digital health and other supporting businesses such as contract research organisations supporting clinical trials, contract manufacturing organisations commercialising innovative treatments and equipment to improve quality and prolongment of lives.
Regional Learning Partnership	A brokerage of strategic education partners that facilitates research and prioritisation of the region's access to investment and funds in the delivery and execution of its Employment and Skills Plan to support the region's evolving economy.
Regional Sector Skills Advocate	A role established by the Welsh Government under its Sector Priorities Programme to facilitate interactions between industry, sector skills councils and education providers to pilot interventions to support greater alignment between education provision and its outputs with that demanded by employers. The researcher undertook this role as a secondment from Gower College Swansea working with the Regional Learning Partnership. The Regional Skills Advocate facilitated interventions and their design from educational providers in the FE and HE sectors with various industry sectors such as the life sciences.
Sector Priorities Fund Programme	A Welsh Government programme supported by European Union funding to allow the FE and HE sectors to respond and develop provision to address sector specific higher-level skills and capability gaps at a regional level as identified by the Regional Skills partnerships. It also provided funding for FE institutions to develop the skills base of their staff through continuous professional development activity.
Skills Supply Pipeline	The flow from the supply side of education i.e., schools, colleges and universities, of students with the correct qualifications, skills and experiences needed to succeed in the workforce, both now and in the future, often referred to as a talent pipeline.
South West Region of Wales	A geographical region of Wales represented by four local authorities: Swansea, Neath Port Talbot, Carmarthenshire and Pembrokeshire.
Stakeholders	A group that has an interest in an organisation or action that can either affect or be affected. The primary stakeholders in this research are: Employers, Educators and Learner Participants.
Welsh Government	The devolved government of Wales, United Kingdom, established in 1999 with direct responsibility for several key policy areas including education.

Contribution to Knowledge

The original research of the Life Science Skills for Life (2014) provides the background to this research. It outlined a set of regional issues relating to a lack of talent pool to support the recruitment needs of the evolving life science sector in the south west region of Wales. The recommendations from the report provided a call to action on the further education (FE) sector to embrace change, to collaborate and contribute to the broader regional skills strategy that could address the life science sector's workforce needs. Reference to existing literature in relation to the regional context, identified gaps in knowledge, information and a lack of previous STEM studies in further education that were linked to the life science sector. This provided the impetus for further enquiry and confirmation of the real community need for this subsequent action research study.

The research contributes to new understandings in several areas, including knowledge and process outcomes, contributions from the application of learning theory and its impact on stakeholders, as well as generating some surprising and unexpected outcomes. The new knowledge generated in the attempt to close the gap and solve the identified talent problem, is an unchartered course and therefore represents my contribution to knowledge in this field. The main benefactors of this knowledge are the participants and the stakeholders involved and other education stakeholders including employers across the region's health and life science sectors. Table 1. shows the claims from this study that contribute new elements to the current state of knowledge.

The study responds to these identified gaps, most notably on the development and application of a hybrid integrated STEM model which has become known as the Talent Bank. The model is designed as an additionality programme to complement the individual STEM discipline provision, traditionally taught at a local further education college. It assesses the use and application of experiential education as the underpinning pedagogical learning theory in the curricula design. The programme of STEM learning opportunities is created drawing on the expertise and resources from employers and academic actors in the regional life science ecosystem. The intervention was delivered on a day-release basis and set in a university location within the context of the evolving life science sector; it explores the utilisation of action research to generate the iterations and change in practice to support the design, implementation and delivery of the model.

The study provides a singular record of the creation of Talent Bank; a novel and innovative industry facing STEM education intervention. Participants of the 26-week, day-release programme, experienced a broad and inclusive integrated STEM curriculum with an extensive range of learning experiences. The research provides knowledge outcomes relating to insight and understanding of how the regional community and its stakeholders within an ecosystem can collaborate to create and deliver better alignment of STEM education provision to support the needs for the sector.

The study applies the theoretical contribution from Kolb (1984), and his experiential learning theory to underpin the design of the Talent Bank model. The constituent features and application activities provide learning experiences from which participants develop their reflexive practice habits set within the real-world context. Student participants are able to build upon their individual STEM disciplines using their prior and new experiences and develop a deep understanding and awareness of the life science sector, the required skills sought by the sector and the careers opportunities it has to offer. The programme enhances each individual participants' awareness and employability prospects and may also contribute to enhanced success in their individual STEM subjects.

The Talent Bank model tested with two small cohorts of participants offers the potential for opening-up the STEM skill supply pipeline at an earlier junction than the current state. There is a potential to open the outflow of STEM talent, post college education, rather than the current graduate entry point which could lead to potential employment in the sector at an earlier interval than currently the case. However, this would require further action research on sustaining the Talent Bank model and strengthening collaboration between the sectors. The programme has created greater interest and understanding of the career prospects within the sector. Whilst the intention was to create an increase in young people pursuing careers in the health and life science sectors and taking advantage of being better prepared for earlier employment opportunities, this has not been proven. What has been evidenced, is that participants have been inspired by working closely with employers and progressed into STEM related programmes at university on the strength of the range of learning experiences afforded by the intervention. Some participants have been able to compensate for some average grades at GCSE and rebalance their individual profiles with the Talent Bank learning experiences to secure places on highly competitive university programmes in life sciences, medicine and health. These institutions will benefit from more experienced and knowledgeable students with transferable skills and a broader insight into the workplace than most of their counterparts.

The key benefits of this work were intended to support the workforce needs of the immediate region and its expansion of economic development projects. The Talent Bank provides a case study that can illustrate some of the opportunities and challenges associated with bringing about change in education in the region. It contributes to other case studies of key strategic importance supporting the regional skills agenda by showcasing an insight of what can be created by the cyclical actions in action research and how incremental change can make a positive difference in practice. Whilst colleges that apply the model and processes from the collaborative approach may or may not derive comparable results, it is hoped that other colleges can mirror the relationship building with employers and their sector ecosystems, as this could lead to strengthened relationships that support curricula development praxis and enhanced learning experiences for students.

The researcher was given a privileged position to conduct this research with the knowledge of the Welsh Government, further education, higher education and other regional stakeholders with a vested interest in the skills agenda. The researcher had the unique advantage of accessing employer networks across the health and life science sectors in Wales, supported by colleagues from the Institute of Life Science at Swansea University. These networks would ordinarily take considerable time to develop and nurture but ultimately the payback and value make this a very worthwhile aspect of the programme development as evidenced in participant responses to employer engagement on the programme. Other action researchers may need to consider the time needed to invest in replicating such networks in other contexts.

A further contribution to any action research study should be the sharing of knowledge gained with peers and the academic world. The researcher has presented the Talent Bank as a case study to a range of audiences to share the learning from the study and its approach to creating change in practice whilst trying to resolve the regional talent issue. The personal growth gained from the experience has also transformed the researcher’s own praxis in developing her craft as an action researcher. This personal contribution is further discussed in the epilogue in Chapter 9.

Category of Contribution	Description	Contributing to Literature
Knowledge Outcomes	Rich insight with valuable explanations drawn from an interpretative study of a regional context. Many findings congruent with existing literature – new constructs – model, process, geographical scope Contributes a solution to a community problem and potential to open-up skills supply pipeline.	Perspectives of three stakeholder groups in action research What works in designing a bespoke integrated /hybrid STEM intervention for adolescents Drawing on ecosystems to collaborate in education. Participants interest for potential careers in STEM /life sciences
Process Model	Talent Bank model - (early stage) novel approach to hybrid STEM integration which aims to develop knowledge, skills and attitudes through the design of experiential learning opportunities and reflective practice habits.	Intervention Design Theory and model development Integrated STEM intervention – extends 4 STEM discipline model with hybrid approach. Action research approach
Practical Contributions	Implications to practice in curricula design praxis. Contributes to integrated STEM intervention/hybrid model. Contributes to practical lessons for the application with others. Contributes to practitioner's own praxis.	Action Research Collaborative partnership to education and industry alignment Professional development/ action research craft
Theoretical Contribution	Contributes to an existing theory/confirms/replicates/extends with extra constructs/contradicts/eliminates.	Experiential Learning Theory (Kolb,1984) A hybrid model of experiential learning features
Contributions to Benefactors/Stakeholders	Improved participant's curricula vitae and university application profiles Enhanced awareness of life science and careers/ enabled progression to medical, health and life science related courses at university Strengthened relationships between FEI and life science sector. Presentations on Talent bank model shared at various conferences.	Stakeholders Adolescents Employers Educators Curriculum Developers Action Researchers
Unexpected Outcomes/Surprising Contributions	Second chance programme for participants who may be excluded from medicine, health, or life science programmes due to previous GCSE grades. Model can be used to compensate for lower results with learning experiences on TB programme to re-balance and enable access to competitive university places.	Academic and Regional Community programmes and their impact

Table 1: Contribution to Knowledge from the study (adapted from Munkvold 2016).

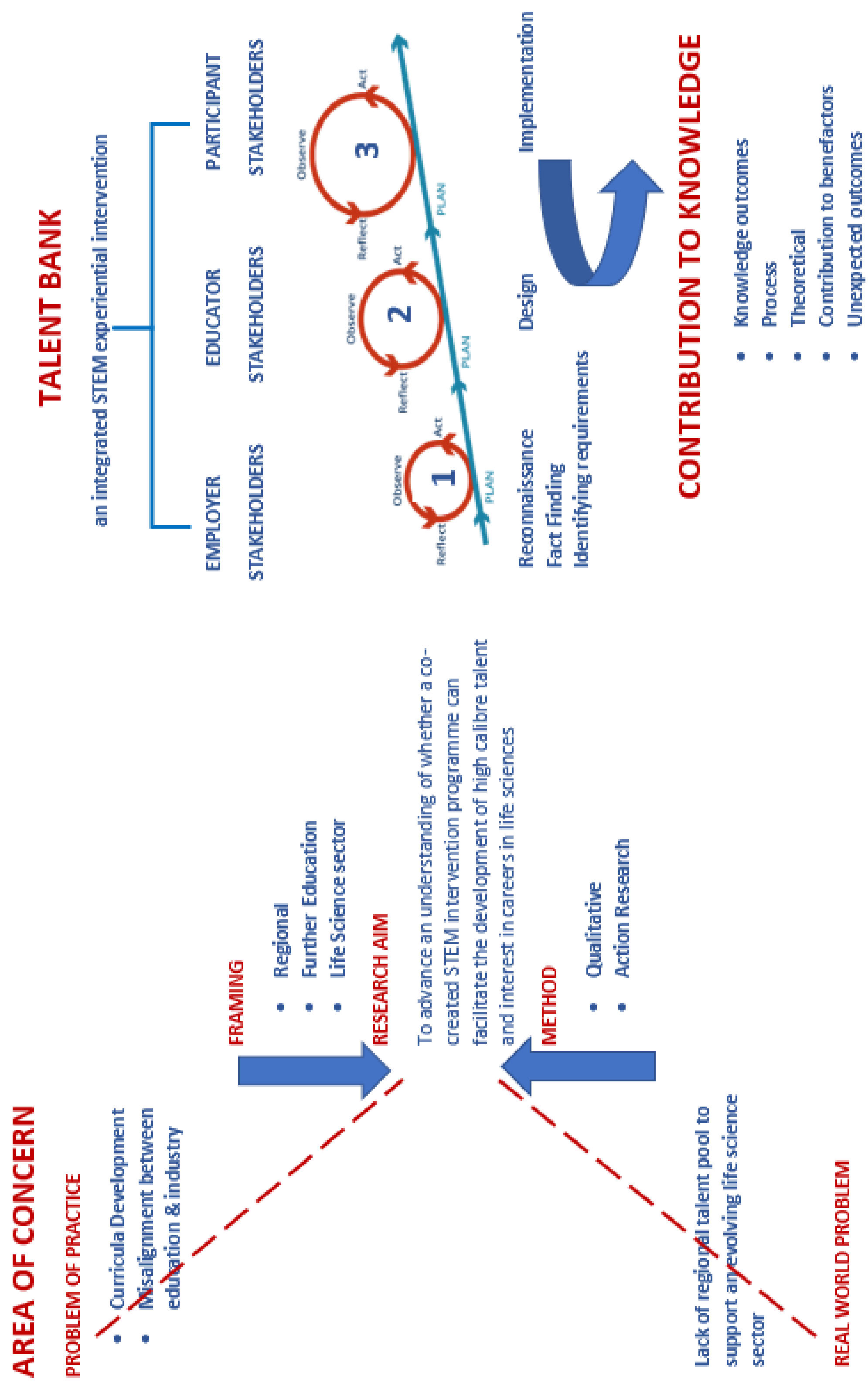


Figure 1: Summary of Research Study and Contribution (adapted from Mathiassen *et al*., 2012)

Part A
Context

'If you always do what you've always done

You will always get what you've always got!'

Henry Ford n.d

Chapter 1

INTRODUCTION

1 INTRODUCTION

This thesis is structured into three main parts: Part A is concerned with the context of the study, Part B concerns the action research and its application, and Part C is focused on the outcomes and contributions. Each section holds three chapters. The purpose of this first chapter is to introduce the context and orient the reader into the action research (AR) study and how it is presented in the body of the thesis. The initial chapter provides an overview of the problem under investigation and its scope within the study. It outlines the research purpose and goals; identifies the stakeholders involved, including the researcher's role and the circumstances in which the study is set. The sections introduce the context which led to the problem statement and subsequent research aim and objectives. Finally, a summary of the study's significance and its' limitations is outlined, together with an illustration of the thesis structure is provided to guide the reader and for ease of reference.

1.1 Introduction to Research Context

Both the UK and Welsh governments have identified the life science sector as one of key strategic importance, for its potential of significant expansion in employment opportunities and economic growth (Life Science Industrial Strategy, 2014). The life science sector is considered to be at the vanguard of change as the sector is diverse, research driven and global in its characteristics (Deloitte Global Life Sciences Outlook, 2014). Its dynamic nature is constantly evolving as new subsectors emerge and are developed (Life Science, Skills for Life, 2014, Appendix A). Enterprises operating within the sector include those in ground-breaking fields such as pharmaceuticals, genomics, medical technology, biosciences, diagnostics, wound healing and contract research organisations (ibid). With an export market of over 1 billion pounds, Wales' life science sector is a key contributor to the nation's health and economic prosperity (National Statistics Office, 2018).

According to the Life Science Hub Wales website (accessed on 17/3/19 via www.lshubwales.com), employment in the life science sector in Wales has grown in the years between 2013 and 2018, as a direct consequence of a range of government interventions and policies targeted at accelerating the pace of growth. According to the Office of Life Sciences (2018), there are over 350 companies employing over 11,000 people in well-paid, high-quality jobs which equates to over 10% of the Welsh workforce.

In its publication Delivering Science for Wales (2013), the Welsh Government set out its strategic intention to create less dependence on the public sector and to boost the country's knowledge economy with support for advancing specific sectors. The Welsh Government through the Department for the Economy & Transport identified six priority sectors for their potential to create new employment opportunities and growth of the Welsh economy (Economic Renewal: a new direction, 2010). In September 2011, three further priority sectors were announced which included the life science sector, the smallest in terms of employment (Annual Population Survey, Inter-Departmental Register, ONS, 2015). The Economic Renewal: a new direction policy, (2010) attempted to stimulate and generate economic growth, create movement between regions and attract inward investment. The Regional Learning and Skills Partnership for South West and Central Wales (RLSP) illustrates a pre-growth position in its' RLSP At A Glance datasheet (2015) with 1,300 life science employee jobs in the south west region (Appendix B). Sixty-six percent of these roles were attributed to managers, professionals and associate professional occupations within predominantly, medium and small sized enterprises.

The Welsh Government committed significant financial investment via various programmes to support and accelerate the evolvement of the life science sector and its ecosystem. The Economic Renewal: a new direction policy, (2010) highlights the importance of strengthening links between the scientific research community with the processes of innovation, development, and commercialisation. This led to funding of programmes such as Accelerate, the Horizon 2020 project supporting long term sustainability of large-scale research infrastructures (www.accelerate2020.eu, accessed on 21/4/20). A later project was launched in 2020 called AgorIP with the aim of supporting the development of ideas and inventions and bringing them to market (www.agorip.com, accessed 21/4/20). Both projects support the Welsh government's policy to draw benefits for economic advantage and the potential for rapid returns on investment, in addition to beneficial health and social returns for Wales (Pugh et al., 2018). Further government interventions include the establishment of the Life Sciences Hub in Cardiff Bay, a collaborative space for the NHS and industry which offers advice on funding, networks and hosting events for the sector. The establishment of the Arthurian Fund, a 100 million pound investment fund to support both emerging and established life science companies to support the Welsh government's vision of attracting innovation in a vibrant life sciences sector; and Ser Cymru, a funded fellowship programme to attract the best research talent and capacity designed to strengthen Wales' innovation research capabilities; each intervention contributes in part to the overall strategy to stimulate growth of the Welsh Life Sciences sector. However, at the commencement of this study, there had been little attention paid to the required skills base or workforce needs to support the life sciences and its anticipated expansions.

1.1.1 **Sector Priorities Fund Pilot Programme**

In April 2009, the Welsh Government created the Sector Priorities Fund Pilot programme (SPFP) funded in part by the European Social Fund. The programme intended to pilot innovative, novel approaches and programmes to support employer-led demand for skills. The programmes involved research studies generating labour market intelligence (LMI) to provide an evidence base to better understand the issues of supply and demand. The LMI would aid decision making when targeting or designing learning provision and solutions which would be more aligned to sectoral needs. The programme was supported in four regions across Wales with eight newly devised Regional Skills and Sector Skills Advocate posts. The roles were offered as secondment posts targeted at further education, higher education, sector skills councils or government agencies. At this time, the researcher was employed by Gower College Swansea, a large college of further education as a Faculty Director and member of the senior leadership team. She applied for the Welsh Government secondment for the Regional Skills Advocate for the southwest region and successfully took up the post in December 2010. The role as the Regional Advocate was primarily to facilitate partnerships and dialogue within the geographic region between sector skills councils and training providers. This included facilitating innovative, transformative projects or interventions within the priority sectors of the economy to better align education provision more closely with the needs of employers. The project was supported by investment shared by the Welsh Government, European Social Funds and industry, highlighting a more collective responsibility than had previously been the case.

1.1.2 **Regional Learning & Skills Partnership**

The Advocate position was offered on a secondment basis within the Regional Learning and Skills Partnership, South West & Mid Wales (RLSP). The RLSP is a brokerage of strategic education partners that facilitates research and prioritisation of the region's access to investment and funds for the delivery and execution of its Employment and Skills Plan, to support the region's evolving economy. In October 2013, the Swansea Skills Group with a membership of local strategic leaders with an interest in the education and skills agenda, was tasked by the RLSP to conduct research to examine the Life Science sector to better understand its value and importance to the south west region.

At the commencement of this study, the researcher had led research into the STEM skill supply, collating secondary data on the three sectors of schools, further education and higher education. In collaboration with the Institute of Life Science, the RLSP commissioned research into the current and future skills needs and demands of the life science sector as articulated by its life science companies. The research culminated in the publication of the Life Science Skills, Skills for Life (2014) and was presented by the researcher in May 2014 at the Marriott Hotel, Swansea, to an audience of strategic leaders with a stake in the regional education and skills agenda. The presentation of the findings reported on the region's lack of capacity and effectiveness in part, in supplying STEM skills to support the current and future talent needs for the evolving knowledge economy, specifically in relation to the life science sector. The study determined that the life science sector was of key value and strategic importance to the regional economy of south west Wales. A set of recommendations was outlined for key stakeholders including the Further

Education (FE) sector, and these are set out more clearly in Chapter 2. However, the recommendations and call to action within the report focused on key areas around the underlying talent supply issues and did not offer a prescribed resolution. Following the publication, Gower College Swansea presented the research and findings to its Governing Body and agreed commitment to supporting the talent needs of the life science sector. It accepted responsibility on behalf of the FE sector in the region to respond to the recommendations levied, in collaboration with the work of the Regional Skills Advocate and the Regional Learning Skills Partnership. It is from these recommendations that the researcher takes on the research as her own whilst performing her role as the Regional Skills Advocate for Life Sciences. An opportunity was subsequently offered to the researcher to combine the research with the requirements of a Doctorate degree of Philosophy in Medical and Health Care Studies at Swansea University.

1.1.3 A Regional Collaboration for Health (ARCH)

In 2013, Professor Marc Clement, the then Chair of the Institute of Life Science at Swansea University and his Scientia group of PhD scholars began brainstorming ideas for holistic, transformative and collaborative approaches that could be formulated into projects with the aim of improving the health, wealth and wellbeing of citizens in the south west region. Developed as a joined up, collaborative approach to drive and develop a vibrant life sciences ecosystem within the region, a portfolio of ambitious projects began to emerge and became latterly known as A Regional Collaboration for Health Portfolio Delivery Plan, (2017). The ARCH project evolved with regional stakeholder support and was put forward as a prospectus of ambitious regional activity to secure investment from the UK and Welsh Government under the Swansea Bay City Deal. The Swansea Bay City Deal offered funding of 1.3 billion pounds for intervention projects to support economic growth by working collaboratively between private and public sector organisations. The interventions would tackle some of the regional barriers to economic growth and further support sectors of strength which include health, energy and manufacturing. The Deal promised to broaden the economic base by increasing the number of businesses within these sectors and to create high value employment opportunities with an overall increase of over 9,000 gross direct jobs (Swansea Bay City Deal, 2018). Within the prospectus of projects, there was an identified Skills and Talent Strand dedicated to the aim of boosting and supporting the regional economy with STEM talent for the new emerging businesses and expanding job opportunities.

Awareness of the life science sector and other niche STEM sectors is deemed limited amongst 16-year-olds (Crawford et al., 2011) unlike medicine and health, however research suggests early exposure to what the sector has to offer in terms of careers and job opportunities has been shown to help stimulate interest and influence potential career choice (ibid, Organisation for Economic Cooperation and Development, OECD, 2020). This view is reinforced within the recent report, Teenagers' Career Aspirations and the Future of Work published by the OECD, (2020) which states that young people in their knowledge about the world of work and the career opportunities available 'cannot be what they cannot see'. The researcher had already completed the study at this time but was able to draw on the collaborations from this regional backdrop to support the trial of a solution to address the region's need for talent specifically for the life science sector. The research study fitted within the scope for new initiatives and ideas that were sought from across the further and higher education sectors.

In March 2018, the Swansea Bay City deal announced its successful award of the 1.3-billion-pound investment for the transformative projects across the South West region. The projects of interest to this study relate to the key themes within the life sciences and health sectors designed to boost the regional economy and create a lasting and impactful legacy whilst creating new high-quality, well-paid jobs. A Life Science and Wellbeing Village and Campuses are two large scale projects designed to give local people a pathway to access the anticipated 9,000 new jobs as outlined in the prospectus, (A Regional Collaboration for Health, 2017). In addition to the significant impact on accelerating the growth of the sector across Wales, these regional development plans for high yielding projects within the region, outline an enhanced need for an effective skills supply pipeline and talent pool resultant from a corresponding skills strategy. However, as with other UK nations the life science sector already highlights difficulties recruiting high calibre talent and competes with other sectors for young people with STEM qualifications and capabilities (Smith and White, 2019).

1.1.4 Need for STEM Talent

Clearly, the availability of sufficient talent to support ongoing growth of this scale is a critical factor. In a global economy, people's skills, learning, talents and attributes i.e. their human capital, has become key to both their ability to earn a living and to wider economic growth and competitiveness of a country (Tsai et al., 2010). This is particularly important in the context of this research, as the south west is often identified as a lagging region which fares much worse than the Wales average against the UK on most measures of economic performance, including employment and qualification levels (Pugh, 2017).

Young people holding STEM qualifications combined with experience are a highly sought-after asset, as firms try to innovate and improve their productivity whilst also trying to offset displaced job roles from high rates of retirees (Life Science, Skills for Life, 2014). University graduates with STEM qualifications have been steadily increasing over the last few years, however, employers suggest growth is not keeping pace with the universal increase in demand (Smith and White, 2019). One of the challenges facing the sector is the reliance on high technical knowledge and an expectation of direct role experience which often narrows and restricts the recruitment field to graduates and experienced workers. Rather than focusing on training technical capabilities, some recruiters suggest alternative strategies, such as considering younger talent, training in soft skills and professional experience which could still transform and support organisations within the dynamic and evolving sector (Strange and Banning 2015). Further suggestions put forward by the CEO of Hyper Recruitment Solutions (2014), include a consideration of the current skill supply pipeline to identify potential openings to alternative sources of untapped talent, such as directly following further education. The regional recruiter suggests the talent from within ‘the region’s schools and colleges could be a potential source of supply that is often overlooked, as existing recruitment practices solely focus on recent graduates from universities’ (ibid). This assertion is supported by the findings of the regional report, Life Science Skills for Life (2014) that suggests workforce needs could in part be met with entrants into the sector, that need more than the existing tertiary college qualifications but not necessarily a bachelor’s degree.

A key issue is that a regional talent pool with these credentials does not currently exist, demonstrating a real gap which reinforces the ongoing need for FE and its curriculum provision, to be responsive to future workforce needs. In addition, future projections in Wales identifies new sector specific higher apprenticeships that could provide a pathway to professional development and qualifications, in ‘earning whilst learning’, that negates the need for a traditional university experience. Recognising these gaps assists the researcher to better interpret where further understanding is required.

1.1.5 **Life Science Sector Needs**

The original research in the Life Science, Skills for Life report (2014) provides a view of the regional issues relating to an identified lack of a talent pool for the evolving life science sector across the south west region of Wales. The report identified a knowledge gap for further enquiry with a set of recommendations set out encouraging further education and employers to work more collaboratively. The regional appetite for change coupled with the ARCH portfolio of projects enabled the opportunity to explore an innovative approach to supporting the development of younger talent entering the skill supply pipeline into the life sciences. Armed with understanding of the regional context and its aspirations for change, the researcher set about utilising this platform of understanding and insight into the issues surrounding the lack of local talent as the focus for this research study. The lack of human capital to meet the demands of the future workforce needs can be a barrier to further expansion and continued growth (Hyslop, 2009). To ensure a pipeline of STEM talent, earlier education of young people (OECD, 2020), and raising awareness of the opportunities, is viewed as essential to supporting the evolving life science sector and to limit employers resorting to other recruitment solutions such as hiring from abroad.

Careers education has been a staple element of secondary and further education; however, it is limited in its effectiveness by the experience and knowledge of careers specialists and teachers (Hughes et al., 2016). Criticism from employers is that education provision is not sufficiently focused on workforce skills needs or aligned and responsive to their dynamic demands for STEM talent. Even vocational programmes provide limited connection to employers in the community (Kerckhoff, 2002). In response to these criticisms, some FEIs have trialled interventions to test approaches to more innovative and novel ways to address a broader range of industry and education goals. In their study, Mortimer and Krueger (2000), trialled an approach to improving collaboration forming a ‘structural’ bridge between college and work in the life science sector. Encouraging collaboration in this way, between stakeholders could indeed support greater understanding of each parties’ requirements and promote closer alignment. Early exposure of young people interested in STEM to life science sector careers, employer workplaces and the skill requirements could potentially provide a local solution and ‘an alternative to filling job roles with over-qualified, new graduates’ (Magnusdon and Starr, 2000).

1.2 Problem of Practice

This section outlines the problem of practice and defines an ongoing issue facing further education. Regional employers complain about the lack of work ready talent within the region from education providers that their recruiters can access, having to rely on over-qualified graduates for many jobs, as the talent pool they need does not actually exist. Pressures to find solutions to today's problems are more acute than ever in times of public sector austerity. Using traditional approaches with incremental changes are no longer appropriate to resolve existing and persistent problems, as reinforced in the historical quote by the American industrialist and founder of the Ford car company, Henry Ford.

'If you always do what you've always done

You will always get what you've always got!'

Henry Ford n.d.

Practices of today may be no longer relevant to creating effective solutions for tomorrow. The education sector, just as in private industry, needs to look outward to alternative and innovative approaches to problem solving. At a micro-level, teachers are continuously improving their educational provision to enable the best life chances for young people under their care and guidance. The identified problem of practice involves young learners in post compulsory education predominantly aged 16 – 19 years studying existing individual qualifications in STEM disciplines. Whilst there is existing FE provision for individual STEM disciplines both in general and vocational qualification choices, there are identified gaps relating to student's preparedness or work readiness and lack of opportunities to apply knowledge and make connections to authentic settings or real-world problem contexts.

The role of developing curricula within the FE sector is for the most part, pre-determined by awarding bodies for qualifications and groups of employers within a given sector. Minimal provision is designed for localised solutions to meet local needs, however, there are opportunities for institutions to undertake this work, but the take-up is not widely practiced. Qualifications usually have a shelf-life of around 4-5 years which means keeping abreast of developments within a sector is limited, content remains static and can quickly become out-dated. This impacts on the outputs of further education in terms of student capabilities and their experiences and the value they can provide to recruiting employers. Many reports criticise the capabilities of young talent and their preparedness for industry (Forbes, 2014; CBI, 2014). The problem of practice exists between what employers look for in future young talent and what education providers such as schools, colleges and universities provide as the outputs of learning experiences and preparation for young people and what they can do or achieve via their courses.

Teachers play a key function in shaping the learning environment (Zara and McGuigan, 2006). The researcher-practitioner considers the problem of practice that focuses on an area of change that is actionable, directly observable and connects to the FEI's broader educational portfolio. Involvement in "activities that produce efficacious results and positive outcomes usually contributes to interest development" (Lent and Brown., 1996). Developing bespoke curricula to meet local need is an area of limitation where the study aims to gain a deeper understanding of the problem and its causes so that the FEI can appropriately respond. The researcher-practitioner aims to use the study to bring together three stakeholder groups to understand their perspectives, in order to use any differences or benefit that can be gained, to resolve the talent issue with a more aligned solution. Additionally, the study will facilitate understanding and learning on the practitioner's own competencies in curriculum development praxis through the application of a collaborative approach.

1.3 Theoretical Perspectives

Existing theories or models often facilitate as frameworks or blueprints to guide the development of the research (Yin, 2014). Additionally, theories serve as lenses or a stance by which to: identify interventions; define and interpret constructs; guide and inform research questions and procedures; and analyse data collected (Creswell and Plano-Clarke, 2017; Yin, 2014; Creswell, 2009). Several theories are used as part of the framework for this study and are discussed in detail in their respective sections and applications, however, Kolb's Experiential Learning theory serves as the key framework that underpins the body of this study. His theory is utilised in relation to the design and implementation of an integrated STEM education solution to develop a regional talent pool that meets employers' needs through the study's collaborative action research approach.

There are many theories which attempt to enhance or modify the learning process for greater success.

> “The learning process is defined as a process that brings together personal and environmental experiences and influences for acquiring, enriching or modifying one’s knowledge, skills, values, attitudes, behaviour and world views.” **OECD, 2010**

Experiential learning theories build on social and constructivist theories of learning but situate experience at the very core of the learning process with meaningful everyday life experiences that lead to a change in an individual’s knowledge and behaviours (Kolb and Fry, 1975; Dewey, 1938; Rogers and Freiberg, 1994; Schon 1991). Experiential learning theory attempts to express the holistic nature of the learning process and attempts to integrate and illustrate what Eickman, Kolb & Kolb in their publication Designing Learning (2004) describe in a four-stage experiential learning model. Kolb’s Four Stage Experiential Learning Model was first presented in 1975, influenced by the work of other theorists, drawing upon the work of John Dewey (1938) and Kurt Lewin (Burns, 2004) described as the ‘Practical Theorist for the 21st Century’ (Coghlan and Brannick, 2014).

Drawing on the learning theories associated with experiential learning such as situational learning theory and community of practice, developed by Lave and Wenger (1991), it is recognised that there is no learning that is not situated. According to their theory, it is within communities where learning occurs most effectively. Interactions within communities of practice that involve problem solving, working to build trust and development of relationships that fosters community social capital that enhances the community members’ wellbeing (ibid). Sergiovanni (2004) reinforces the idea that learning is most effective when it takes place in communities and teaching becomes more learner centric. He argues that academic and social outcomes will improve only when classrooms become learning communities and teaching becomes more learner centred. These community of practices cover not just school or college settings but other learning environments such as the workspace within organisations as Kolb (1984) refers to in his concept of learning spaces.

Building on the theories of Kolb, Lave and Wenger, curriculum designers can increase the effectiveness of college instruction particularly in course design, delivery and preparation of students to move from the classroom to the work environment (Sims and Woodridge, 1995). The experiential learning theory is useful in curriculum development because it focuses on interactions between participants and the social environment that may affect their career choice. Exploring experiential learning theory and its application in the design of an integrated STEM intervention could lead to a resolution to the issues identified so far. The researcher hopes to provide valuable insight and information on effective approaches to effectively plan and structure STEM career education, drawing on a region's life science ecosystem to provide relevancy and alignment to its talent needs.

1.4 **Action Research Methodology**

This study was conducted using qualitative action research methodology and draws upon both primary and secondary sources of evidence in its research findings. Action research (AR) has been selected as the main methodology for the study following an initial assessment of the range of approaches and their appropriateness to the given context. Given the researcher-practitioner's pragmatic principles and values, combined with a strong background in education and her own need for professional development in the praxis of curricula alignment to meet the needs of employers, action research was deemed the most favourable methodological approach to adopt. Action research assumes that education practitioners know and understand their local communities and context and can identify actions that can lead to improvements in education, practices and provision in order to improve student learning and outcomes. Through an on-going cyclical process of action research and the development of modern designs and practices, staff can bring about change for sustained improvement (McTighe, 2009).

Action research presented the opportunity to conduct the immersive research study in tandem to fulfilling the requirements of a professional role. Action research has been embraced because of its practicality in deriving understanding in real life situations and environments (Carr and Kemmis, 2003). The approach supports the idea that knowing happens through action and knowledge obtained by doing and reflecting (Biesta, 2007). The world we construct emerges out of the doing-undoing-doing dynamics of what Dewey calls experience (ibid). The researcher's philosophical standpoint and its influence in the choice of this methodological approach is offered in more detail in Chapter 3.

The three cycles of reflective action research summarise the key themes derived from the thematic analysis of each data set from the application of five data collection instruments across the three stakeholder groups represented in the study i.e., employers, educationalists and learner participants. The thesis explores the perceptions from each stakeholder group of developing the intervention programme, producing research that aims to support positive youth development utilising existing expertise and resources from within the region's life science eco-system.

1.5 Purpose of the Study

The central aim of this thesis is to gain qualitative insight and understanding of the knowledge, skills and attitudinal requirements of talent identified by the life science sector. This will assist to inform the design, implementation and evaluation of an intervention STEM programme targeting 16-18-year-olds (pre-university) to raise awareness of the life science sector and its' career opportunities. The premise of the intervention is to understand the potential for opening-up the skill supply pipeline at post further education to create an indigenous talent pool that serves the recruitment needs of life science employers with young, fresh talent, whilst also enhancing the talent profiles of participants. The collaboration between stakeholder groups with a vested interest in a resolution are important to better understand the phenomenon and to identify if the intervention model improves interest amongst participants in the life science sector and develops skills and experiences aligned with the needs of the future workforce. The study aims to also deepen understanding of the value of practicing participative or collaborative action research and bringing about change in education design praxis.

There were a multitude of purposes for this action research study; primarily, the study aimed to address the recommendations levied at the FE sector for its lack of aligned education provision that meets the needs for STEM talent in the region's evolving life science sector (Life Science, Skills for Life, 2014). Secondly, to support the host FEI to craft an education response to meet the identified regional problem without disrupting existing education provision. This would require change in the existing professional praxis of curricula development to work more collaboratively to design solutions that are aligned to sectoral workforce needs with the cognisance of operating within a limited range of resourcing. Finally, a personal purpose to this study supports the researcher-practitioner's own professional praxis and professional development within strategic education intervention planning and design in her role as a Regional Skills Advocate.

1.6 Research Aim and Objectives

The predominant aim of this research is to advance an understanding of whether a STEM experiential learning programme can facilitate the development of high calibre talent whilst increasing awareness and potential interest in careers in the life science within the evolving regional economy of the south west region of Wales?

The following objectives have been identified:

1. To identify the knowledge, skill and attitudinal requirements of young talent for the life science sector and to identify successful STEM education approaches that could be transferred to the regional context of south west Wales and the further education sector.
2. To design and create an integrated STEM intervention programme and to assess the opportunity to draw upon existing expertise and resources within the region's life science and health eco-system.
3. To implement and pilot the intervention to test its suitable delivery methods and key features and to evaluate its effectiveness in enhancing young people's profiles and preparedness for careers in the life science and health sectors.

Specific research questions related to each of the research objectives are detailed in the respective action research cycles. In addition to the gaps in existing literature, this research will contribute to the development of an evidence-based and practical response specifically addressing the recommendations of the Life Science, Skills for Life report (2014). These are referenced in more detail in the literature review in Chapter 2.

1.7 Study Significance

The significance of the study lies in gaining a better understanding of whether an integrated STEM intervention programme provides a framework for a solution to address the real talent issues identified. Effective change in education curricula development praxis can only manifest from understanding the regional context, its needs and characteristics. The literature identifies uncharted gaps in education intervention design and approaches, particularly in regional further education research which this study contributes to improving local conditions.

1.8 Study Limitations

This AR study was affected by several limitations. The specific context was set within the life science sector in the south west region of Wales and focused on students studying a defined and limited range of STEM subjects at a local further education institution. The host institution set out a series of terms which limited the scope of the study in terms of its design and timing. Firstly, any intervention design had to complement existing STEM provision ensuring no significant duplication with existing and traditional qualifications. Secondly, the participants for the limited sample study were invited to apply to participate for a maximum of 12 places set for the pilot and follow up cohorts. These restrictions influenced the study design and the consequential selection of a qualitative approach although some nominal quantitative data was collected. The small size groups and corresponding data samples limits the relevance and power of the study’s findings to other study settings.

A restriction relating to a maximum of 3 AS levels in singular STEM subjects (it is usual for students to study 4 AS levels) or a vocational science subject were set to allow participation and work-balance combined with the Talent Bank programme. Timetables to allow the release of participants to attend the off-college site programme created some challenges for the curriculum manager and the researcher-practitioner. These issues were addressed but some clashes remained for a minority of students. The recruitment process resulted in a group of students with a range of abilities and potential interests in STEM and associated careers. Two secondments were agreed for teaching staff from the college to support the programme with a minimal resource budget. The teachers delivered key elements of the programme and acted as a focal point for the participants. The scheduling and time constraints required the programme delivery to not exceed 26 weeks (reduced to 24 weeks in the second cohort) to limit work pressures on participants at a time when they should be focusing and preparing for external exams. The scheduling of the programme each Wednesday was pre-determined by the institution from 9am - 4pm following induction week, September - early April 2016 and 2017 - early April 2018, respectively. The Talent Bank programme is not prescribed with activities each week, more that the holistic design allows for a range of experiential learning experiences and skill development activities within an immersive real-life environment.

Whilst Beckett et al., (2016) suggest long term interventions show better results than reduced periods, the researcher in this instance disagrees and argues valuable outputs and impact from this relatively short study timeframe. The researcher drew upon the existing life science sector employers within the region's ecosystem initially using contacts from colleagues within the University's Medical school and their offer of support to the Talent Bank programme. The contacts and relationships with the life science ecosystem was limited in the first instance but developed over time. The availability of employers and academics expertise and access to resources dictated the scheduling that may have impacted learner's overall perception of their experience and overall findings. The findings are specific to the locality and its unique context and are therefore not generalisable.

1.9 Structure of the Thesis

The thesis is presented in three parts each with three chapters. The document has a total of nine chapters and a summary of the key content is illustrated in the flow diagram Figure:2.

Part A – Context

Chapter 1 INTRODUCTION provides the general orientation of the thesis presenting the focus of the study, its rationale and context. A brief overview is presented of the statement of the problem, the aims and objectives and the significance of the research and its application and how change will be implemented, together with an overview of the thesis structure.

Chapter 2 LITERATURE REVIEW presents a review of the literature in relation to the aim of the research. The chapter provides a foundation of understanding on what other research has been done in the field and serves to focus gaps in the literature that may be 'filled' by the design of the study. The review of literature includes prior research studies of significance and their methods and outcomes that may be of value in identifying new perspectives or approaches that can be incorporated. Experiential Learning Theory (Kolb, 1984) provides the theoretical framework which underpins the study and its intervention design that aims to address the regional talent issues.

Chapter 3 METHODOLOGY presents the research design, methodological considerations and justifies the selection of action research and its appropriateness as an empirically valid research method for the context and overall approach adopted. The approach is considered alongside the methodological limitations and ethical considerations.

Part B - Action

Chapter 4 ACTION CYCLE 1 - IDENTIFYING REQUIREMENTS presents the first reflective action research cycle and data gathering: The planning of actions to identify the skills required and demands from talent for a tailored intervention programme to serve the needs of the region's Life Science sector. Interviews with employers in the life science sector coupled with observation records from visits to education providers identified with model examples of best practice are documented.

Chapter 5 ACTION CYCLE 2 - DESIGN THE INTERVENTION presents the **second reflective action research cycle**: Designing and creating the Talent Bank integrated STEM intervention programme. The action planning, use of intervention design theory, the ADDIE and Logic design frameworks and iterations of the intervention programme together with the key processes and experiential learning opportunities are discussed.

Chapter 6 ACTION CYCLE 3 - IMPLEMENTATION, ANALYSIS and FINDINGS presents the **third and final reflective action cycle**: Implementing the Talent Bank intervention programme with pilot cohorts of participants. An overview of the implementation process, the data gathering tools through to the use of thematic analysis is outlined to identify the emerging themes and findings from the qualitative data.

Part C - Differences

Chapter 7 DISCUSSION summarises and discusses the results and the six broad themes that emerged from the research in relation to existing literature and considers the contribution of new knowledge from the thesis.

Chapter 8 CONCLUSIONS AND RECOMMENDATIONS presents the conclusions and implications of the study together with the limitations and recommendations for further research.

Chapter 9 REFLECTIVE EPILOGUE presents an account of the researcher's personal reflections which highlights key elements relating to her learning and development journey and the ultimate changes to her praxis.

Finally, the thesis is concluded with relevant documentation curated over the research duration within the Appendices. Documentation has been provided for reference and in response to the criticism of Sagor (2011), who states that education practitioners undertaking action research often take 'intellectual shortcuts" to routines and considerations they have taken without expressing the precise nature of the actions they take for others to consider or replicate.

Figure 2: Illustration of Thesis Structure

1.10 Conclusion to Chapter

This chapter introduced the background and context to the action research study designed to determine the effectiveness of an integrated STEM intervention programme utilising experiential learning theory. It provides an outline of its rational, overarching aim and research objectives, an outline of its significance accompanied by a structure of the thesis. The next chapter (Chapter 2 - Literature Review), examines the literature relating to the research problem, previous studies and any gaps which provides a useful foundation on which to design this study.

Chapter 2

LITERATURE REVIEW

2 LITERATURE REVIEW

2.1 Introduction

The literature review enables the researcher to grasp an understanding of the historical and current field of knowledge, debates and gaps in a particular field before carrying out a further investigation (Scribbr, 2014). The literature review strategy adopted involves an initial review to provide the researcher with sufficient understanding to initiate the study, whilst in essence the review of the literature is a continuous process throughout, as thought-provoking ideas and concepts arise as identified by the action cycles and reflections. Each action cycle chapter contains reference to existing literature as the study evolves and unfolds. The final chapters weave reference to literature in the face of the findings with discussions of how these contribute to existing knowledge.

The focus of the study at the outset was to understand how other studies of further education have resolved regional workforce education needs for STEM sectors. The search presents an abundance of peer reviewed literature about Science, Technology, Engineering and Mathematics disciplines which is most often referred to by the acronym STEM. Whilst STEM has more recently become a discipline in its own right, it is a relatively ‘new’ concept that can be traced back to its original guise in the early 1990s (Yeping and Wang, 2020). This chapter discusses the interest and importance of STEM talent for the competitiveness of an economy and its knowledge intensive activities, (UK Commission for Employment and Skills, 2013) with the importance of growing the supply of a human capital skills base in STEM (Chiu and Duit, 2011) and the impact of STEM talent shortages which raises implications for education (Keep, 2012). Transferred into the realms of education with the responsibility for increasing participation and supply of STEM talent, a plethora of curricula programmes have evolved combined with educational research and published literature. A dedicated section introduces a definition of STEM education and presents an overview of research studies relating to this domain in further education, with an overview of what has worked and what gaps are identified within the literature. The study focuses on STEM in particular reference to integrated STEM intervention programmes (Sanders and Wells, 2006) and their constituent parts and how these studies have impacted on further education students' interest and their career choices. Research exploring key components for an effective STEM intervention programme within the context of its setting is reviewed (Thibaut et al., 2018) and leads into the problem of practice with the study's research aims, objectives and scope of the study and the gaps in literature it aims to address. The literature review serves as a foundation of identified gaps and inconsistencies in knowledge from previous studies which this research may be able to build on, address and justify in its scope as outlined. The reality of reviewing literature in an action research study is different to other more scientific approaches, as literature is read throughout the study and through each action research cycle to inform the researcher's understanding. Action research refers to a family of research methodologies that combine the pursuit of action or change in practice that has positive social value with the intention to create research outcomes to a problematic situation (Mertler, 2010). It is the methodology adopted for this study and an overview of the approach is provided with an historical background through to recent studies relating to STEM education interventions using this approach.

The theoretical framework that underpins this study focuses on pedagogy, particularly the use of Kolb's Experiential Learning Theory (Kolb, 1984). The theory's contributory concepts guide and underpin this research of seeking a FE solution to address the talent development deficiencies of existing programmes of study in order to support future workforce needs. Finally, the chapter concludes with a summary and leads on to the selected research design in Chapter 3.

2.2 Science, Technology, Engineering and Math (STEM)

STEM is the acronym or common abbreviation for the four closely interrelated subject disciplines of Science, Technology, Engineering and Mathematics. The discipline subjects are often associated due to the similarities that they share in both theory and practice. The STEM movement began in the early 1990s by the National Science Foundation in the United States, as the analogy SMET, but decided to make the change to STEM purely for phonetic reasons (Martin-Paez et al., 2019). The first explicit use of STEM is recorded in 2005 with the creation of a STEM degree at Virginia Tech University in the US and from where the gradual dispersion of the term became more universally widespread (Friedman et al., 2017; Sanders, 2008; Moore et al., 2013, Burrows et al., 2018, Martin-Paez et al., 2019). The original impetus for STEM education related to the growth and critical sustainability of job opportunities from expansions in emerging fields in the US economy. Whilst there is much written and spoken about STEM education, it has reached the point where the interest in it has become 'an almost universal preoccupation" (English, 2016) yet it is a relatively new term, coined just a few decades ago.

In the US publication in 2005, Rising Above the Gathering Storm (Hoeg and Bencze, 2017), released by the National Academies of Sciences and Engineering and the Institute of Medicine, argued that US students were academically behind in STEM achievements compared to other nation counterparts. The publication predicted dire economic consequences for a poorly prepared workforce and galvanised education institutions into a newfound focus on STEM curriculum and careers. This led to a subsequent investment for STEM education and research programmes under the America Competes Act of 2007 (ibid). This is identified as a catalyst moment in the growth of STEM education not just in the United States but worldwide. Many developed countries have positioned STEM central to their own nations' competitiveness influencing industry, education and research. Education is more than ever compelled through government funding and educational policies to tailor provision to prepare students for a STEM dominated future.

2.2.1 **STEM Talent Shortages and Employment Outlook**

Research highlights a focus of STEM related jobs and the difficulties industries have in recruiting STEM talent (Confederation for British Industry, 2014). Jobs are reported as going unfilled which affects businesses and their ability to grow because of an identified skills gap (UK Commission for Employment and Skills, 2015). In its report, the Commission reported over 43% of STEM roles were difficult to fill due to the lack of talent with the required STEM skills. This view is endorsed by the World Bank with the outlook that nearly three quarters of prospective careers in the future will transform and require STEM skills and capabilities (World Bank, 2016). As the world of work landscape changes, so too must the skills base adapt to match the skills need. Globalisation, automation and technological advancements have brought new and emerging sectors whilst many traditional ones have declined and changed the way we think about future careers (UK Commission for Employment and Skills, (UKES) 2015). The gap between the knowledge developed in our current education system and the skills demanded by employers in the future world is widening (Robinson, 2010). Overcoming these challenges requires a change in approach and emphasis on STEM skills including the development of workplace skills (World Economic Forum, 2016). Future predictions suggest that careers in the future will rely heavily on skills for the 21st century such as collaboration, problem solving, critical thinking and creativity and that job roles will require twice as much time on job tasks than currently the case of workers today (ibid). Individuals are predicted to need to be more responsible and shoulder the investment in their own skills development as part of the hybridisation of the skills agenda (UKCES, 2015).

However, it appears from the evidence that a STEM shortage or surplus depends on the sector and geographical location. These issues are not presented uniformly across the whole of the UK as different regions have different infrastructures and economies. Therefore, it is important to consider the issue in the context of the situation to adequately address the shortage by basing solutions to skills shortages on knowledge of local demand rather than on broad general assumptions (Economicmodelling.co.uk accessed on 9/9/16). Skill shortages in the life science sector has been a priority for the UK government in recent years. Forecasts identified within the Life Sciences 2030 Skills Strategy, identify the critical importance of plugging the STEM skills gap to protect its position in the global economy (SIP 2030 Skills Strategy, ND). With a predicted 133,000 jobs across the entire sector, new talent is required in part to address the expansion of the dynamic sector but also to replace an expected

55,000 retirees. The Skills Strategy builds on the ABPI Skills Gap Research (2019) which highlights specific skills deficits that require solutions to enable the sector to fulfil its full potential and ambitions as a leading life science sector in Europe.

A set of STEM skills shortages identified across the sector include:

- Leadership
- Computational skills
- Statistical Literacy
- Communication
- Inter-disciplinary working
- Translation and Commercialisation Skills
- Sales and Marketing Skills

These skill priorities are also highlighted in the Life Science Industrial Strategy Action Plan and outline the increasing need for the convergence at the interface between life sciences and education. STEM occupations are expected to grow by 8 percent by 2029 in STEM fields compared with 3.7 for all occupations (ibid). This is a comparable situation in OECD countries where the number of students entering the job market are not able to keep pace with demand which has the effect of inflating salaries and industry costs, such as when employers resort to expensive solutions like recruiting from abroad. The STEM workforce shortage is also evidenced by the numerous efforts, across governments of different countries, to boost the involvement of young people in the STEM disciplines (Tripney et al., 2010; Marginson et al., 2013; Archer et al., 2014).

The UK's economic future lies in high value, innovative and knowledge intensive activities. To pursue this ambition, a workforce of STEM talent is essential. Growth in the volume of undergraduates in STEM in Wales are reported (Office for Statistics, 2014) but many of these graduates disappear from the regional economy to seek employment elsewhere or return to their home regions. Growth in regional infrastructure projects such as A Regional Collaboration for Health (2017) highlight a need for additional STEM talent, suggesting an urgent response to educate more indigenous young people to engage their interest and awareness of opportunities for high skilled and high paid employment in the STEM arena. To ignore the issue will lead employers to seek solutions elsewhere. The data on the fastest growing job positions in STEM that went unfilled in 2016 identified a reliance on recruitment from other countries or regions. Governments have invested substantial funds towards interventions that encourage young people's interests, aspirations, participation and achievement in STEM disciplines (Tripney et al., 2010; Archer et al., 2014). Although the majority of the evidence in literature surrounds interventions in Higher Education and secondary schools, there has been a gradual shift in widening participation to involve the younger age groups so that a pipeline of STEM talent is now evident that commences from primary education (Hughes et al. 2016; Kim, 2018). However, these regional STEM talent pipelines are piecemeal and unintendedly unconnected, losing any synergetic benefits from a more planned and co-ordinated regional strategy.

2.3 STEM Education in UK and Elsewhere

Over the last 20 years, STEM education has been a popular discussion item in the United Kingdom with a plethora of academic studies focused on its phenomena and on improving young people's engagement and career choices within STEM. This is due in part to the findings of the Robert's Review (2002) which identified the vital element that STEM skills play in the overall UK economy and how the real threat of shortages in STEM skills can affect the UK's competitiveness internationally and its capacity for growth, as it is faced with solving the greatest challenges within society. A call to action from the report identified the need for educators to consider the findings and to re-purpose their STEM programmes to play a part in addressing the recommendations. Over a decade later, the World Economic Forum Global Competitiveness Report (2016) reports that China has become a leading player in the STEM education agenda, boasting over 4.7 million graduates as of 2016. The country has swiftly taken action to implement STEM initiatives driven by governmental policy and raised awareness of the benefits of STEM amongst parents that could future proof the careers of their children. This recent reform is already showing benefits that provides China with a distinct advantage in that it is preparing a more STEM capable workforce. This capability will enable China to thrive in the technology and knowledge-based economies which supports solutions to real world problems thereby transforming their ‘Made in China’ to a ‘Designed in China’ approach which is likely to have dire consequential impacts on other countries’ economies if they do not address their own STEM capacities. (Wei, 2017).

STEM can be considered as a single discipline or a multidisciplinary field with no clear agreement on the nature of the content or the pedagogic interplay between the STEM subjects (Sandall et al., 2018). STEM education initiatives have permeated all parts of the education sector, in public and private education offering an abundance of STEM permutations and variations in institutional practices (Hollund et al., 2018). Different format of STEM activities ranging from after school clubs, summer camps, course units, and full programmes across primary, secondary, tertiary and higher education provide an insight to its importance for the future prosperity of industry and students in their future working lives (ibid).

A review of existing research identifies a range of studies with a focus on a single STEM discipline to those that refer to STEM holistically and include the four disciplines, whilst others combine more than one discipline and include related subject areas (Rottinghaus et al., 2018). The field and subject areas included in the categorization of STEM is broadening and constantly evolving, particularly with current technological developments and its influences across nearly all sectors of the economy (Zollman, 2012; Rottinghaus et al., 2018) including sectors that previously did not have much need for technology (UKCES,2015). A review of UK academic evidence behind the priority of STEM education reviewed in secondary documents and research studies, identify successful interventions that could be applied to the regional context. There is a broad evidence base of good practice, identification of conducive environments and a range of interventions and features that lend themselves to creating positive impacts (Straw, 2012). More recently, Moore et al., (2014) introduced the concept of integrating STEM education as an effort to combine some or all the four disciplines of science, technology, engineering and mathematics. The importance of the holistic integration of the STEM disciplines has become more prevalent in the last five years and was raised in several reports (Burns, 2015; Sandall et al., 2018). While it is necessary to teach skills from individual STEM learning areas, reports have shown the benefits of an integrative approach, which include improved problem-solving skills, increased motivation and improved maths and science outcomes (Blackley and Howell, 2015; Becker and Park, 2011; English and King, 2015). An integrated approach is also evidenced to assist students to understand what they are learning but also why and how their learning can be applied (Everett et al., 2000; Hanover Research, 2012). According to Masters (2016) an integrated approach to STEM can teach more than the skills, competencies and knowledge of the four domains as identified in the 21st Century skill categories i.e., ways of thinking, ways of working, tools for working and skills for living in the world. Masters (2016, p.6) highlights concern that 'school subjects tend to be taught in isolation from each other, at a time when solutions to societal challenges and the nature of work are becoming increasingly cross-disciplinary." Developing and implementing integrated units of STEM can provide chances for students to combine the development of knowledge with skill capabilities that include critical thinking, creativity, communication and self-direction. According to the international Maths and Science Study (Trends in International Mathematics Science Study, 2018) in its seventh cycle of studies designed to measure trends in science and mathematics achievement, a recommendation is made about the benefits of designing provision in an integrated way to better prepare students with the sought-after STEM skills.

In order to stimulate change in generating interest and encouraging, inspiring and motivating the next generation in STEM, there has been a broad spectrum of efforts to address and promote from a range of localised interventions, national programmes as well as changes in government education policy (Confederation for British Industry, 2014). As STEM education is an ever-changing and evolving field with a requirement to constantly adapt and continue to learn to new situations, a wealth of STEM initiatives have sprung up. Ranging from after school activities, field trips, speciality programmes, summer camp activities etc most highlight the value of active learning, experiential or inquiry-based learning in integrated STEM programme design and teaching. Active learning involves students using multiple senses and interacting with other people and resources to solve a problem which also help to develop soft skills like creativity and innovation, problem solving and critical thinking, collaboration and leadership. Experiential learning is a form of active learning and according to (Kolb, 1974) can be used to guide simulation-based learning experiences offering a foundation of experience and a process for knowledge acquisition based on the needs of each individual learner. Inquiry-based learning builds from a natural process of inquiry in which students experience a 'need to know' from real life problems or issues that motivates and deepens learning as illustrated in Figure 3, (Nugent et al., 2010). Barker and Ansorge (2007) also emphasises the importance of hands-on, real-world problem-based learning that develops more than domain-specific skills and knowledge. Through these pedagogies, students learn to collaborate with others, follow areas of interest, become creative and solve problems which is often a deficiency in the delivery and student experience of their siloed mainstream A level STEM qualifications.

Many of these exemplars have found to have contributed to increases in science literacy, the development of a range of employability skills and careers education that enables growth within the STEM pipeline to create the next generation of innovators. However, to reiterate earlier mentions, there is no one successful or effective or unified approach identified for post compulsory education whilst there are an abundance of initiatives. Despite an increase in common use of the term STEM, there remains a broad understanding as to what constitutes STEM education and what it means in curricula design and learner outcomes (Breiner et al. 2012; Lamberg and Trzynadlowski, 2015). It may be possible to create sub-categories to provide greater clarity in the STEM education landscape.

2.3.1 **Successful Factors in STEM Education Interventions**

All students are not given fair and equitable chances to experience STEM subjects during their schooling. Often, students who want to pursue higher learning in STEM disciplines encounter deep institutional bias and barriers to entry (Prieto-Rodriguez et al., 2020). This problem is being addressed at education policy level with targeted funding and initiatives however, despite these initiatives the deficits in STEM interest is much lower than the economy needs (Catterall, 2017). Recent studies also highlight a range of issues in the study outcomes highlighted by research, such as continued barriers to entry, underrepresentation of specific learning abilities as well as gender imbalances ((Prieto-Rodriguez et al., 2020; Jeffes et al., 2012). This research further identifies a need for deeper insight and understanding in a range of areas, calling on the design of holistic approaches to STEM education that combine several elements that have shown to engage young people in STEM. These include successful practice in the use of role models and mentoring; the approaches to effective recruitment to intervention programmes and the value of STEM employer's involvement in the education of young people and how collaboration in the research community can be increased (Hoyles et al., 2011). In addition, Rosicka (2016) suggests there is a lack of practical forms of research or 'rarely published and shared literature' around STEM education, such as through action research methodologies that focus on the effectiveness and implementation of such interventions and how it can be used to inform practice in other contexts.

Studies highlight a range of factors that influence student participation and subject choices. In their study, Palmer et al., (2017) identified the most key factors young people consider when selecting future careers concern one's ability in a subject, the interest and enjoyment level it provides as well as the perceived need in the future career options. Outcomes from other studies suggest increasing students' awareness and perceptions of the value of STEM in future careers in the context of the world of work outlook may result in greater participation (Osborne et al., 2003; Palmer et al., 2017).

A further important aspect of STEM education refers to the quality of the educator. According to Slavit et al., (2016) "a teacher's role is a combination of learner, risk taker, inquirer, curriculum designer, negotiator, collaborator and teacher".

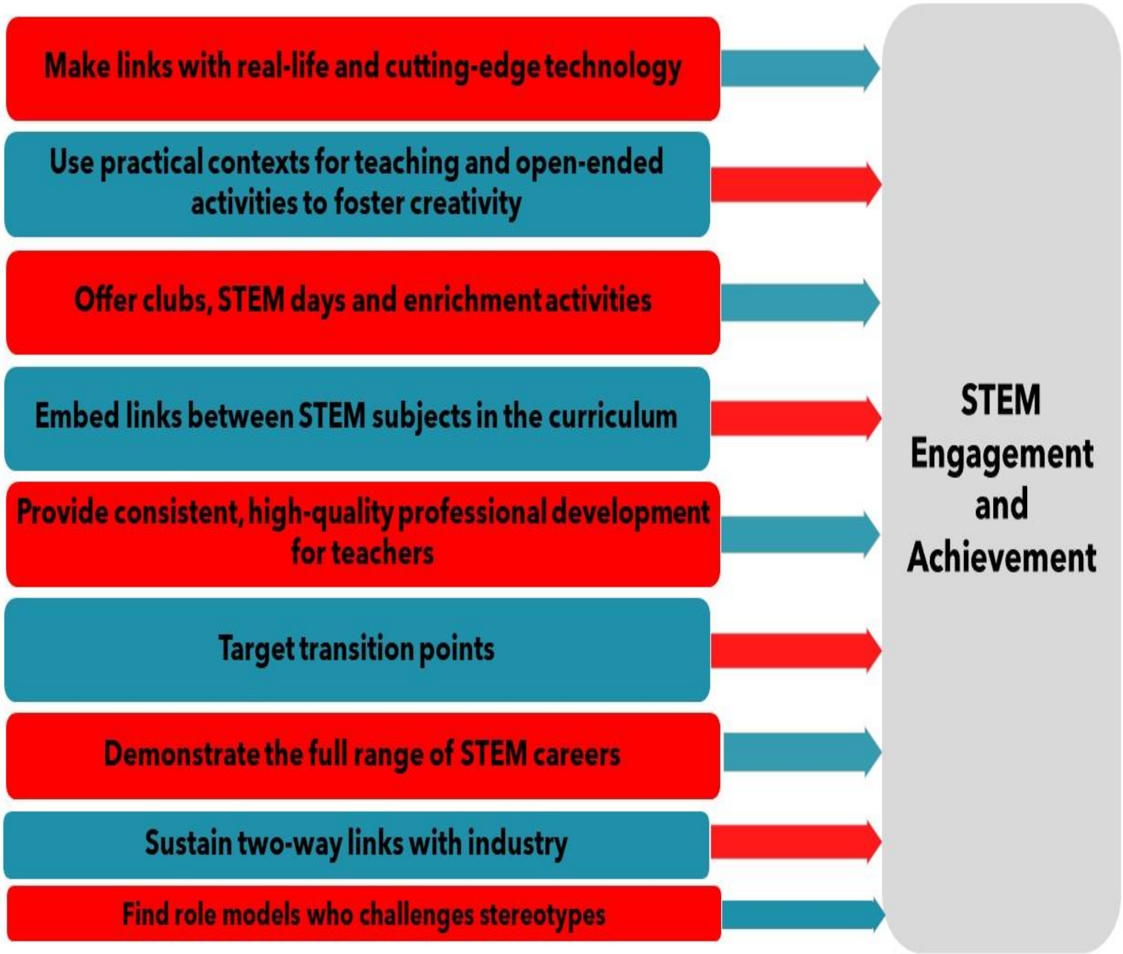


Figure 3: Success Factors in STEM. (Nugent, et al., 2010).

The importance of understanding a teachers' own beliefs and perceptions in relation to STEM talent development is another important consideration (Margot and Kettler, 2019), as increased confidence can be instrumental to better facilitation and performance which leads to gains in student learning.

Despite this evidence of progress, a review of the UK government's policy direction in STEM education suggests a need for a robust evidence base with a shift of the responsibility to educational settings to liaise with local STEM industry by forming partnerships (STEM Learning, 2016; Gatsby Foundation, 2014). The reports concur that partnerships between education and STEM employers can enrich STEM curriculum, provide teachers with opportunities to develop their own knowledge in context and to gain up to date knowledge of careers which in turn will entice more students to consider STEM career pathways. Within the wealth of STEM education research, there is also criticism of the lack of evaluation of such studies (Martin-Paez et al., 2018) and it appears the most effective ways to promote learning and inspire careers relating to regional STEM contexts, remains elusive.

Whilst there is an interest in improving student achievements and attracting more students into STEM careers, the evidence base in Wales regarding successful intervention design is relatively sparse. Despite targeted government policy, investment and delivery plans that spotlight STEM in education and training, as well as efforts to change perceptions to positively reinforce the importance of STEM (The National Science Academy STEM Enrichment Strategic Plan, 2015-2018), evidence suggests lower rates of participation and gender imbalances remain. This is not due to a lack of national programmes, innovative approaches or interventions, as this is plainly evident, however, that few studies have been evaluated to assess if they are more effective than previous approaches.

For example, there is little research into the effectiveness of different interventions that utilise the expertise and resources from within a region's ecosystem, to support young people studying STEM subjects within the further education sector. This appears to underscore a significant gap in data and knowledge of the set circumstances and influences of intervention design that can lead to more young people opting for a career in a STEM sector (Kaleva, 2019). This gap in the literature therefore provides an opportunity to focus this study, set within further education and the context of the life science sector in the south west region of Wales, with its diverse range of workplaces and career opportunities.

2.4 **Problem of Practice**

The identified problem of practice involves students studying STEM subjects at a local further education college but who have limited, if any opportunity of applying their knowledge to the context of the real working world. There is existing additional education provision such as the Seren Network and HE + programmes (Gower College, 2019) that aim to develop talented and gifted, young people motivated to pursue careers within medicine and related careers delivered though a range of masterclasses and university visits. However, there is no existing work experience provision or support for students deemed to be ‘average’ according to their GCSE profiles who may be also interested in pursuing a career in medicine or other sectors such as health or life sciences.

Deficiencies in work experience opportunities and insights into potential careers are contributary factors that often lead to drop-out rates at university, as students quickly realise the degree programme is not what they imagined, or they were not prepared or equipped for as they experienced the transition (Jackson, 2015; Andrews et al. 2012). Research studies have been shown that work experience improves students understanding of the world of work, helps to develop professionalism including adapting to routines and a range of work-related skills such as teamwork, working on one’s own initiative, communication and problem solving etc. (Smith,2016; Crisp 2018).

2.4.1 Research Aims and Objectives

The review of the literature has identified STEM education as a relatively new field of research. The current study hopes to address some of the identified gaps and test theories related to the application of a STEM integrated intervention, set in the context of the life science sector in south west region of Wales. Continued exploration and more data are required for meaningful debate on what is effective integrated STEM education and how it should be delivered (Prieto-Rodriguez, 2020). Therefore, the current study hopes to clarify and address this issue in part as it focuses the topic of experiential learning design in an integrated STEM intervention placed within the context where no other research has previously been identified. The study implements a research strategy to determine some of the successful aspects of other interventions and exemplars and to test their transference to the regional context. Therefore, the predominant aim of this research is to advance an understanding of whether a co-created intervention programme through action research can facilitate the development of high calibre STEM talent with a view to rebalancing the capacity needs of the life science and health sectors within the evolving regional economy of the south west region of Wales? The following objectives have been identified:

1. To identify the skill requirements of talent for the life science and health sectors and to identify approaches undertaken in other contexts that can be adapted to the regional context.
2. To design and create an experiential learning intervention programme drawing upon existing expertise and resources within the region's life science and health eco-system.
3. To implement and pilot the intervention to test suitable delivery methods and features and evaluate its effectiveness in enhancing young people's profiles and preparedness for careers in the life science and health sectors.

This research will contribute to the development of an evidence-based skills solution specifically addressing the recommendations of the Life Science Skills for Life report (2014). The recommendations set out were categorised by stakeholder groups with calls for their action. For the purpose of this research, five out of six recommendations identified for the Further Education sector are of particular interest to this research and are listed below:

Further Education:

1. Closer integration of curriculum planning between Schools and Further Education Institutions to support learners across all institutions

2. Increase the levels of practical work experience and industry mentoring to promote career opportunities

3. Offer additional courses and educational opportunities to supplement A-Level provision

4. Engage and consult with employers in the STEM sectors to ensure curriculum suitability for local and regional skill needs

5. Continue to develop appropriate vocational pathways into employment within the Life Science sector and the broader Science, Technology, Engineering and Math areas.

2.5 Action Research

The approach to identifying a regional solution to address the talent issue in this study has been designed using a qualitative action research methodology. It is a philosophy and methodology of research that is frequently applied to improving conditions and practices in a range of education and healthcare contexts. It combines the need for transformative change through the dual process of taking action and conducting research (Whitehead et al., 2003). Kurt Lewin, a German- American social psychologist is often considered to be the originator of 'coining' the phrase 'action research' and its theory relating to the relationship of taking action in the research process (Adelman, 2006).

> "No action without research; no research without action" **LEWIN** (in Adelman, C. 1993).

Action research unlike more formal research studies is typically conducted by practitioners in their field. The research methodology involves the researcher from an inside perspective rather than by independent, impartial observers from outside the organisation (Bound, 2012). The approach is less formal, or prescribed or theory driven, since the main aim is to address problems and bring about bespoke solutions rather than independently validated and reproducible findings from others outside of the context under investigation. However, while action research is typically focused on solving a specific problem the findings can also make meaningful contributions to larger body of knowledge and understanding in the field (Somekh, 1995). This is important to consider especially in the context of this study in the further education sector where the relationships with a regional community may lead others to engage in similar work.

The professional development needs and 'problem of practice' of the researcher in her role as a researcher practitioner, was a contributory factor in considering the appropriateness of the action research method. As suggested, there would be outcomes from the research that would help create practical solutions that resolve or bring about change in the community needed for STEM talent. Secondly, the researcher's own personal self-development needs are addressed as a problem of practice (Parkin, 2009). Action research (AR) focuses on resolving problems in the real world which increases the relevancy and applicability for the action researcher / researcher practitioner whereas traditional educational researchers decide on their topic of study and how to study it based on literature studies and removed from the classroom setting (Dana and Hoppey, 2014).

AR provides a two-pronged approach to learning and knowledge creation. Firstly, improvement of personal practice through an action research cyclical process of planning, acting, developing and reflecting whilst in contrast traditional educational research is linear and does not allow for procedural adjustments during the process. (PDH Education, 2014).

Dick (1993) suggests that linear, traditional research methods gain their rigour by control, standardisation, objectivity and the use of numerical and statistical procedures which is easier to replicate. Advocates of AR believe that the rigour gained using the traditional research method sacrifices flexibility and prevents researchers from adapting study procedures if warranted by the situation or based on new knowledge (Mertler, 2014). Huang (2010) states that unlike conventional research the purpose of AR is just not to understand but to provide a path to change while generating knowledge and empowering the practitioner researcher. The conclusion drawn is that this viewpoint makes action research an appropriate choice of method to identify if the actions and decisions taken result in the desired outcomes.

Action researchers do not separate understanding and action but instead believe that true understanding comes from action and experience. This allows the action researcher to critically examine their own practice, implement strategies for specific issues relevant to their situation and impact change in a much more expedient manner than the traditional paradigm (Mertler, 2014). The researcher practitioner focused on an identified problem of practice specific to the regional context of a lack of talent pipeline to support an evolving life science sector. With permissions granted for the AR with the governing body and leadership of the FE institution, the researcher recruited two cohorts of learner participants to the Talent Bank intervention programme which was designed to increase awareness and understanding of the career opportunities within the life science sector whilst addressing the skills and work experience deficient of young people (pre - university). The study is designed to gather data on learner perspectives on their experiences of the intervention programme delivery processes, content and its impact following completion. The study aims to provide knowledge to improve curriculum development practices within the FE institution to better align provision with demands of industry whilst also supporting the personal growth and development of the researcher practitioner on the six-year learning journey.

2.6 **Learning Theory**

‘Learning refers to the acquisition of knowledge or skills through experience, study or being taught (Oxford English Dictionary Online, 2018) or the activity or process of gaining knowledge or skill by studying, practicing, being taught or experiencing something (Merriam-Webster Online Dictionary, 2018). Learning may be defined in numerous ways but in essence, it is a process that binds together personal and environmental experiences and influences for acquiring, enriching or modifying one’s own knowledge, skills, values, attitudes, behaviour and world views. Effective learning describes a range of methods and strategies of teaching and learning that actively involve individuals in their own learning and development. There is no broad consensus on what effective learning looks like or should entail but the following definition draws out the key elements which have implications for individual educators and education providers.

“Learning…is a reflective activity which enables the learner to draw upon previous experience to understand and evaluate the present, so as to shape future action and formulate new knowledge” Abbott, J (1994). The importance of learning is linked to our existence and how society, individuals and the world develops and evolves.

Theories help drive decision-making about learning providing a framework for application in actual practice. There is an array of learning theories that can be grouped into a range of categories for simplification and understanding. In this study, it is useful to categorise the learning theories of direct interest into three main groups which are influenced by epistemologies: objectivism, constructivism and connectivism. There are many epistemological approaches to learning that influence teaching practices today. Educators will hold different epistemological positions that influence their choices of teaching approaches in a given situation.

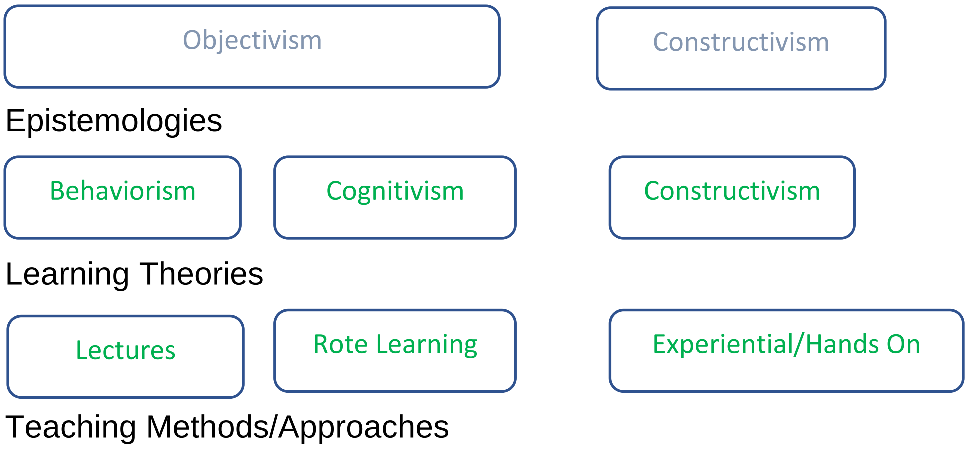


Figure 4: An Educator's Epistemology Adapted from A.J. Bates (2019)

A simplified illustration of how An Educator's Epistemology may influence the selection of theories and adopted approaches in the classroom according to contexts is illustrated in Figure 4. For instance, a teacher may adopt a more objectivist approach with novice students then proceed to a more constructivist approach when the basic understanding of facts and concepts is grasped. It is possible for a practitioner to change their epistemological position even in the same course or lesson blending different approaches to enable the best conditions for all learners to gain knowledge and skills. The researcher-practitioner considers the more traditional objectivism position of using behaviourism and cognitivism learning approaches utilised in the existing individual STEM subjects taught in the FE setting and the focus for this study.

The researcher identifies the gap in learners' experiences and considers the value to learners and educator's practice of a more constructive approach. Whilst arguments can be made for and against any of the epistemological positions or even that academic knowledge today is now redundant, Bates (2019) makes the case for further development of academic knowledge with a focus on development of skills and partnership between stakeholders rather than an emphasis on learning content.

There is a wealth of empirical evidence to support theories of behaviourism and cognitivism as these are well established theories however, constructivism and studies relating to these theories is still an expanding field. Whilst there are differences between the theories on how individuals learn, they do not universally agree on how educators should teach. It is argued that these theoretical positions are mostly developed outside of education and therefore educators often have difficulty in practically applying these theories to the reality of education. Most recent discourse relates to developing skills for the 21st century and for our existing education system to promote deeper forms of learning. Interestingly, many critics suggest what is missing from the discourse is recognition that much of what is known from research on learning and education has yet to affect the design of our modern-day education system in the form of curriculum, instruction and assessment (Goldman, 2015). The engagement of the education sector to engage with research evidence and to use it to inform and enhance practice is very weak. Whilst there are numerous reasons attributed to this, one important and compelling reason is the complexity of the research in terms of how articles are written and their accessibility to practitioners. "The Education Endowment Foundation published two independent reports concluding that educators are not willing to invest their time to engage with learning or education research as senior leaders are not willing to support them and invest resources to enable them to do so" (MacLellan, 2016). A study conducted by Durham University by Cartwright and Joyce (2020) highlights this gap between the results of academic education research and praxis of educators. The study highlights the disconnect between the academic papers and the audiences they are written for and the separate needs of educators and practitioners with outputs that provide minimal basis for predications of what would happen in local contexts. Suggestions to resolve these issues include education conduits that translate the academic research into practical instruction or alternatively the promotion of action research which combines learning research in tandem with implementing actions in practice with the intention to understand if it leads to change. Whilst there is recognition of value in the generalised theories from their guidelines and principles that can be interpreted and adapted to test in a local context and under unique conditions, it is the application in these new contexts that can add to the body of existing research.

Despite these criticisms, education across the world, particularly through the Covid-19 pandemic has witnessed a fundamental transformation and shift. Educational theories and processes including teaching and learning methods have undergone change processes to adapt to a new reality of online learning at least until 'normal' education resumes. According to Nejkovic and Tosic (2014), the traditional educational frameworks have not met the emerging needs of society particularly with the emergence of technology and the continuous flow of development, highlighting some of the key limitations existing in education practice:

- Limited involvement of students in the teaching process
- Inability of students to influence and contribute to the learning process in a meaningful way.
- Inability of students to organise their learning around themes and contents of learning and interest (Mott, 2010).

Many recent studies criticise the approach of traditional and didactic learning where knowledge is delivered by teachers (Mott and Wile, 2010). These traditional learning theories are now being compared with more contemporary and innovative approaches to teaching and learning which provide greater possibility for improvement (Chatti et al. 2010). The reality is probable that a blend of learning theories is required for education and no one theory alone can holistically develop individuals.

2.6.1 **Constructivist Education**

According to constructivist theory, learning occurs by creating meaning from experience. Individuals create interpretations of the world based on their first-hand experiences and interactions. The learning is influenced by environmental factors and how individuals interact with them. Effective learning takes place when content and knowledge are embedded into the context or situation in which it will be applied. Constructivism contends that knowledge is always under construction from a culmination of experiences and interactions. Learning about a concept will continue to evolve as a consequence of a learner combining new learning experiences or situations with activities. The transfer of knowledge occurs through the individual's involvement and interaction in authentic tasks anchored in meaningful contexts. The constructivist view is that learning always take place in context and is most effective for developing advanced knowledge. By understanding experiential learning theory and linking practice in the classroom, educators are better equipped to promote opportunities that promote learning.

2.6.2 **Experiential Education**

Experiential education is a philosophy of education that describes the learning process amalgamating hands-on learning experiences with the learning environment and content. The concept of learning through doing or experience can be traced back to Aristotle in 350 BC, where he wrote in the Nicomachean Ethics, "for the things we have to learn before we can do them, we learn by doing them" (Griffin, 2010)). Although, in relation to education and pedagogy, John Dewey, the philosopher and educator is attributed with the theory and the importance of experience and its centrality to the educational process and is considered the Modern Father of Experiential Education (ibid). In his publication Experience and Education in 1938, Dewey criticised both the traditional didactic approach and styles to education suggesting that they did not meet the goals of education and were too concerned with the delivery of knowledge and less about understanding learners' experiences (Neil 2005). His learning theory is about social learning and the belief that school should represent the social environment and that students learn best when in a natural social setting (Flinders & Thornton 2013). His theory deals with the acquisition of knowledge within a framework of a philosophy of action and advocates encouraging students to find a personal interest in the subject matter in order to feel a connectedness, which supports the retention of information and its adaption for use in other contexts in the real world. Dewey argued that education should be relevant to student interest and their lives. He identified learning by doing and development of practical life skills as crucial to students' education with the notion that experience could guide educational innovation. Dewey suggested that in order for experiential education to become effective pedagogy, physical experience had to be combined with the process of reflection to gain a new understanding and to mentally grow from the experience. He advocated and encouraged reflection about an experience that would lead to the development of new skills, attitudes or ways of thinking. His research is still relevant today and has had a profound impact on educators who have adopted his hands-on philosophy with students to enable them to learn easier and better. Dewey held the view that education should be based upon quality experiences and that certain parameters needed to be in place. The most important of which was that the experience had continuity and linked to future value and that it occurred with interaction with others (Hildebrand, 2018). His ideas were that interactions with others aided individuals to learn more from each other.

Dewey's work informs many educational pedagogies and practices throughout today's education system and other influential works on experiential models. Experiential education serves as a key category of learning approaches that links traditional knowledge production with skill development and practice. According to Hawtrey (2007) experiential learning is the incorporation of active, participatory learning opportunities in a course, sometimes referred to as situational learning. Supporters of experiential learning believe that it promotes greater student interest in the subject content whilst enhancing learner motivation, interest and retention. The learning approach can enhance development and positive outcomes in skills such as communication, problem solving, analytical thinking and critical thinking as well as interpersonal skills

(Bricker and Etter, 2008). Experts in the field agree that when students take an active role in their own learning journey, their learning and understanding is optimised (Smart and Csapo, 2007). "Students remember only a fraction of what they hear but a majority of what they actively do" (Hawtrey, 2007, p.145) and supports the old adage of "I hear and I forget, I see and I remember, I do and I understand" by Confucius, 551 BC-479 BC (Brainyquote,2016). Such examples include vocational learning, outdoor education, active learning, environmental education, and university sandwich degrees where students work in industry for a year in their academic programme.

2.6.3 **Kolb's Experiential Learning Theory**

Experiential learning theories have developed over nearly a century, building on the foundational theories of John Dewey, Kurt Lewin and Jean Piaget with many common ideas and variations. The early works of these 20^{th} century scholars shared the similar view that experience should be at the centre of human learning and development (Kolb & Kolb, 2005). There are numerous theories which attempt to enhance or modify the learning process for greater success. However, it is the work of Kolb (1984) and his model of Experiential Learning Theory that is applied in the design of an educational STEM intervention, which promotes awareness of the life science sector by exploring career paths and engaging in vocationally relevant activities that is of interest in this study.

Kolb (1984, 2005) built his model of Experiential Learning Theory from a perspective of understanding that learning from experience requires four different abilities.

These are:

- The learner should be open and willing to be involved in new experiences.

- Observational and reflective abilities are developed in order to view new experiences from differing perspectives.

- Abilities to analyse and integrate latest ideas to create new understanding from observations.

- Ability to apply new skills including decision making and problem-solving skills in practical situations and new contexts. (Merriam et al., 2007, P.164).

Experiential learning theories build on social and constructivist theories of learning but situate experience at the very core of the learning process with meaningful everyday life experiences that lead to a change in an individual's knowledge and behaviours (Kolb and Fry, 1975, Chisholm et al., 2009; Rogers and Freiberg, 1994; Schon 1998). Experiential learning theory attempts to express the holistic nature of the learning process and attempts to integrate and illustrate what Eickman, Kolb & Kolb in Designing Learning (2004) describe in a four-stage experiential learning model. The theory of experiential learning is used to organise the thinking involved and will underpin the design of the intervention programme in this action research study. According to Kolb and his four staged learning model the four phases are interrelated and influence each other in turn throughout the learning process (ibid).

His theory works on two sets of levels. Firstly, a four-stage cycle of learning which outlines the bases one passes through in developing new understanding and knowledge. The second level refers to the four learning styles and inventory that can be tailored to the individual preferences of learners to ensure better learning outcomes. This research is concerned with the experiential learning cycle of level one only. Kolb's theory outlines that the four bases of the learning cycle which are concrete experiences, reflective observation, abstract conceptualisation and active experimentation, support effective learning.

- Concrete experience (CE) – in applying Kolb's model, a learner lives through a concrete experience. This experience can be a simulation or a real-life workplace experience the learner encounters (Chan, 2012).

- Reflective Observation (RO) – in this stage the learner will review or reflect on the encountered experience and answer questions to create meaning and understanding of the experience.

- Abstract Conceptualisation (AC) – in this stage the learner will use the insight from reflection to create an abstract conceptualisation of their experience.

- Active Experimentation (AE) – finally at this stage, the learner may apply the new knowledge and learning through actively experimenting to determine how to improve the process in the future; the learning will be continuously revised and reshaped through experimenting.

The process is illustrated as a learning cycle or spiral in Figure:5 where the 'learner connects or touches with all four bases' in a recursive process that is sensitive to the learning context and the content of what is being learned: – the concrete experiences are the basis for the observations (CE), the reflections are assimilated into outcomes (RO), and through the process of thinking are distilled into abstract concepts (AC), from which new implications and actions can be drawn and actively tested in experimenting or serving in new experiences (AE) (ibid).

Since the early 1970's the principal concepts of experiential learning have been utilised to create educational curricula programmes across a broad range of subject areas in a range of settings or contexts such as in school education (McCarthy, 1987), undergraduate programmes (Mentkowski, 2000) and professional education (Boyatzis et al., 1995). Similarly, experiential learning principles have provided the underpinning framework to integrated STEM interventions and practices in career education. In the following section, some of the considerations identified in literature regarding the adoption of experiential learning as an educational approach utilised in intervention design for raising awareness of career opportunities are outlined (Clarke et al., 2010).

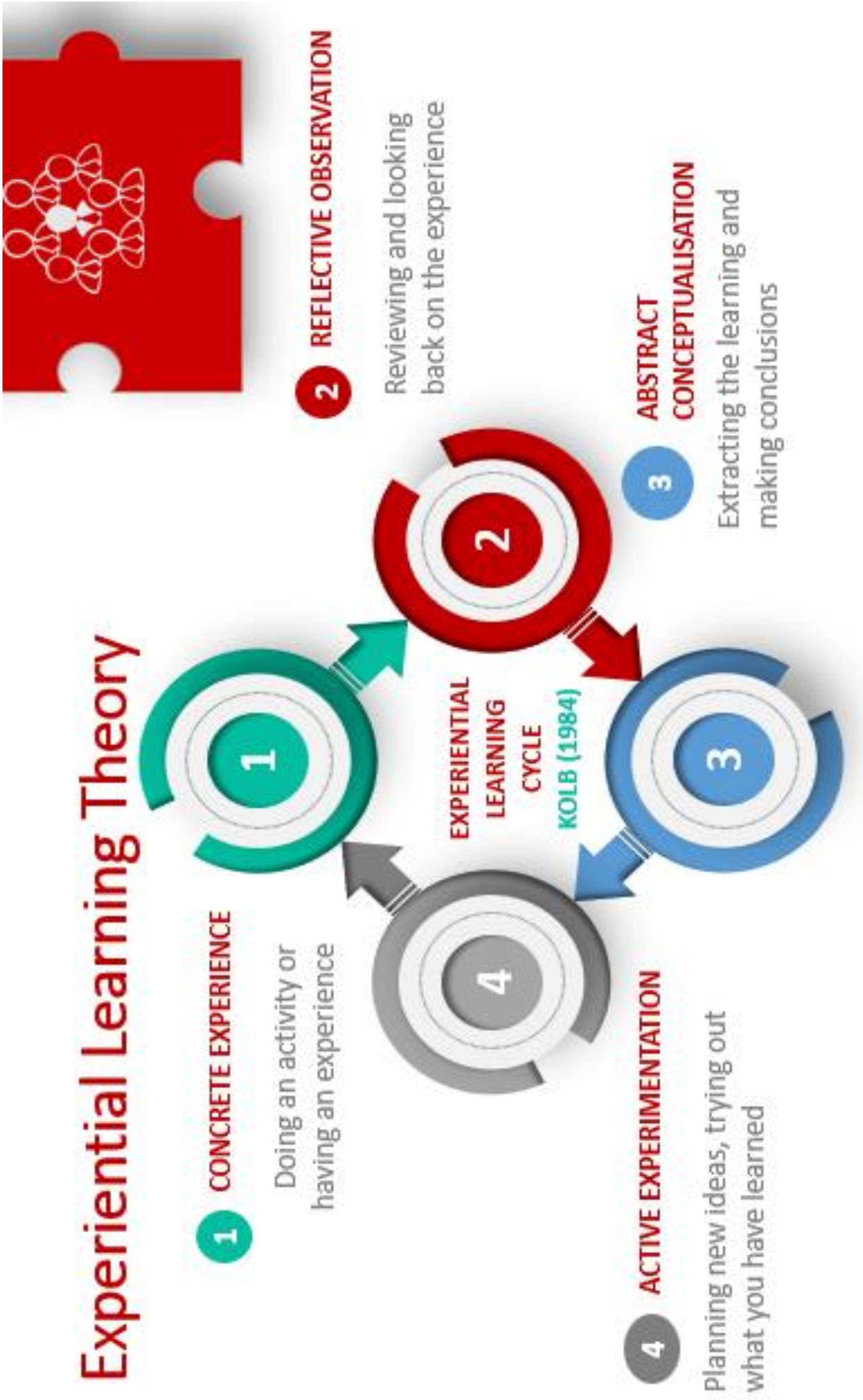


Figure 5: Kolb’s Experiential Learning Theory Model (Kolb, 1982)

A varied programme of learning experiences set in an unfamiliar setting can provide rich opportunities for growth and development. An instructional design model that incorporates a broad range of learning activities that leads students through the full cycle of learning offers students more complete learning experiences gained from multiple perspectives.

- Instructional models that emphasize learner participation, a range of learning activities and an element of choice tend to transcend personal investment in learning.

- Use of processes or activities such as a group research project can help learning opportunities from the application and ‘safe’ development of skills and understanding through to the intentional process of transforming experience into knowledge.

- The value of establishing learning relationships with industry and university academic representatives within a study’s learning environment provides a unique opportunity to open up student’s limited network of learning relationships at the age of 16-18 years that are usually based around their teachers.

There are other models of experiential theory adapted from Kolb’s model. Some focus on the whole experiential learning cycle whilst others focus on enhancements on key aspects such as reflection. However, the researcher selected Kolb’s model for several reasons. In the first instance, the model is viewed as a reliable learning theory with an extensive body of knowledge generated from its application in education and training contexts. Secondly, the model can be easily implemented and applied across a number of disciplines and topic areas. In addition, the model of experience can be applied in innovative ways in the design of many different learning interventions and lastly, the model focuses on the individual and puts the learner at the centre of the learning process whenever a new learning experience is created (Dennison, 2000). Kolb’s theory was selected to guide the design of this intervention, its education content and delivery adopting his four-part learning cycle as its relevance is still highly regarded today (Parahakaran, 2017).

2.6.4 **Importance of Experiences in Learning**

Since experiential learning is learning by actual experience it is also part of the larger category of active learning, because it directly involves students in the process of their own learning. This essentially means understanding and meaning are created when learners participate in real-life experiences or activities. Many programmes of learning are designed with experiential learning opportunities, such as end of term projects on a local issue, or placements or internships in a workplace or study abroad opportunities etc. Experiential learning in design of curricula actively considers components such as activities and experiences that connect with participant emotions and create memories through reflections. These experiences thereby act as anchors to the learning through application, forming new understanding as well as enhancing skills and knowledge. By engaging students in practical, hands-on activities combined in real world settings with the process of reflecting on the changes that have occurred between the start and end of the learning experience, students are better enabled to connect theories, knowledge, derive understanding and form new capabilities.

Much of the literature around STEM interventions discuss the disconnect of learning in schools or colleges and its lack of application in context with the real world. Whilst it is argued, the ability to learn in context allows for deeper understanding with the application of learning ‘by doing,’ it ideally forms the fundamental principle of all learning activities.

The application of Kolbs’s experiential learning theory provides benefits for students, educators and employers. The value of Kolbs experiential learning theory has a number of benefits for students. Firstly, they have a curated set of experiences which are designed in real world environments such as places of work and decries the ‘artificiality of the classroom’ (Dennison, 2010). This provides the chance to meet employers first hand and question them on their career path and organisations they work with. Motivation is usually high as students ordinarily are interested in learning in real world situations. The habit of reflecting on learning experiences assists with knowledge development and retention and strengthens the learning experience for future recall or skill application in another setting.

The benefits of applying Kolb's experiential learning theory as an educator, provides the opportunity to create engaging and relevant learning opportunities in courses or as part of a module that informs and opens students' eyes to future opportunities that enhance their employability and career choices. Education providers are responsible for the progression of their learners, so this supports their mandate to assist students to either progress into university or into the world of work and enjoy success in the long term. There are also criticisms of experiential learning that suggest it can be chaotic for an organised and authoritarian- style teacher who may find it uncomfortable to lose control of learning as its outcomes from learning from experience can be different for each individual. The loss of control stems from the empowerment of the learner to explore and discover dispensing the need for teacher control (Dennison, 2010). This may also require more preparation time to curate the learning experiences or parallel experiences and to organise timely reflective practice.

The main benefits for employers are derived from employing students who have developed skills and knowledge through a range of experiential learning opportunities. These new employees are generally well motivated and equipped with practical employability skills and the latest knowledge and awareness of the workplaces and its practices as they have experience of collaboration in real world activities with industry employers.

Kolb is praised by some critiques for drawing together several different theories into one. However, over the years there have been many criticisms since the publication of Kolb's seminal work on ELT and experiential development connecting of learning to real life situations in 1984. Criticisms ranging from Kolb's model being too simplified as many people do not learn in a sequential linear way and paying insufficient detail in the experiential learning cycle. Rogers (1996) criticises the lack of clarity of the elements of learning goals, intentions, choice and decision making and how the elements are applied into

Kolb’s learning cycle. Dickson (2000) also suggests the model may present the impression that the four stages or bases in Kolb’s learning cycle are equal in emphasis and time. Jarvis 1987 views the model from an informal education perspective and is critical of the lack of empirical evidence to test or support the model (Tennant, 1997). This is further supported by Dickson (2000) and Anderson.(1998) that criticises the lack of research basis of the model applied to different education settings, ages, gender and cultures. Boyd et Al, 1985 Further, Miettimen and Reijo (2000) concurs that Kolb’s experience and reflection occur in isolation whilst suggesting that the individual learner needs to interact with others and the environment in order to draw understanding and conclusions . As Dewey (1933) highlighted in the context of reflection a number of processes can occur at once , stages or bases can be jumped suggesting that Kolb’s presentation of the Experiential Learning may be too simplistic. Greenway (2016) suggests Kolb’s model is flawed and widely misunderstood and widely misapplied with many recommending adjustments or amendments to enhance the perceived compared to the reality of learning and the relationship of learning processes to knowledge is also problematic (Coffield et al. 2004; Smith, 2001).

Despite these criticisms Kolb’s contributions have enduring influence and cannot be underestimated. He has helped to move the topic of learning from experience forward and his theory seems to have influenced the work of many across learning, development and education fields and remains as relevant today as it was when he first introduced his ELT in management training in the workplace in 1984. Many contributors have cited Kolb and his theory for advancing the discussion around experience in learning (Brookfield, 1990; Jarvis, 1995, McKeachie, 1994) and is still the most cited source justifying the use of reflective practice. A Google search of studies using Kolb’s ELT generates over 1,370,000 results across education sectors particularly dominant in USA, in the workplace and higher education. Kolb remains active in his research and continues to add to the literature surrounding his model (Parahakran, 2017; Dennison, 2010).

2.7 Conclusion to Chapter

STEM education has evolved greatly since the analogy was first used in the launch of a university STEM degree in Virginia, USA in 2005. Over this timeframe, many influential studies with varying approaches and modes of delivery have been designed in response to broadening participation. Directed from an array of national policy reforms worldwide, these STEM interventions have been responsive to a need for economic growth and greater national competitiveness. However, the review of literature identified the need for more research in the field of integrated STEM interventions in relation to the further education sector in collaboration with industry. The literature indicated that more young people could consider careers in STEM related fields if provided with regular exposure to employers through experiential learning opportunities at places of work; both private and public sector and understanding of industry and their expectations. (NCFER, 2011; Straw and Macleod, 2013**).** Figure: illustrates and summarises the literature that has been referred to in determining the scope of the study. The next chapter (Chapter 3- Methodology) will introduce the philosophical approach and methodological design and considerations taken in the study.

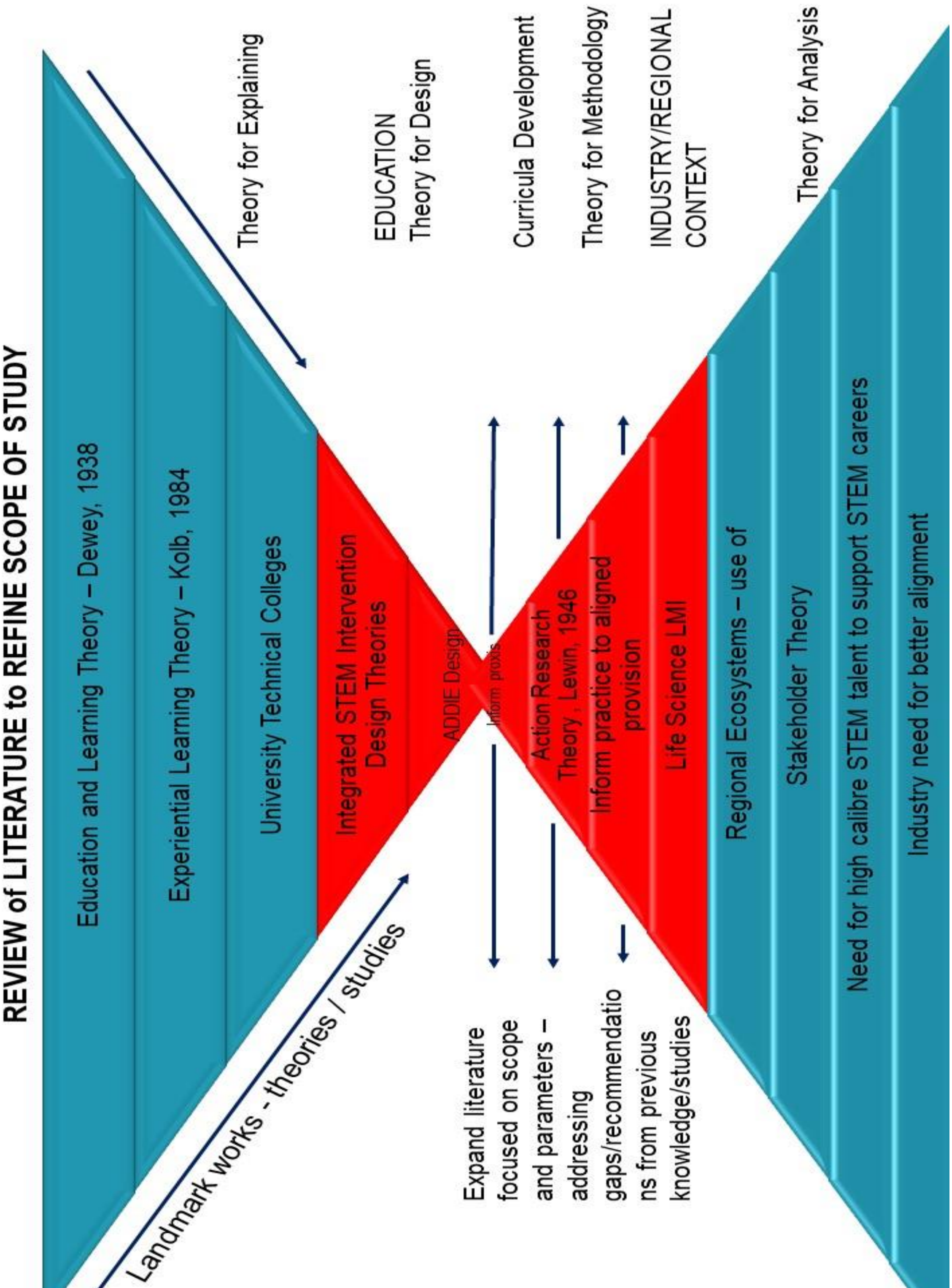


Figure 6: A review of key literature informing the research study

Chapter 3

METHODOLOGY

3 METHODOLOGY

3.1 Introduction:

The purpose of Chapter 3 is to describe the research methodology selected for this study with its rationale and justification. Since the chapter underpins the entire research, it is developed after consideration is given to other possible methodological decisions, including literature relating to previous studies of a similar nature. The chapter outlines how the adoption of an action research methodological approach supports the research framework which shaped the planning of the systematic investigation in its use and application of qualitative action research. The study was carried out in three phases: the reconnaissance, design and implementation. A description on how the research data was collected and analysed in each iterative action research cycle is presented and finally the ethical considerations in undertaking this study are discussed. The chapter is set out in six main sections:

- Research Aims and Problem of Practice
- Selecting an Appropriate Methodological Approach,
- Methodology Mapping
- Data Analysis
- Ethical Considerations
- Ensuring Rigor Within Its Application

3.2 Research Aim and Objectives

The principal aim of this research is to advance an understanding of whether a co-created STEM intervention programme and designed learning experiences can facilitate skills development, raise awareness, understanding and interest in the career opportunities the life science sector has to offer? In order to address the talent needs problem, the research aims to facilitate effective change in institutional outcomes, enhanced participant profiles and curriculum design practice.

The following objectives have been identified for each of the three action cycle phases of the study:

Phase 1:

To identify the skill requirements of talent for the life science and allied sectors **(Qualitative – Employers)**

Phase 2:

To design and create an intervention programme drawing upon existing expertise and resources within the region's life science and health eco-system **(Qualitative – Educators).**

Phase 3:

To implement and pilot the intervention to test suitable delivery methods and features **(Qualitative – Participants).**

To evaluate the intervention for its effectiveness in enhancing young people's profiles and preparedness for careers in the life science and associated sectors.

Supplementary data **(Qualitative – Participants / Employer and Educators).**

The specific questions relating to each action cycle will be outlined in each phase within their own dedicated chapters.

3.2.1 **Research Statement of the Problem of Practice**

The identified programme of practice involves further education students (pre-university) studying individual STEM disciplines; A levels or alternatively the BTEC vocational qualification - National Diploma in Applied Biology (Forensic Sciences) at level 3. These students are not identified as 'talented and gifted' but often attain average or above average GCSE scores of six Grade C's or above including Maths, English and Sciences. These students may have an interest in medicine but are often excluded from real consideration because of their prior GCSE results. Currently, there is no support in place to enable these students to identify other career opportunities in sectors related to medicine which they may be suited to. The study aims to identify if the curricula intervention can support the development of talent that meets the recruitment needs of employers in the sector and thereby inform STEM and workplace education intervention design praxis. Exploring the perceptions of participants, educators and employers is important to develop the types of instructional strategies that support and inspire interest in learning. In order to increase the numbers of students entering into STEM fields, their educational experience must be engaging and positive.

3.3 Selecting an Appropriate Methodological Approach

To determine the appropriate selection of a research methodology that supports the type of enquiry, its circumstances and which compliments the researcher's personal philosophical positioning, the spectrum of positions were reviewed (Table 2). The researcher considers her philosophical, theoretical and methodological approach which would underpin the research study. This enables the researcher to refine the scope and range of suitable methods to select the appropriate approach.

In order to aid with the decision-making process and refining of the scope and range of suitable methods, the researcher selected the Research Onion model (Saunders et al., 2009) developed to assist in planning and conducting research ensuring a subsequent and effective methodology. The framework of the Research Onion and its six levels has been adopted as a tool to structure and explain the choices adopted by the researcher.

The Research Onion model represents six key aspects of the research process, working with the premise that you start from the outside and peel each layer away until you reach the inner core. The illustration in Figure 7 summarises this concept: Layer 1: Research philosophies, Layer 2: Research approaches, Layer 3: Research strategies, Layer 4: Research choices, Layer 5: Time horizons, and Layer 6: Techniques and procedures. To determine the research design for a study like this, the researcher has to weigh up the given possibilities of conducting the research and make the most logical methodological decision, based on the context and the literature which in turn will assist and lead to the development of a credible piece of research (Saunders et al., 2009; Creswell et al., 2011).

The context of the research situation is set within the researcher's own multiple working environments and provides the setting for the delivery of the intervention programme involving multiple stakeholders, each with their own motivations, interests and perspectives on actions that are required to solve the social phenomena set out. The researcher takes decisions to make the research design clear with valid justifications for choices made at each stage until a final choice of methodology is derived. This process will lead to choices that are deemed to be appropriate and fit for purpose given the context for this study. In the next section the researcher outlines her position and assumptions that have led to her methodological choice and design.

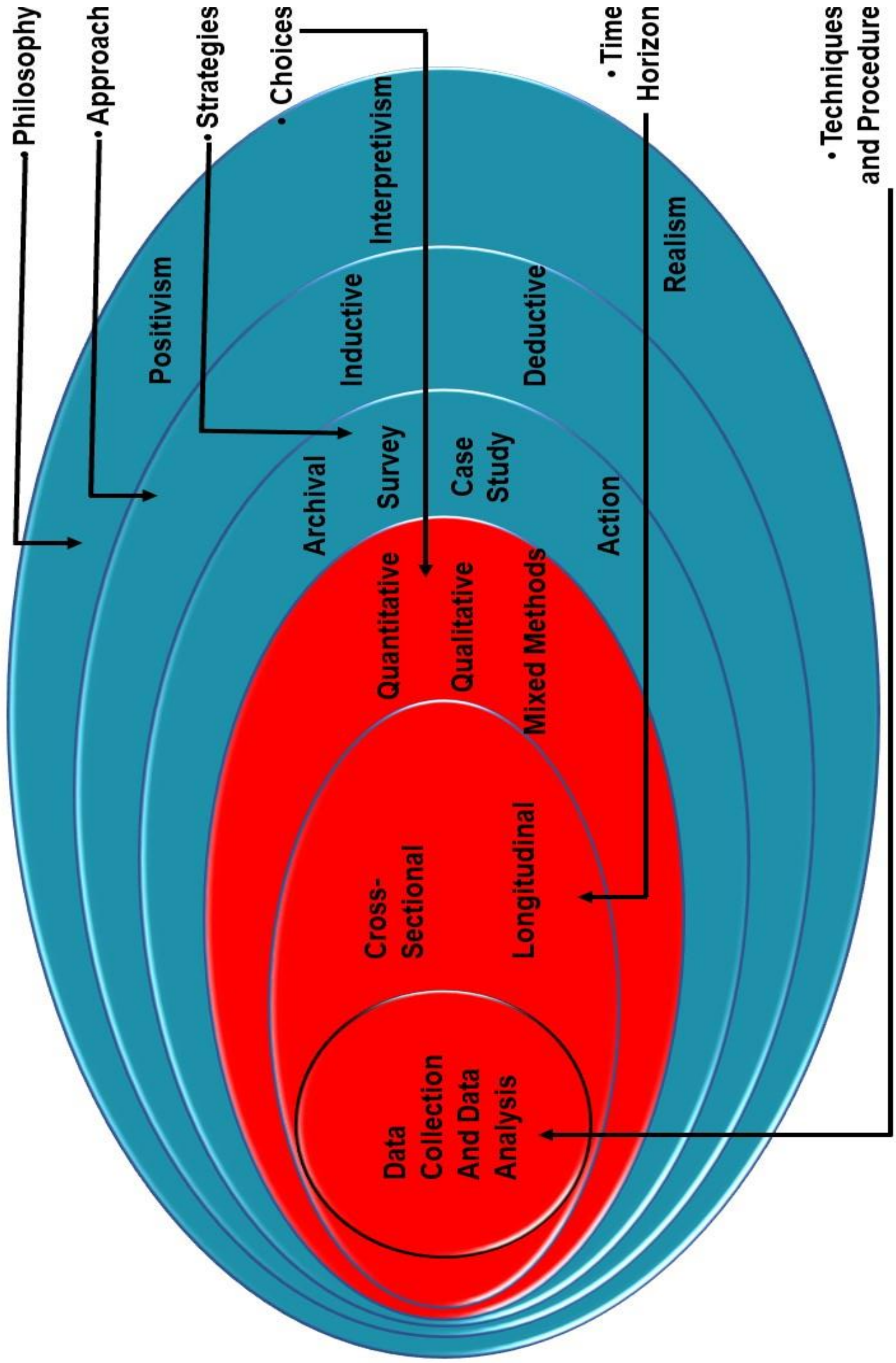


Figure 7: The Research Onion, (Saunders et al., 2009).

3.3.1 Researcher's Philosophical Viewpoint – Layer 1

Worldviews or philosophical assumptions refer to how we view the world around us, also known as philosophical paradigms (Lincoln, Lynham & Guba 2011; Mertens, 2010). These are the beliefs that impact researchers and how they approach their research (Creswell, 2009). According to the literature, world views differ depending on the ontology (belief about reality), epistemology (how the researcher acquires knowledge of what is being studied; the rationality of belief), axiology (the value system of the researcher that guides what they do), and methodology (the research process) (Lincoln & Guba, 2000; Creswell & Plano Clark, 2011). There is a spectrum of research-oriented positions and the well-known worldviews in the literature being positivism, constructivism, pragmatism and realism.

The researcher's own position is that reality is constantly re-negotiated, debated and interpreted and therefore the best method to use is the one that resolves the problem practically and brings about change. Pragmatism employs an epistemology of practicality and can adopt either a single reality or multiple realities depending on what works in order to resolve the research question.

The main objective of this perspective is problem solving (Dewey, 1988) and it provides a link between theory and its application in practice. Some other advocates for this paradigm are Patton (1990) and Creswell (2014). This paradigm allows for a combination of different research methods depending on what is being studied. Advocates of this perspective argue that there is a continuum between positivists and constructivists and the direction adopted should be dependent on the research or problem (Creswell, 2003). This perspective highlights the importance of the observer and actions taken with less focus on describing context (Umpleby, 2007).

Applied research has its purpose grounded in improving the understanding of a specific social or organisational problem. The aim of which could be to create solutions of practical relevance either for the organisational stakeholder/s or the wider community in which the context is set. The researcher's interest in conducting the study is primarily to seek and subsequently generate change improvements for the given context, addressing the host institution's needs, and secondly to support personal development and praxis in curricula development.

3.3.2 Researcher's Epistemological Approach – Layer 2

The researcher's epistemological position is that knowledge is created through doing. It is defined by what works in the situation at that moment in time. Since this study stems from recommendations from previous primary research and other studies similar in nature, it is this that provides the platform and criteria for seeking a practical solution to a specific problem related to STEM talent in the context of the south west region.

Polyangulation of data strands to validate perspectives between stakeholders also provide a more detailed and descriptive understanding of knowledge and experiences, that increase situational interest in learning about STEM in order to construct an effective intervention (Mertler, 2014). The inductive approach is most appropriate where the process takes its focus from the working title and not necessarily built on any existing theory. This in effect means the research commences with the outline of a research aim and associated objectives through to design of a proposed solution. Once implemented and analysed, conclusions can be drawn, or new knowledge generated which can then be situated into existing theory/theories.

3.3.3 Researcher's strategies – Action Research - Layer 3

The decisions in terms of the research strategies used to collect and analyse the data are influenced by the researcher's philosophical viewpoint and each will have their own range of benefits versus limitations. The researcher considered the various strategies including that of case studies, grounded theory and ethnography before deciding upon action research as the most appropriate for the context and problem in hand. For the purpose of this study, the researcher adopts a dual role as a researcher-practitioner within the field of further education. A plethora of previous literature highlights the development of industry focused STEM intervention programmes, identifying action research as the most appropriate methodology to meet the needs of the problem and context. Action research promotes an inductive, preparatory approach and is largely associated with seeking improvements to practical social contexts such as the education and health settings within which this study is set. Action research is a method of inquiry grounded primarily in qualitative research. It is phenomenological and hermeneutic because it is centred around specific experiences and/or events and considers how such events or experiences are interpreted and/or socially constructed respectively (Stringer, 2014). It is also consistent with the constructivist and realist paradigms. Denzin and Lincoln (1994) refer to action research as a localised action-based approach to providing customized solutions in specific contexts. Other researchers have referred to action research as a life enhancing, collective and a community-based approach (Whitehead et al., 2003; Lingard et al., 2008; Stringer, 2014). One of the main advantages of action research (Figure 7) in this study, is that innovative solutions can be created and identified for a specific situation by a combination of varying sources of knowledge, expertise and experiences. This is due to the agreement, collaboration and a collective vision of participants and stakeholders that should occur by using this research approach. In this study, action research supports an in-depth understanding of the integrated STEM intervention and gives room to reveal new insights and understanding that might not be straightforward or clear-cut. This provides avenues for creating innovative solutions to significant issues or circumstances.

Further motivations for selecting action research as the most appropriate research methodology in the education context, was the ability to effect change by testing an intervention within the available timeframe. The approach is unique and bespoke because it serves the needs of the local region and involves action designed to be applied practically to solve a real community problem. It is for these reasons that action research sits outside of the two main paradigms of research. An emerging approach to educational research is the paradigm of critical and applied educational research. From this standpoint, the two previous paradigms are regarded as presenting incomplete accounts of social behaviour because they ignore much of the political and ideological context of educational research (Cohen, 2011).

Further, action research was chosen as the design for this study because the approach facilitates the developing of interventions in existing practice (ibid), which was aligned with and suited the intentions of the study. Educational action research commonly provides opportunities for organisational insiders to conduct research in their own contexts with the view to improving problem solving, practice, personal reflection and personal development (Herr and Anderson, 2015). Action research also has the ability to be empowering and emancipatory (ibid.) due to the unique position of the researcher practicing and researching inside the research context and thereby having the unique insight and understanding of the hidden complexities of the situation. However, the strength of the claims about empowerment for researchers using AR can to some extent be arguable, as AR could on the other hand be viewed as relatively inadequate in the face of change from reform and policy actions in education.

The acceptance of the researcher as an insider within AR suggests that the researcher's positional influence on observations and interpretations play a significant role in the AR process. 'Because of the importance of the nature of the relation between the researcher and the research learners, the researcher's biography – including class, gender, ethnicity, ideas and commitments needs to be made explicit' (Thomas, 2009, P.110). However, in doing so, the research is potentially laid open to claims of subjectivity by positivistic biased researchers. Authors in support of AR suggest researchers should accept their subjectivity and not be ashamed or afraid of it (Thomas, 2009).

The proposition of studying a known context was attractive given the researcher's amount of first-hand knowledge and experience of working with young people in the target population. Understanding of the education processes and awareness of issues relating to learner experiences, allowed the researcher to access the context more readily, perhaps where an outsider would likely find this access more difficult. In addition, the researcher-practitioner's employment provided the ideal situation to conduct research in tandem with her work role. Ordinarily, the depth of data collected from the various perspectives would not have been feasible, if this had not been the case. Outsider generated knowledge can also be regarded as unhelpful by some practitioners (Herr and Anderson, 2005). Whilst this perceived advantage offered by inside knowledge can be difficult to qualify, the researcher's relationships within local networks provided a clear advantage that the researcher could put to early use at the outset of the study.

Wright Mills (1959), suggested action research 'gives credence to the development of powers of reflective thought, decision and action by ordinary people participating in collective research on private troubles that they have in common'. Whilst the stakeholders involved in the study have vested interests, the initial stakeholders namely, the employers, learner participants and educationalists were freshly recruited specifically for the research and their interest in the topic of study.

To help researchers consider their own positionality, Herr and Anderson (2005) developed a continuum of positions that can be referred to.

1. Insider (studies their own self/practice)
2. **Insider in collaboration with other insiders**
3. **Insider in collaboration with outsiders**
4. Reciprocal collaboration (insider -outsider teams)
5. Outsider in collaboration with insider
6. Outsider studies insiders

The situation that most closely resembled the researchers' position within the study was between 2 and 3 - Insider in collaboration with other insiders and outsiders. Recognising the researcher's own positionality, it is important to acknowledge key influences within her biography so that claims of subjectivity can be countered, and the reader is able to know where the researcher stands metaphorically as well as literally (Thomas et al., 2015). For this purpose, the researcher includes a brief account of her latest biography and how it relates to the study.

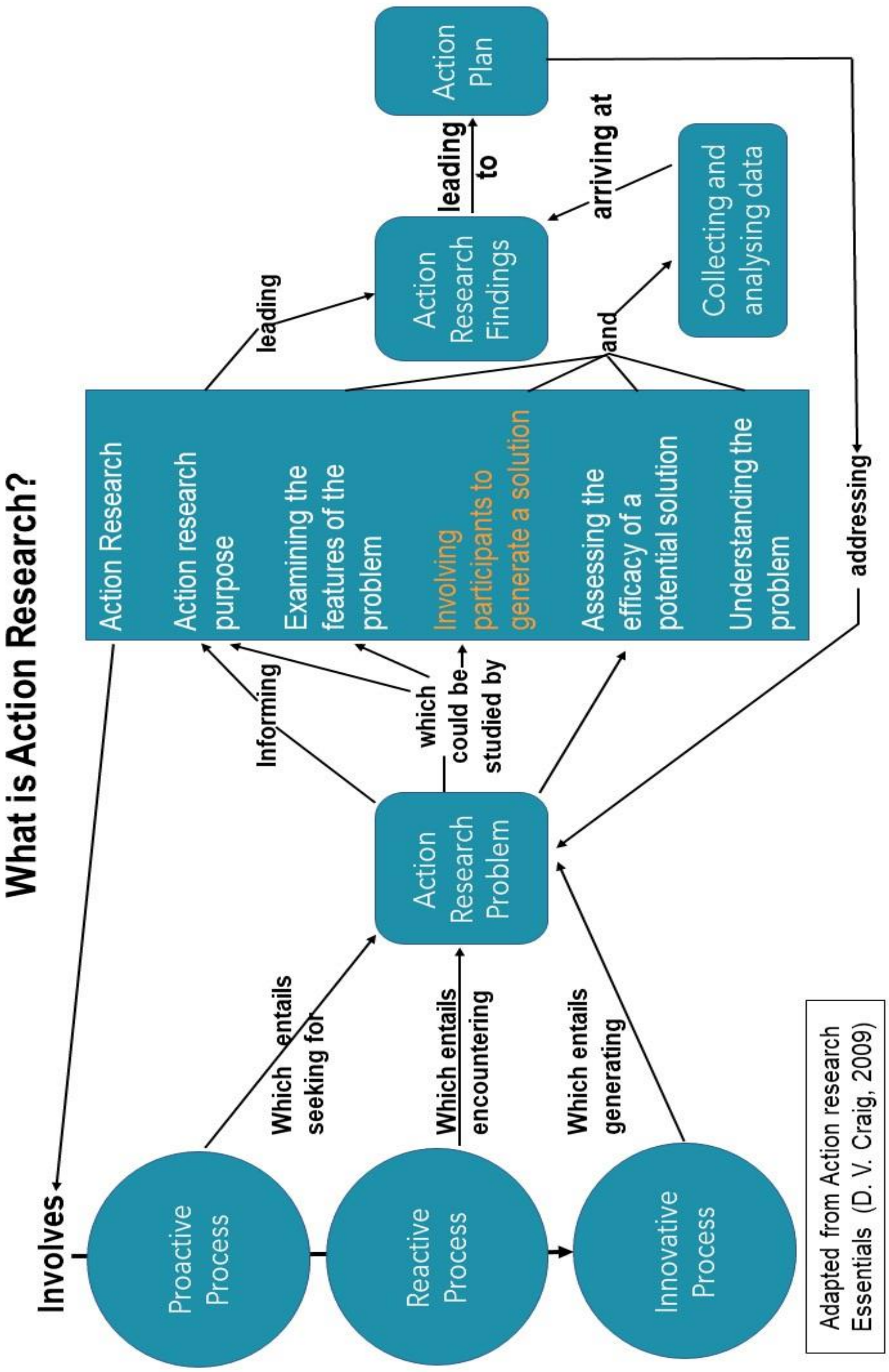


Figure 8: What is Action Research?

The researcher is a qualified teaching practitioner and has career experience in post-compulsory education of over twenty years. She has extensive experience working on innovation within the further education sector and driving forward the quality of learning experiences for young people aged 16-19 years. As part of her strategic leadership responsibilities for a faculty at a local further education college, she has a broad experience of planning curriculum and designing new programmes. In addition, her remit involved the role as a senior mentor to support the practical development of new student teachers on the Post Compulsory Graduate Education students from a local university. At the commencement of the study, the researcher was also on a secondment with the Welsh Government's Sector Priorities Fund Programme based at the Regional Learning and Skills Partnership for the southwest region of Wales, in the position of a Regional Skills Advocate. In October of 2013, the Swansea Skills Group was tasked by the RLP with examining the Life Science sector in order to gain a fuller understanding and appreciation of its true value to the region. The researcher took the lead in this research and began working closely with colleagues at the Institute of Life Science, Swansea University to identify the issues surrounding the skills supply side of Science, Technology, Engineering and Math (STEM) talent from the region's schools, further education and higher education institutions. In addition, the first study canvassed views of over 45 companies on their current skills needs and those likely skills demands predicted for the future.

The three action cycles comprise of a process of thought, planning and taking action followed by a period of analysis and reflection. The key purpose of the enquiry is to utilise the perceptions of key stakeholder groups to design and deliver an intervention programme that could improve the employability of young people and enhance the STEM talent pool that would also be effective in meeting employers' needs in the region. With limited time and resources available the researcher believes it may be possible to enhance existing academic programmes with an intervention utilising the expertise and resources within the region and its communities via a more collaborative partnership working approach between all stakeholders. The context and work environments of the researcher in the thesis therefore further endorses the conditions for action research as identified by Thomas et al., 2015):

These include:

- The opportunity to study local practices.
- A situation that lends itself to identifying enhanced or new practices within curricula development to improve the reality of the situation.
- Where the practitioner/ researcher makes the decision to study an educational practice to improve the situation and address the inherent problems identified whilst also improving practitioner's own practice.
- A focus on learner participation experiences and on the collaborative development and strengthening relationships between stakeholder groups and the researcher which results in co-creation.
- The incorporation of an emancipatory aim of improving and empowering individuals and organisations involved.
- The implementation of an action plan over an extended period.
- Reflections on practices and approach.
- A situation which informs future decision making and wider literature on action research and co-creation of intervention programmes.

3.3.4 **Researcher's Choices – Qualitative Research - Layer 4**

The selection of action research as the research strategy lends itself to aligning with the choice of qualitative research. Qualitative methods are widely used in teaching and learning research and scholarships (Divan, Ludwig, Mathews, Motley and Tomlienovic Berube, 2017). At the outset, the FE institution set out its criteria in permitting the study, in that it would test an intervention approach using a small group of participants. The limit set up to test the pilot intervention would be a cohort of twelve students. It was at this point that quantitative data was not considered as ideal as no significance would have been possible with such limited data. Alternatively, a qualitative study was deemed more suitable and appropriate to the given context. Meyers (2009) identifies qualitative research which uses interviews, conversations with participants, field notes, documents and participant observation data to help understand and explain social phenomena.

3.3.5 Researcher's Time Horizons - Layer 5

Saunders et al (2009) believe that most research studies when undertaken for academic purposes are necessarily time constrained. Accordingly, it is suggested that when planning for research, there are usually two timelines to select from: cross sectional whereby a study in which a group of participants are composed into one sample and studied at a single point in time or alternatively, longitudinal, a study in which a group of individuals is observed over a period of time. The researcher has selected a cross – sectional timeframe which highlights each of the three cyclical action cycles along a timeline as illustrated in Figure 10. The research builds on the recommendations for further research as identified in the regional report Life Skills, Skills for Life Science (2014), however, the physical pilot of the intervention programme with learner participants would not begin until September 2016.

3.3.6 Researcher's Techniques and Procedures – Layer 6

The researcher's understandings and associated decisions regarding the outer layers of the Research Onion provide context and boundaries within which the data collection techniques, processing of data and analysis procedures are selected. The final elements, the core of the research onion need to be considered in line with and not in isolation of the previous choices selected for the design elements at layers 1- 5. The researcher's choice of techniques to gather data include semi-structured interviews, focus groups, observation, photographic images and artefacts and reflective diaries. Justifications for their choices are highlighted in the data collection section of this chapter.

3.4 **Methodology Mapping**

Using Saunder's et al (2009) Research Onion Model, the researcher planned each component of the study design. Following the considerations at each layer the final choices are outlined in the methodology mapping.

A. Literature review – previous studies – STEM, context, regional, sectoral, Action Research (AR) method, design, gaps in literature.
B. Related theory research – AR – Lewin, Experiential research – Kolb, Research design – Saunders.
C. Philosophical standpoint, role of researcher-practitioner, type of study.
D. Intervention Design – ADDIE and Logic Model – Integrated STEM intervention.
E. Research Aims and Objectives.
F. Role of the Researcher – Practitioner – co-constructs reality with participant stakeholders.
G. Goals and Purpose – duality – research and change to solve problem, personal growth and development – professional goals.
H. Intended Audiences – regional community, stakeholder groups, fellow researchers, purpose of PhD requirements.
I. Methodology – Action Research – Plan, Act, Observe, Reflect.
J. Methods – 3 Action research Cycles – Reconnaissance and Identification of skills, create and design, implement & evaluate.
K. Participants – recruitment, convenience sample, pilot and second cohort.
L. Guided Enquiry Approach to Intervention Design – Features, Delivery, Scheduling, Setting and Outputs.
M. Data Collection – Qualitative Data Instruments: Semi - structured interviews, pre and post focus groups, observations, photographic evidence, artefacts, reflective logs.
N. Data Analysis – Thematic analysis to derive themes -Braun and Clarke.
O. Validity/Credibility of Data – Polyangulation – 3 stakeholder perspectives/use of external researcher, multiple data instruments, pilot and re-run
P. Conclusions and new knowledge to existing literature.

. Figure 9: Methodology Map (Researcher's own)

3.4.1 **Methodology Spectrum and Action Research**

	Blue Sky /Curiosity Oriented Research					Mission /Outcome Oriented Research
	Theoretical research	**Interpretative research**	**Experimental Research**	**Survey Research**	**Qualitative Research**	**Action Research**
Ontological Assumptions	Knowledge is created by devising logical, abstract theories of some reality	Knowledge is created by developing alternative interpretations of reality in order to understand the human condition	Knowledge is created by developing and testing general theories that apply to areas of interest	Knowledge is created by developing and testing general theories that apply to all social/psychological issues	Knowledge is a socially constructed reality and cannot be generalized	Knowledge is generated through the process of change. Generalized knowledge is less important As a pragmatic educator – philosophy - believe in education being about life and growth - applied learning and keeping things practical – 'doing what works best' Greek – pragma - deed
Epistemological Assumptions	We know through our own reasoning capabilities	We know through intuition combined with reasoning	We know only what we perceive through our senses (logical positivist)	We know only what we can measure and test (logical positivist)	We know by developing an in depth intimate understanding about individuals	Participants learn and are impacted trying to improve conditions/situation
Disciplinary Bases	Philosophy, statistics	Usually history and the Arts	Natural sciences	Social sciences	Cultural anthropology; Ethnography	Practice and results based e.g. Suited to education, health –application to bring change
Research Goals	Develop theories	Develop interpretative theoretical understanding Can be abstract notions and lack real life application	Identify causal links, explanations or test theory	Casual explanations; test theory	Describe situations holistically and from the perspective of the participants	Focus is on developing practical results solving real problems; set change in motion – more realistic than an idealistic way Key theorist John Dewey / Charles Sanders Peirce – to be meaningful it must have practical bearings
Methodological Orientation	Logical, abstraction, use of deductive logic	Both inductive and deductive Idealistic	Experimental and quasi-experimental; induction 'scientific method'	Quasi-experimental; induction	Case studies,; thematic and content analysis	Diagnosis, development and implementation of action cycles Good judgement and common sense
Key methodological concepts Variables	Logic Emerge during research	Develop critical perspective Emerge during research	Validity, reliability, bias, test of null hypotheses Predetermined – control or comparison group required	Validity, reliability, bias, test of null hypothesis predetermined	Empathy; descriptive orientation Emerge during the research	Empowerment to create change of status quo Emerges during research
Data Analysis	Not relevant	Descriptive, possibly augmented with quantitative approaches	Usually parametric (correlation, t-test, regression	Usually non parameters; rank correlation, chi-square	Usually thematic or content analysis; descriptive focus	Depends on the client or context and
Participant's Role in the research process Researcher's role in the research process	None (excluded) Seeks theoretical interpretation	Provides first hand record of event Seeks theoretical interpretation	None Seeks to be objective	None Seeks to be objective	Usually as an informant Interactive; often as participant observer	Actively participates in the process Collaborates with participants
Research Findings /Report and communication	Presentation of logical conclusions (an academic focus)	Presentation of interpretation (usually with an academic focus)	Presentation of statistical proof (academic focus)	Presentation of statistical test and interpretation (academic focus)	Present holistic portrayal of participants and settings (academic or pragmatic focus)	Presents the context and the processes that lead to any changes and impact (a pragmatic focus)

Table 2: Research Spectrum Table - leading to selection of Action Research (adapted from Mahgeob, 2008)

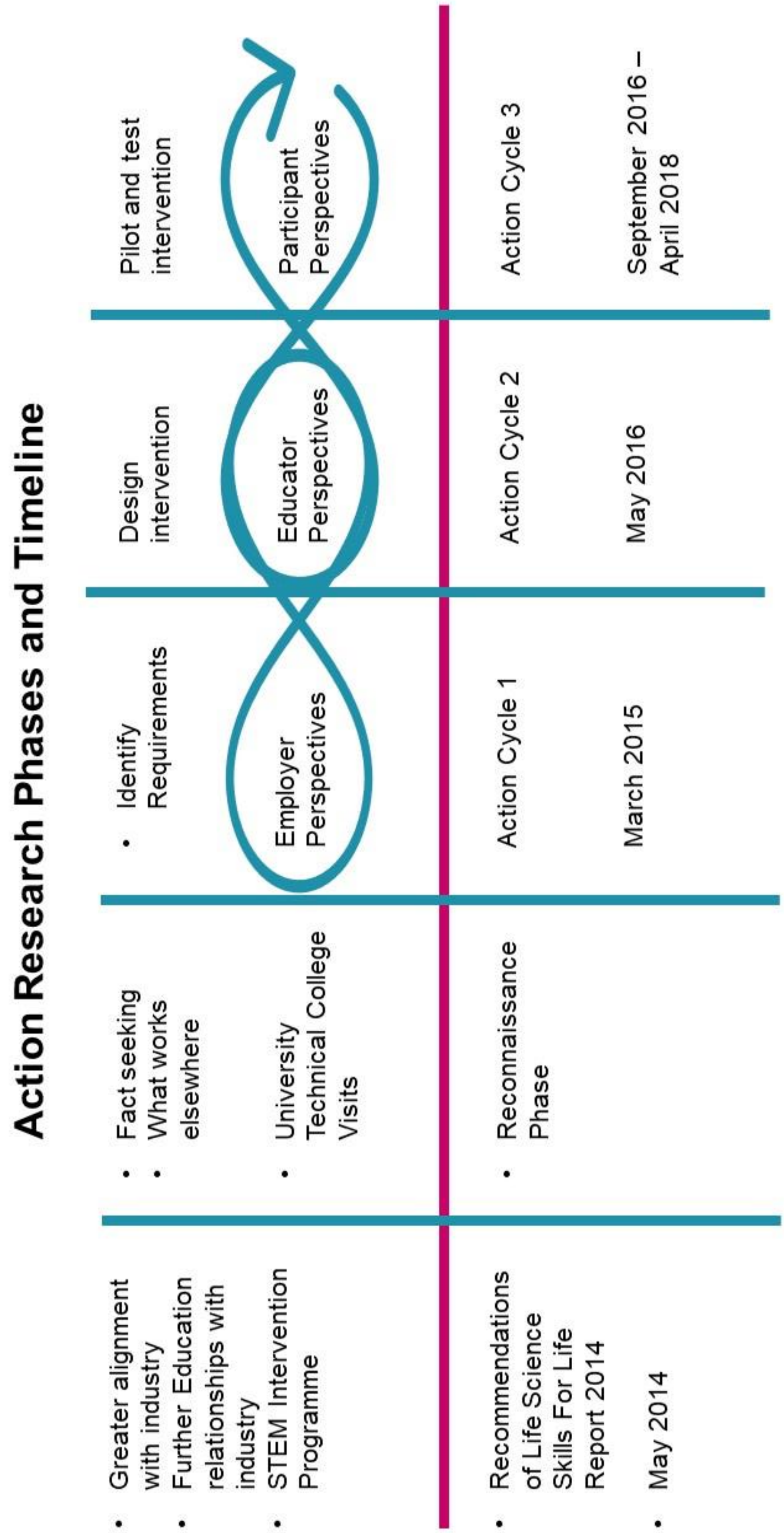


Figure: 10 Action Research Phases and Timeline

3.4.2 **Planning Stage of Action Cycles**

For the reader's ease of reference, the researcher adopted the following data presentation format for each action research cycle:

An overview of the context and focus of the action research cycle provides understanding of the starting position prior to any actions or research. Following this introduction each chapter will be sectioned into four key steps of the action research cycle:
Planning/Actioning/Observing or Monitoring/Reflecting

STEP 1. PLANNING: A holistic overview of the planned data collection process within the whole AR cycle using a planning table to summarise the intended key elements and questions.

PLANNING

Phase of Research	Identifies Action Cycle and Dates
Stakeholder Groups	Identifies from Employers / Educators / Learners
Background Activity and Key Areas of Qu **Questioning**	Description of the purpose of the action research cycle and link to respective objective. Key areas of questioning linked to objective and overall aim of the study that need answering.
Data Collection Locations	Description of the location of where the data is collected
Data Collection Instruments	Description of the data collection instruments used with the relevant stakeholder group

Table 3: Planning Step for Each Action Cycle

STEP 2. ACTIONING and STEP 3. OBSERVING/MONITORING: The acting and observing stages are undertaken sequentially for each stakeholder group to aid understanding but may be conducted synchronously as implementation necessitates. A description of the actions taken in the data gathering process for each stakeholder group with the subsequent observations will lead to the analysis and reporting of the data findings

ACTIONING and OBSERVING

Processes and Procedures	Description of the processes and procedures followed
Data Collected	Description of the type of data collected
Data Analysis	Description of the thematic analysis procedures
Data Findings	Description and summary of the emerging themes
Data Presentation	Data presentation methods used.

Table 4: Actioning and Observing Steps for each Action Cycle

STEP 4. REFLECTING: Similarly, to the planning phase, the researcher will combine the evaluations from the data collection phase to inform the next iteration, revision and planning for the subsequent action research cycle.

REFLECTING

Reflections on AR Cycle	Reflective summary of the outcomes of Action Research Cycle against its plan
Key Learning Points	Summary of any key learning points derived from the data analyses
Considerations	Identification of any key considerations to take forward into the next Action Cycle
New Questions	New areas of focus and specific questions to answer in next Action Research Cycle

Table 5: Reflections Steps for each Action Cycle

3.5 Data Collection Research Instruments

Qualitative action research is the identified primary form of data collection. Table 6 illustrates the data collection and methods over the study timeline. The data was collected through a series of five instruments. The researcher's choice of techniques to gather this data include observation, interviews, focus groups, photographic images and artefacts. Actions and procedures for the implementation of each data collection instrument are highlighted in the relevant action cycle phase in Chapter 4, 5 and 6 whilst justification for their choice is outlined in a separate section for each. The various data collection instruments and their use with each stakeholder group are illustrated in Figure:11.

3.5.1 Instrument 1 Semi-structured Interviews

Interviews can be structured, semi-structured or unstructured. Structured interviews consist of the interviewer asking each respondent the same question in the same way. For structured interviews, a tightly structured schedule of questions is used.

Semi-structured interviews involve a series of open-ended questions based on the topic areas the researcher wishes to cover. The open-ended nature of the question defines the topic under investigation, but it provides the researcher and interviewee to discuss topics in more detail and to open discussions and lines of enquiry. If the interviewee has difficulty in answering a question or provides only a brief response, the researcher can use cues or prompts to encourage the interviewee to consider the question further.

However, the researcher recognizes that the way the interview is conducted can influence the outcome of the interview. According to Bell, 2000, p/139 'a bias can creep into interviews particularly if the researcher holds strong views on aspects of the research'. This can be improved by the discipline of the researcher keeping to the schedule of questions and as Burns (2000, P.425) suggests in allowing the respondent to speak in their own voices. Conversely, unstructured interviews are those where the researcher wants to find out about a specific topic but has no structure or preconceived plan or expectation as to how they will deal with the topic (Hancock, 1998).

Stage	Method of Data Collection	Date Undertaken
Reconnaissance Phase 1	Employers and educationalists interviews on their views about the Life Science skills for Life recommendations, skills need of talent, the key design elements of an appropriate learning intervention programme and delivery mechanisms viewed from good practice.	September 2014 - January 2015
Plan Intervention Design Phase 2	Design and create intervention programme – presentation, scheme of work; establishing relationships with employers to support the programme, gaining support and approval from FE institution.	November 2014 August 2015
Intervention Pilot Phase 3	Implementation with Pilot - Cohort 1 Implementation with Cohort 2	September 2016 -April 2017 September 2017-2018
Evaluation	Initial thoughts and session observation evaluations.	Throughout 2015-2017
Reflections	Post interventions focus group with learners to review findings of research. Researcher – Phase1/2/3 Post intervention focus group with educators. Post interventions focus groups to gather summary of stakeholder views and to provide feedback.	April 2016 April 2017 April 2016//2017 April 2016/2017

Table 6: Overview Timeline of Data Collection and Methods

‘Interviews may be highly formalized and structured using standardised questions for each respondent or they may be informal and unstructured conversations’ (Saunders et al., 2009: P.248). Mason (2002, P.62) asserts that the term ‘unstructured’ is a contradiction because no research interview can completely lack structure. As Mason (ibid) suggests research requires a great deal of planning. Easterby-Smith et al (1991, P. 72) comment that whilst interviewing is often claimed to be the best method of gathering information, its complexity can sometimes be underestimated. Whilst the researcher acknowledges the challenges this type of approach presents, she anticipates it will facilitate greater levels of understanding of the issues and allow a more flexible and dynamic approach to the study.

3.5.2 **Instrument 2 – Observations**

Observation refers to the direct observation and careful watching of those taking part in a study (Brainyencyclopedia, 2004). It is a technique that can be used when data collected through other means can be of limited value or is difficult to validate (Hancock, 1998). The accurate observation of participants is key to the success of this study and principally determines the validity of the findings. Observation as a research insider allows for a better understanding of the context within which the study is evolving. In this study, the researcher is well versed with the context of the study given her education background and role as Regional Skills Advocate, however, if this was not the case then the observer would need to be well trained in the content of the area of interest needed to collect the data (Mohoney, 1997).

Despite these advantages the researchers is mindful of several drawbacks of using observation as a key data gathering technique. Firstly, this method can be expensive and time consuming especially when balancing work and research commitments and secondly the presence of the researcher observing may cause participants to alter their behaviour patterns, such as what is being observed does not truly reflect the topic of interest. Fortunately for the researcher, the time spent observing and delivering the programme to the participants was frequently one and the same and counted as part of the

Regional Advocate role and responsibilities as granted by the employers. The participants were made aware that their participation of the programme was also part of a research study conducted by the researcher in conjunction with the requirements for a PhD at Swansea University in an information sheet (Appendix C).

3.5.3 Instrument 3 – Pre and Post Focus Group Discussions

Focus groups are defined as a group of individuals selected and assembled by researchers or representatives such as moderators to discuss and comment on a topic or subject of research from their own first-hand experiences, (Powell and Single, 1996). A focus group may consist of 8-12 participants with whom the researcher or a moderator conducts a guided conversation. For the purpose of this study a moderator impartial to the research was recruited prior and after the programme to conduct focus group sessions and discussions with guiding questions that were designed beforehand. According to Gibbs (1997), the benefits of focus group research include gaining insight into people's viewpoints and understandings gained from their experiences. However, this data could be misleading if the group possesses shy or dominant individuals influenced by others in a group situation.

3.5.4 Instrument 4 - Photographic Evidence and artefacts

Photographic evidence in research has been an increasingly popular method particularly in action research (McNiff, Lomax and Whitehead, 1996). According to John (1991), and McNiff et al., (1996) photographic material can not only evidence actions taken but it can have value in its use to monitor and evaluate strategy as well as other benefits such as showing change over cycles and adaptions over time. Additionally, "photographs can show the quality of participant's engagement in an activity" (Hannon, 1996: p.109-120). At the end of an intervention programme photographs can also add value to remind participants to talk about their experiences. Despite the advancement of technology and calls for more visual methodologies in organizational research according to Smith and Ray (2012) the use of photographs remains limited. The inclusion of photographic evidence to track the contemporary actions and change within the research cycles can provide enormous benefit in translating the learner experiences. Whilst there is ethical consideration about ensuring participant learner identities are not revealed, the use of photographs present viable but under-utilized methods of recording change within the action cycles. The photographs were used in the post programme focus groups to remind the participant learners of their learning experience journey.

Artefacts refer to unintended but tangible by products of a study or project. In reference to this study the artefacts collected relate to videos, presentations, learner work, testimonials, press releases etc. The value of collecting such artefacts as evidence within the study enables the researcher to capture data and information that may not have been learnt from elsewhere.

Figure 11:Summary of Five Data Collection Instruments

3.5.5 **Instrument 5 - Reflective Logs**

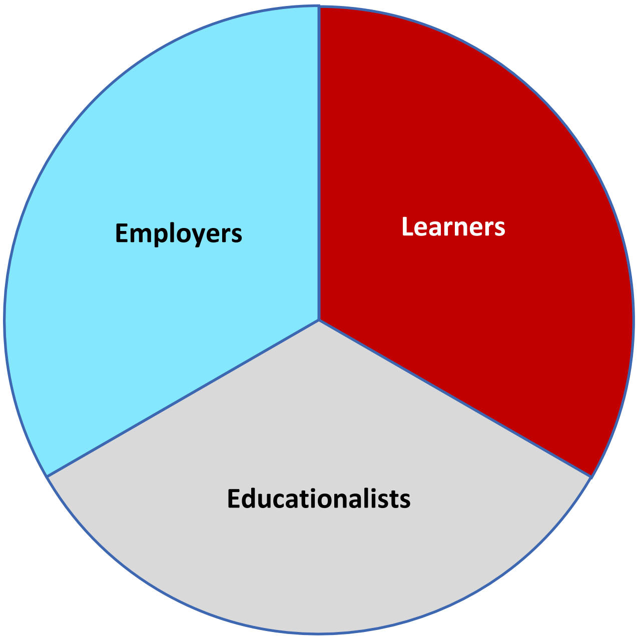
The researcher opted to record her own personal thoughts and opinions including feelings throughout the study as part of the action research reflection process and her own personal learning journey as a research practitioner. The purpose of the reflective log was to capture the critical self-reflection that led to decisions and subsequent plans of action throughout the research process. Participants would also keep reflective logs on their learning on a weekly basis.

Employers	Educationalists	Learner Participants
• Semi – structured interviews • Post- Programme Focus Group	• Focus Groups • Observations • Post – programme focus group	• Pre- Programme Focus group • Observations • Reflective diary logs • Photographic Images and Artefacts • Post-Programme Focus Group
Researcher - Practitioner • Reflective diary		

Table 7: Data Collection Instruments and Stakeholder Groupings

Different data collection instruments were needed for different stakeholder groups. Table 7 illustrates the five data collection instruments used with each stakeholder group. These instruments were selected according to convenience in time available and the most appropriate for the circumstances.

3.5.6 **Stakeholders**



The key stakeholders in this study were identified through a stakeholder mapping activity and due to interest in other research involving learners and employers in education intervention design. The study collects data from each of the stakeholder groups distinctly until the final and third AR cycle where the findings and reflections are shared within a post intervention focus group.

Figure 13: Stakeholder Groupings in Study

Employers	Representatives from employers / organisations, business, institutions, small, medium sized enterprises
Educationalists	Representatives from universities, colleges, schools, training providers, university technical colleges, studio schools, principals, teachers, lecturers, curriculum designers, trainers
Learners	Representation from students, pupils, learners, scholars, participants, graduates

Table 8: Stakeholder Terms and Groupings

Various terms exist for each stakeholder group and are used interchangeably; where possible they are referred to in this study as the key stakeholder groupings of Employers, Educationalists and Learners were indicated as Participants. Each cycle considers the views of each stakeholder group equally but separately until the post-programme focus group following action research cycle 3 where representation from each group considers the findings of the study and any similarities or differences in perspectives are explained.

3.6 Data Analysis

Qualitative data collected from the five data collection instruments: interviews, focus groups, observations, photographic images, artefacts, reflective logs were analysed for themes, patterns and relationships. The process of thematic analysis was applied in analysing the data which is the process of identifying patterns, themes or trends within the qualitative data (Braun and Clarke, 2006; Bryman, 2012). According to Maguire and Delahunt (2017) data analysis is central to credible qualitative research. This view concurs with Braun and Clarke (2006) who suggest that a lack of focus on the rigour of the data analysis process itself has implications on the credibility of the research and its findings.

The model is one of the most influential approaches used in social sciences due to its simplicity and guiding framework (Bryman, 2012). In this study the objective was to utilise the perceptions, views, opinions and experiences of stakeholders in the design, implementation and evaluation of the Talent Bank intervention programme. The researcher would utilise the six-step framework by Braun and Clarke (2006) to analyse the data collection from the various instruments across each of the action research cycles, in order to understand, interpret and derive meaning from the data that may address the research issue. The continuous process of evaluating the research and consistently reflecting on what is working and what is not, enables adaptions to be made iteratively towards an optimum outcome and understanding

Braun and Clarke (ibid) distinguish between two levels of themes: semantic and latent. Semantic themes are those within the surface meanings of the data i.e. not looking beyond what the participants say or have written whereas latent level of themes looks beyond what has been said and starts to examine underlying ideas, assumptions and contextualisation. The study's research questions focus on stakeholder perspectives of the design, implementation and experience of the intervention programme to address the talent issue identified with the intention of leading to a deeper understanding of what works and doesn’t work within the regional context, leading to a better aligned solution.

For the purpose of the reconnaissance phase the data was drawn into an initial corpus to analyse the emerging themes to order to identify the requirements of an effective integrated STEM intervention programme.

STEP 1: Actions include reading and re-reading of the data across the various formats such as transcriptions, notes, observations, images in order to create any early interpretations.
STEP 2: Ideas start to emerge on meaningful categories that arise from the research questions or the researcher’s perspectives by grouping the data using open-coding or preliminary ideas about codes. The researcher worked through each transcript and segment of text using highlighters to identify quotes or information that seemed relevant, or which specifically addresses the research questions.
STEP 3: The researcher re-runs this process, modifying any codes where groups could be merged and entered the data into an Excel spreadsheet. This process allowed the researcher to sort the categories into smaller data sets which facilitated the identity of patterns or words describing similar aspects. Preliminary themes start to emerge from the data.
STEP 4: The next step taken is to review the codes and to start to make sense of the emerging themes. The themes are generated by the reflexivity conducted by the researcher in the sense making process. However, as some data may not fit into the identified themes, a miscellaneous theme may need to be created. At this point some themes can be grouped together or a new grouping created to separate dimensions in the data. The researcher will also look at the prevalence of how often the themes are occurring in the data.
STEP 5: The researcher at this point creates a thematic map which summarises the themes and any relationships that can be identified between them.
STEP 6: The emerging themes are identified and briefly summarised in each action cycle – Chapters 4,5 and 6 will discuss this in more detail in Chapter 7 –

Discussions. Theoretical perspectives may be reviewed to understand current thinking around emerging concepts. A summary of the key literature reviewed will be summarised to support learning.

3.6.1 Data Merging

The original planning of the study over three action cycles suggest a relatively linear and discrete approach to collecting data. However, the reality is that action research can be rather disorganised, chaotic and messy (Cooke, 1998, 2004; Ladkin, 2004). The researcher would combine and weave different strands of perspectives and data collected from the various collection instruments to create a more balances and detailed understanding and narrative to the phenomena. The data collected in phase 1 would be used to inform the design of the STEM intervention in phase 2. Data from the three phases over the course of the research timeline are drawn together to create a holistic integration to uncover the issues and complexities and to draw final conclusions presented in Chapter 7 and 8, providing a more gradual process of generating clarity and understanding of a complex issue (Fielding, 2012; Guba and Lincoln, 2005).

3.7 Ethical Considerations

This section focuses on the ethical issues inherent in carrying out the research which involves employers, educationalists and learners under the age of 18 years. Consideration is given to the process of gaining ethical approval as well as discussing the issues of anonymity and confidentiality of participants and that of informed consent.

Data collection in the initial cycle focused on semi structured interviews with employers and educationalists and referred to the findings in the Life Science Skills for Life publication. Data collected from this phase helped to design the initial Talent Bank intervention programme. As this empirical research involved working with learners under the age of 18 years to pilot and test the Talent Bank programme in action cycle three, ethical approval was required. Once this was planned, approval was first sought from the principal of the institution (Appendix D) to support the pilot programme with recruitment of a group of learners who would participate in tandem with their existing A-levels or Vocational qualifications relating to science and mathematics. In turn, a letter of approval from the principal was submitted as part of the ethical approval checklist for the research study. This was submitted for approval to Swansea University's Medical and Human and Health School Ethics Committee (Appendix E), prior to the start of the third cycle which recruited students under the age of 18 years to participate on the pilot of the Talent Bank programme. Sieber (1992 P.14) sees ethics in research as, 'the application of a system of moral principles to prevent harming or wronging others, to promote the good, to be respectful, and to be fair' (Stringer, 2014). Both the BERA Ethical Guidelines for Educational research (2011) and the National Children's Bureau (McLaughlin, 2015) advise on conducting best ethical practice with students. Both emphasise that the welfare of the participants should be of the highest consideration and included their consent, safeguarding as a result of their identity and interaction with external stakeholders, data management and rigors of research.

3.7.1 **Consent to Participate on Programme and in Study**

The process of obtaining informed consent from those taking part on the programme and in the study as part of a pilot is an important consideration in planning the research. As the participants were under the age of 18 years, consent had to be acquired from parents/guardians or those in charge of making decisions on their behalf (Ferrer et al., 2016). Letters seeking consent were issued to parents to grant permission for their son/daughter to participate in the study (Appendix H) and to collect data from their participation in focus groups and weekly reflective diary logs. (Appendix N). A set of information data sheets accompanied the consent form (Appendix C) to inform the aims of the study, the commitment and protection to be afforded in protecting participants' identity, safeguarding and data management (Stringer, 2014). A first meeting was held for participants and their parents to explain in more detail the nature of the programme and the study detailing the requirements of participation and to offer assurances of confidentiality and safeguarding at university campus where the programme would be hosted. Swansea University's Ethical Approval was sought (Appendix E) and the Code of Research has been adhered to as student participants under the age of 18 years became involved in the study. All participants were made aware of their right to withdraw from the research without consequence as they were assured their participation was completely voluntary, indicated on the Participant Consent form (Appendix F).

3.7.2 Safeguarding

Two educationalists were recruited to support the programme, one from inside the host organisation on a secondment basis and another recruited from outside on a temporary contract. In line with college policy, the institution supported the Disclosure and Barring Service application for the practitioner where this was not already in place to ensure only aptly vetted people are employed to work directly with students. Consideration was taken to always ensure that a member of the host organisation accompanied the participants at all times at the University location and at external sites where external stakeholders were supporting the programme. Any participants who engaged in work experience as part of the programme followed the FEI institution's guidelines and consenting process. One participant who engaged in volunteering as part of the programme, completed a Disclosure and Barring Service application before participating in weekly volunteering activities at an elderly care home.

3.7.3 Data Management

The collection of personal data from participants was kept by the host institution within their databases securely protected and stored. The researcher did not collect personal sensitive data only demographic data such as age and gender strictly for monitoring purposes. Data in electronic or digital format were only accessed via password protected computer systems. Only the researcher and host institution associated with the study had access to the data collected. In cases where anonymity and confidentiality were needed, identifier codes were created and stored separately from the coded data. Care has been taken to ensure confidential information was not included within any written documents made available.

3.7.4 **Polyangulation**

In order to develop a deeper and more balanced understanding of the phenomena the researcher-practitioner utilised data polyangulation. “Polyangulation has emerged as a very recent alternative to the traditional idea of “triangulation” that qualitative researchers have applied over the years. The basic premise of the technique of polyangulation is that it brings together different angles or perspectives in forms of multiple sources of evidence which may or may not have some relationship with each other so that comparison or contrast between these perspectives can be considered and to verify their trustworthiness, accuracy and consistency (Mertler, 2018; Elliott, 1991,). Several sources of data were utilised within the research design to gain a broader understanding of the potential value of the Talent Bank intervention. The data sources were collected at various action cycles and used to iteratively inform the next AR cycle. This study considers the potential beneficiaries of the research, who might be affected or impacted by it, by contrasting the researcher’s perspective with the perspectives of the three participating groups to identify any similarities or divergence in points of view together with any potential implications. Engaging multiple stakeholders in the research process creates challenges but also provides benefits. Thomas (2013) suggests taking views from several points is better than viewing from one. Deverka et al., (2012) shares similar views as articulated in the following quote:

> “An iterative process of actively soliciting the knowledge, experience, judgement and values of individuals selected to represent a broad range of direct interest in a particular issue, for the dual purposes of: creating a shared understanding; making relevant, transparent and effective decisions.” **Deverka et al., (2012)**

The researcher selected the various sources of data from the stakeholders as it is easy to plan, implement and collect the data derived from interviews, observations, pre and post focus groups, photographs, artefacts and reflective diaries. This data was processed and collated using Excel spreadsheets and encrypted with coding to prohibit individual identification. The trustworthiness of the findings of the thesis were further reinforced using a research log to record reflections taken throughout the research process.

Utilising methodological polyangulation, which uses more than one method to collect data on the same phenomena, assists with the assurance of validating the research through the use of a variety of methods to collect data on the same topic (Mertler, 2018). The researcher has purposely selected five data collection instruments as a means of validating the information collected through various methods and to enable a bespoke solution to be shaped and co-created to meet the needs of the respective stakeholder groups. However, the researcher acknowledges that whilst the purpose of polyangulation is to cross-validate data it is also to capture different dimensions of the same phenomenon. The benefits of polyangulation include 'increasing confidence in the research data, creating innovative ways of understanding a phenomenon, revealing unique findings, challenging or integrating theories, and providing a clearer understanding of the problem' (Mertler, 2018; Thurmond, 2001). The researcher has considered the usefulness of polyangulation throughout the planning and execution of the study and has assessed the value it contributes to deepen the understanding of the issues surrounding the problem and maximizing the confidence in the findings. Member checking with participants also known as participant observation (Barbour, 2001; Doyle, 2007) also helped to ensure interpretation of information accuracy in data collected through observations and pre and post focus groups.

3.8 Ensuring rigor within the application of Action Research

Following the implementation of the action, data is collected so that the action can be critically evaluated (Macintyre, 2000). At this point, it might be that findings are presented or that further reference to literature to aid reflection on the data analysis might be required that could lead to further informed action. A cycle is completed at this stage, but the process of reflection may prompt further action that initiates further cycles of action. A particular weakness of this approach is it that it supposes that 'life occurs only on one track at a time, forgetting that related but dissimilar problems will arise and oust the main focus and that real people will have the flexibility and creativity to move easily to the new problem and then return to the original one' (McNiff, 1988, P.28). The reality of the research process was that some stages with different stakeholder groups blended into one another and that the process was much more complex and messier than designed. In general, action research depends mainly on observation and behavioural data and because it is set within a specific context, it can be difficult or impossible to generalize the results to be confident that the action would be successful in an alternative context.

Research that is rigorous is regarded as credible and trustworthy, with rigor linked to the concept of validity, which in broad terms asks the question 'does the research answer or address that which it is claiming to? In relation to AR, it should not be judged by the same validity criteria that is applied to positivistic and naturalistic research. Herr and Anderson (2005) suggest, 'this is not to say there is no overlap or that it is less rigorous, but that a new definition of rigor is required that does not mislead or marginalize action researchers' and therefore they developed criteria for the validity of action research that considers the rigor of AR by recognizing the significance of both the academic and practice-based nature of AR. They identified five validity criteria – outcome, process, democratic, catalytic and dialogic and applied to the research goals of AR.

To ensure rigor within the research the following actions were taken, each is described alongside the corresponding validity criterion as in Table 9. 'Dialogic and process validity refers to the extent to which problems are framed and solved in the manner that permits ongoing learning about the system or individual. In this sense outcome validity is dependent on process validity, i.e., if the process is superficial or flawed, the outcome will reflect it' (Herr and Anderson, 2005). Throughout the research process, the purpose of the study was shared and reported to various panels and working groups associated with the A Regional Collaboration for Health working groups and latterly the Swansea Bay City Deal. In addition, the researcher submitted annual updates and attended mini vivas to enable scrutiny of the academic research process. ‘Democratic validity refers to the extent that research is done in collaboration with all parties who have a stake in the problem under investigation. If not done collaboratively, how many perspectives and material interests are considered in a study? e.g. teachers, management, parents (Denzin, 1978). In this study, four educationalists aided the planning and delivery of the Talent Bank programme, two cohorts of learner participants took part in the 6-month programme, and over 40 employers contributed to the delivery of the weekly sessions over the duration of the two courses.

Goals of Action Research	Quality/Validity Criteria
1. Generation of new knowledge	Dialogic and process validity
2. The achievement of action-orientated outcomes	Outcome validity
3. The education of both the researcher and participants	Catalytic validity
4. Results relevant to the local setting	Democratic validity
5. A sound and appropriate research methodology	Process Validity

Table 9: Herr and Anderson’s goals of action research and validity criteria (2005, P.55).

Reflections gathered after each session were considered in decision making regarding further actions. These periods of reflection acted as dialogical sounding boards, grounded in both practical and relational reality. Outside the research context, academic supervisors and members of the Scientia PhD research group acted as critical friends providing feedback and commentary on frequent updates and presentations on progress.

The validity criteria described above was used to ensure AR remained credible and trustworthy. To help fulfil validity criteria, researchers might choose to collect data through multiple methodologies that seek multiple sources. Valid data analysis can be achieved by comparing data and interpretations to similar research contexts and using critical friends outside the research context. Several critical academic friends were engaged to consider the research findings and the conclusions drawn.

'Outcome validity refers to the extent to which actions occur that lead to a resolution of the problem that originally led to the study' (Denzin, 1978). This form of validity is closely associated with process validity. Chapters 7 provides discussion on the research outcomes and verify that they have addressed the research aims and objectives set.

'Catalytic validity refers to the degree to which the research process reorients, focuses and energizes learners towards knowing reality in order to transform it' (ibid., p.56). By obtaining multiple perspectives through the three stakeholder groups the research utilised polyangulation to prevent the singular distorted view of reality and provide a level of authenticity. According to Thomas, (2009, P.111) the use of triangulation is recognized as the 'hallmark of the good social-researcher'. 'Triangulation is supposed to support a finding showing that independent measures of it agree with it or at least, do not contradict it' (Miles and Huberman, 1994, P.266). This poses the problems of what to do with different views if they contradict each other. In the instances where this might occur, Miles and Huberman suggest that like a good detective some pieces of data can help build a stronger case than other pieces. The use of different data collection methods to capture multiple data relating to the same situation helps to build a more robust case. The research used multiple data collection methods to develop a complete picture of the situation as possible, therefore ensuring methodological triangulation (Denzin, 1978).

The concluding aspect of the research process involves the researcher practitioner critically evaluating the research design and the processes involved in the data collection that may have detoured from the original plan but may be valuable for future implementation. Acknowledging any issues or difficult encounters that occurred together with patterns or themes that emerge through the study can also lead to the identification of new areas of research as a consequence of the study. These are discussed in more detail in Chapter 7- Discussion and Chapter 8 - Conclusions

3.9 **Conclusion to Chapter**

This chapter outlines the philosophical positions this research study sits within and provides a rationale for the adoption of action research as the guiding research approach to address the study aim to advance an understanding of whether a co-created STEM intervention programme and designed learning experiences can facilitate skills development and raise knowledge, awareness and understanding of the career opportunities the life science sector has to offer.

AR was applicable to this context because it commonly provided opportunities for organisational insiders to conduct research in their own contexts, it is therefore concerned with problem solving, testing new interventions, personal reflection, and professional development. Additional qualities of AR lie in its similarities with learning cycles synonymous with the education sector and which supported the dual approach to combining research and employment responsibilities. Finally, AR is deemed to be well placed and justified to bring about informed changes within the educational context and field of practice. This chapter has described the procedures and data collection methods used in this study. Finally, the ethical considerations are outlined together with an overview of approaches to ensure rigor conducting action research throughout the study.
This concludes Section A of the thesis which provides an understanding of the context within the southwest region of Wales; the issues and problems related to the need for STEM talent and the misalignment of further education provision with workforce needs. The researcher-practitioner has outlined her philosophical position which has an impact on her choice of methodological approach. The circumstances as a Regional Skills Advocate and as a researcher has identified action research as appropriate for the given situation

and reasons justifying the selection of conducting research and amending practice in tandem, have been explained.

Section B consist of three chapters 4, 5 and 6. Each chapter will adopt a similar framework to assist in the clarity and ease of the reader's understanding. The focus of each chapter refers to one of the three complete action research cycles and aims to understand stakeholder perspectives:

Chapter 4: This is a reconnaissance phase to identify existing practice and to set up the research study. The first action cycle also seeks to identify the requirements of the life science sector from perspectives of employers in terms of their requirements of young STEM talent and how this could be addressed in further education.

Chapter 5: Refers to the second action cycle with a focus on design of a tailored STEM intervention programme. It seeks the perspectives of educators on the proposal and the vision for the STEM intervention programme.

Chapter 6: Action cycle 3 is concerned with implementing and piloting the intervention with participants to assess the effectiveness of the programme, its implementation processes and outcomes. Although each chapter adopts a similar structure with an explanation of the starting and end points of the action cycle, the aim is to illustrate the research journey and process of change in practice.

The next chapter will outline the first Action Research cycle in the initial reconnaissance phase of determining the skills needs of young talent as viewed by employers within the life science sector. The understanding of these skills needs will help to identify appropriate content, learning experiences, delivery mechanisms and the formation of an intervention programme that supports greater awareness of the range of careers in STEM and more specifically in life sciences and related sectors.

Part B
Action

'Play is the highest form of research

Play and research are both simply applied creativity'

Albert Einstein n.d.

Chapter 4

ACTION CYCLE 1

4 ACTION CYCLE 1 – Identifying Requirements

4.1 Introduction

This chapter commences the first action research cycle of the study. The researcher led on a key aspect of the regional study, Life Science, Skills for Life (2014) and used the recommendations from the study as a catalyst for further research in seeking a solution to the talent supply issues identified. The chapter details the initial reconnaissance period with key actions taken to determine the nature, scope and focus of the action research. The early actions focused on existing literature with reference to integrated STEM interventions/studies, particularly on the knowledge base of effective approaches to facilitate further education interventions and identified models of good practice, in life science hotspots in other parts of the United Kingdom. Following the reconnaissance phase, the first action research cycle was planned. The four steps of each action research cycle are outlined with an overview of the starting point followed by the four key steps within the action research cycle namely, planning, actioning, observing or monitoring and reflection (Ferreira da Silva, 2010; Kemmis and McTaggart, 1998). The first data collection is concerned with identifying the talent requirements of the life science sector as articulated by employers and representative stakeholders of the industry. Any key learning ideas, concepts or perspectives arising from the data collection and analysis processes are summarised and the learning takeaways are shared in the endpoint to the cycle. The action cycle concludes with a summary of the key areas of focus to take forward into the second action research cycle phase in the following chapter.

4.2 Starting Point

The commencement of the research begins with a reconnaissance phase or period which according to Mills (2007) is time taken to understand the context and nature of the research problem. The researcher had played a role in the research of the life science sector, identifying its value to the region and its economy. The Life Science, Skills for Life (2014) identified a range of recommendations levied at groups of stakeholders including Welsh Government, Higher Education, Further Education, Schools, and employers. The researcher in her capacity as the Regional Skills Advocate for the Life Sciences seconded from the host FEI, was invited to discuss ways of responding to the recommendations from the perspective of the FEI. Presented with the opportunity to identify a practical solution to these recommendations, utilsing funding from the Welsh Government's Sector Priorities Fund Pilot (SPFP) programme, the researcher sought to identify how the value of research could be used to address the issues whilst combining support from the SPFP and carrying out her responsibilities as a Regional Advocate. According to McNiff et al., (2003) the reconnaissance phase enables the researcher to identify a point of commencement as to what they wish to achieve and the process by which they could accomplish this.

The Life Science, Skills for Life (2014) report identified issues between employers and further education stakeholders that contributed to a misalignment between the supply and demand for work-ready talent in the life science and health sectors in the south-west region of Wales. This mismatch presented both a regional issue and an opportunity to seek ways for the FEI to redress the situation, utilising the incumbent researcher's role. With this understanding and following discussion with the principal of the FEI, the intention of the researcher was to gain a deeper understanding of the talent issues in the sector and to identify any previous studies or practice that addressed other regional and sectoral problems of a similar nature. Armed with this intelligence, the researcher could gain approval from the host FEI, and initiate an action research plan to create a response to the Life Science, Skills for Life (2014) findings and recommendations. The overarching aim of which is to raise awareness of the life science sector and its career offerings amongst young people whilst bringing about greater alignment between the FEI's education provision and outputs, so that they better match with the talent needs of the sector in order to support regional economic growth.

The recommendations of the Life Science, Skills for Life (2014), levied at further education are the most relevant to this study and its perspectives. These are repeated to provide context and focus to the reconnaissance phase that will lead to subsequent action cyclical phases with a research aim, objectives and sets of questions (Maxwell, 2003).

4.2.1 Recommendations for Further Education

The Life Science, Skills for Life (2014) provided a set of recommendations specifically for the further education sector to respond to the regional skills agenda in the life science sector:

1.To provide closer integration of curriculum planning between secondary schools and Further Education Institutions (FEI) to support learners across all institutions.

Collaboration on curriculum planning is not currently well practiced between FE and schools or with other stakeholder groups such as employers. However, involvement in the delivery of aspects of curriculum has started to become a practice shared between FE and secondary schools, particularly in vocational areas where pupils attend courses at the college campus e.g. hairdressing, hospitality and engineering; or in subjects where expertise at schools is lacking e.g. GCSEs in Psychology and Law are examples of subjects taught as outreach and twilight classes by FEI lecturers at local schools.

2. To increase the levels of practical work experience and industry mentoring to promote career opportunities.

Careers Wales offers brokerage services between education and employers. They arrange company visits, presentations from employers and work experience. However, these opportunities are limited due to the time-consuming administrative processes, timetabling restrictions and student interest levels. Mentoring is not an option widely available to students across most subjects, however, the Mullaney Fund is a charitable organisation set up in south-west Wales established to offer

mentoring opportunities to support students from the region in the life sciences and medical professions.

3.To offer additional courses and opportunities to supplement A-Level provision.

Gaps in existing education provision identifies the opportunity for additionality programmes and bitesize qualifications to complement existing education provision. These courses would need to address the talent issues identified, whilst ensuring no duplication with the existing course offer.

4.To engage and consult with employers in the STEM sectors to ensure curriculum suitability for local and regional skills needs.

Collaboration with industry stakeholders is evidenced in several recent FE studies/projects, however, the practice is not part of an embedded curriculum development praxis. Engagement between FE and the life science sector at the initiation point is undeveloped.

5.To further develop and deliver employer focused training to both up-skill and re-skill existing employees.

This recommendation is not relevant to this study, but the FEI would need to tailor its training provision to meet the needs of existing employees. The recommendation has been included to illustrate the holistic nature of the recommendations levied.

6.To continue to develop appropriate vocational pathways into employment for the Life Science sector and the broader STEM area.

This recommendation is a call to action to address the lack of identified pathways into life sciences from the vocational curriculum such as BTEC Nationals. However, whilst this is not a prime focus for the current study, there are clear learning parallels and considerations that may fulfil part of this recommendation.

These recommendations prompted a set of broad questions for the researcher to gain answers and understanding before any research focus and design could be considered. Firstly, to understand the context , the researcher would need to verify the situation, secondly, to identify the existing practice in terms of curricula development and the gaps within existing education provision.

In addition, the researcher would need an insight into recent research about existing intervention studies that have addressed similar types of problems (Grundy, 1995).

This process assists the researcher to identify the topic, review the related literature and limit the focus reducing it to what will become the scope of the study (Mertler, 2014). Figure 14: highlights the interconnected aspects of three elements of the reconnaissance phase identified by (Maxwell, 2001) as situational analysis, analysis of competence of the people involved and the analysis of the literature.

These processes help the researcher to understand the inter-connectiveness of the three components; the realities of the context in terms of the resources and existing practices (situational analysis); the identity of key stakeholders and their profiles and initial perspectives (competences); and links with previous studies, experience of others including experts or 'literature' that may influence the direction of the research from identified gaps or debates (ibid).

The researcher gathered information on the regional situation relating to the life science sector and its ecosystem from discussions with expert representation of Cogent. Cogent is the sector skills council that represents the interests relating to the strategic need for skills in the science industries (Cogent, 2014). Its role is to represent employers and organisations on the skills needs and workforce agenda of employers and employees across the life sciences and other science-based sectors. As the Regional Skills Advocate for Life Sciences, the researcher regularly engaged with sector skills councils to facilitate interventions between industry and education providers. In a discussion with the regional Cogent representative for Wales, the researcher became aware of the newly opened Life Science University Technical College in Liverpool.

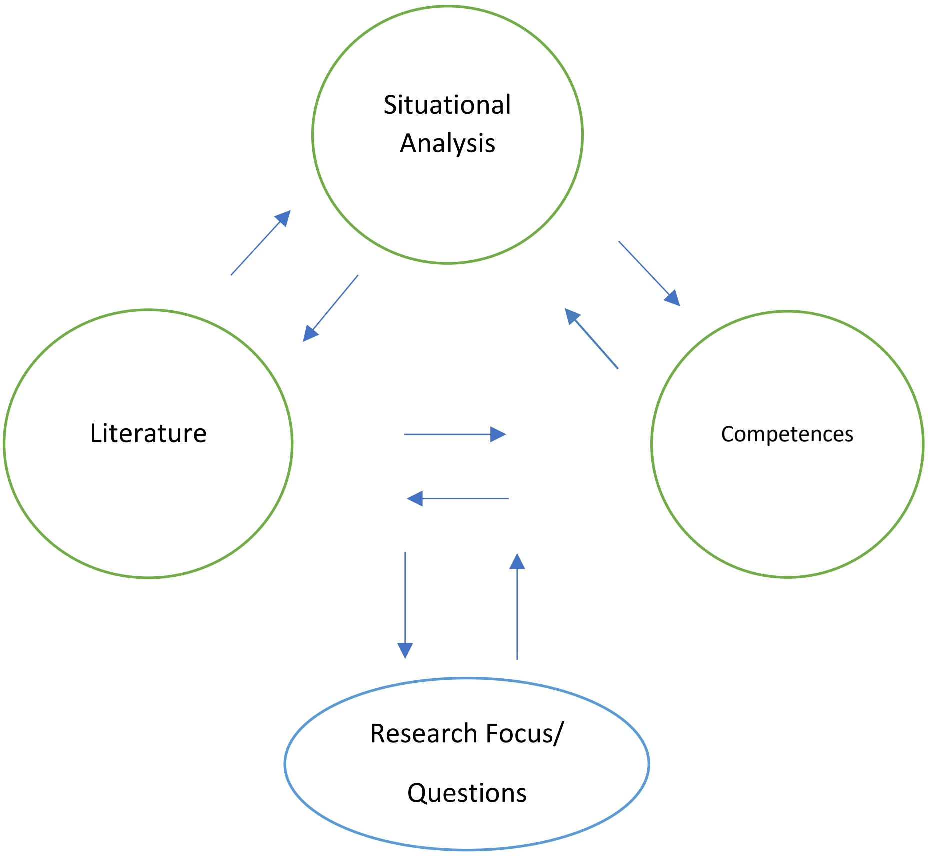


Figure 14: Reconnaissance and Action Research Focus (from Maxwell, 2003).

4.2.2 **University Technical Colleges**

Simultaneously, the researcher reviewed existing literature relating to regional solutions to workforce needs. Of particular interest was literature relating to the creation of a contemporary form of school/college or providers of technical education called University Technical Colleges (UTCs), introduced in England in 2010. Technical education is a term used to prepare young people with the academic and vocational preparation in STEM sectors (Sanderson, 1994).

"UTCs integrate technical, practical and academic learning and create an environment where students can thrive and develop the abilities that industry needs." Lord Baker (2012).

"Technical education is the academic and vocational preparation of students for jobs involving applied science and modern technology. Britannica.com (2021).

The new education provision was set up by the UK coalition government under its Academies Act, 2010, as part of its ‘free schools’ reform programme with direct funding from the Department of Education and operating outside the control of the local authority. The UTC model sponsored by the Baker Dearing Trust is built around relationships with sponsor universities and partner organisations from the region in which each UTC is located. The interest in the UTC model stems from the fact that they are established as new entities in geographical areas of high demand for talent with technical capabilities. They specialise in providing students with education and training for future careers in STEM sectors and industries with projected growth such as IT, health, engineering, and life sciences. The UTCs work in partnership with a network of local industry partners to design a learning programme for the school targeting students aged between 14 and 19 years. The aim is to ensure the education provision supports the skill requirements of the local economy, where high-skilled STEM employment is expected to grow (Sponsors and Partners, 2013). The Baker Dearing Trust’s (BDT) broad aims are to create a national network of UTCs (BDT, 2012), that would innovate the existing education system and whereby students would learn by doing, developing the technical and social skills required for future employment alongside their academic studies. Baker’s view was that the existing and growing skills gap ‘could not be met by the existing education system’ which he believed had never considered it to be its key role, to match the economic needs of the country” (Baker, 2013. P.7) and therefore the UTC model would fill this gap and need.

The Liverpool Life Sciences UTC opened in September 2013 providing specialist scientific and healthcare education. Its’ purpose is to support young people to develop sector specific skills and qualifications to help them secure a career in the sector (Life Sciences UTC, 2014). The discussion with the Cogent regional representative sparked an interest in the researcher to find out more about the contemporary model. ‘Related literature’ (Creswell, 2005; Johnson, 2008) including Liverpool’s regional strategic documents and the website content of the Liverpool UTC were reviewed and contact made with the principal to discuss the southwest Wales regional context and to identify if there were any parallels that could be drawn with Liverpool and its regional life science sector.

The principal agreed to a brief interview with a subsequent invitation for the researcher to attend the next open evening at the UTC premises at Albert Dock in Liverpool in October 2014. The UTC had been given funding from the Department for Education to share best practice with other interested parties and had a visit programme devised to accommodate such interest. This would include a tour of the facilities, a chance to speak with students and a range of employers who offer support at events. The principal presented the context behind the development of the new school and its strategic vision with other open evening guests including parents and prospective students.

The researcher observed the feel of the event and made notes of key points. There was a lively atmosphere, and the event was very well attended suggesting high levels of interest. The principal welcomed all attendees and proceeded to show a film and a presentation highlighting the early successes of the UTC, the curriculum and its key features, its partnerships with business and its vision for growth. The strategic vision showed how innovation within the sector's companies, from local universities and health boards could generate significant growth in a vital sector. This could be achieved by creating new, highly skilled employment opportunities with commensurate income levels and thereby boosting growth within the local economy and supply chains. The regional need for talent to support an evolving life science hotspot in the Liverpool region was underscored. The value of the life science ecosystem to the local economy and high-quality employment opportunities was also emphasised.

A steering board established to navigate the new organisation towards its vision, plays a key collaborative role in the expansion of the talent pipeline into future careers in the health, medical and life sciences sectors. There appeared to be no shortage of companies offering their support, expertise and resources to ensure fresh young talent were equipped with the necessary learning experiences and chances to make successful career choices to join regional companies in the future. An insight was provided into how the Life Science UTC, Liverpool would work strategically with its stakeholders to provide the pipeline of talent to meet the sector's future workforce needs. In return, the sponsors and partners would provide real opportunities to support the education and training of young people that were unique to the UTC. The UTC Liverpool website promotes its branding and use of the strapline 'The first school in the UK specialising in Life Science and Healthcare for 14-19-year olds' and 'preparing students for the world of work and the jobs of tomorrow".

The teaching resources within the UTC were specialised and specific to the life science and health sectors. The learning environment looked more like a company training facility with seminar rooms and contemporary break out spaces, with a lecture theatre more likened to a cinema screen rather than traditional school classrooms and lecture halls. Company identities were seen on notice boards and in rooms with their logos and missions emblazoned across walls.

These companies were representative of the life science sector with examples such as: 2Bio, a technical IP and market analysis company for over 50 companies in pharma, biotechnologies, medical diagnostics and devices; RedxPharma, a pharmaceutical company based in Liverpool developing potential drugs to fight cancer and antibiotics with improved activity against resistant infections; ThermoFisher, a manufacturer and distributor of analytical laboratory instruments and software; Unilever, a manufacturer of a broad portfolio of nutrition, hygiene and personal care brands; Novartis, a pharmaceutical developer of drugs and vaccines to prevent and cure diseases; Siemens, a manufacturer and distributor of blood analysers to hospitals to diagnose medical conditions; Twilight Midwife, a private midwifery consultation service that provides bespoke parent preparation classes; Actavis, a biopharmaceutical company with a portfolio of products; Liverpool Community Health NHS (National Health Service) Trust and The Royal Liverpool and Broadgreen University Hospitals, one of the largest teaching hospitals in the region. These represent just a few of the organisations that offer sponsorship or partnership links with the UTC.

The final words of the presentation centred on what students who attended the Life Science UTC would be able to do following their studies, i.e. the qualifications they would gain, such as professionally recognised qualifications and a portfolio of skills and experience they could expect to develop; their understanding of industry and relevant potential careers; technical and soft skills and capabilities; the opportunity to progress to university or the world of work. Attendees appeared attentive and members of the audience asked more detailed questions about the curriculum, working with employers and progression to apprenticeships and types of universities. The researcher observed the interest and noted the receipt of the message as potent and powerful.

The researcher sought opportunity to speak to stakeholders throughout the evening and some of the perspectives are noted. These observed experiences and conversations would subsequently help to shape the ideas for the proposed research study:

4.2.3 **Perspectives from UTC Teachers:**

'the UTC movement helps the region develop our students through the collaboration between industry and education'

'it is supported by the universities in Liverpool, the NHS hospitals and local and regional companies such as Norvartis and Unilever'

'the curriculum is designed to help students develop the knowledge and understanding as well as the skills needed for a career in the sector'

'our students work in close contact with employers from the outset to develop the right professional attitude and skills that will be required of them when they enter the world of work'

'students are really motivated and enjoy learning'

'this is not a school like any other'

'the students here are treated like professionals and learn skills that university students don't start learning until they are 19' ‘students have access to world class expertise, resources and facilities’

‘my job is so rewarding seeing students thrive working alongside our partners on projects and experiments’

‘The UTC is a much better work environment than my last comprehensive’

‘I learn at the same time as my students when working with employers – it’s the best professional development.’

4.2.4 **Perspectives from UTC Employers:**

‘as a business partner we help educate the healthcare professionals, scientists, engineers and technicians of tomorrow’

‘the teachers come to our company to experience and understand what we are looking for from our future recruitment campaigns’

‘we provide work placements, masterclasses and resources we use in our business to help train these young people’

‘we are proud to be working in collaboration with the UTC’

‘in the future we will undoubtedly recruit the talent into our organisation that has come from this UTC’

‘these students are well prepared for jobs in the region’

‘these students will be highly prized by the regional businesses’

‘we provide access to our organisation’s facilities’

‘we offer training that our new recruits would go through’

‘these students take their education seriously and learn skills needed by industry’

‘we help the UTC staff to understand what we are looking for in future talent’

‘the best practice is evident – speak to any of the students and they will tell you – their motivation is infectious’

‘I wish I had the opportunity to come to a school like this.’

4.2.5 Perspectives from UTC Students

Two instances stood out from many, firstly the preparedness of prospective students to travel from across the region to attend the UTC. It should be noted that the UTC is a regional education provider and competes with other comprehensive schools for students. When asked why they were interested in attending the UTC, a prospective student response was 'my local school doesn't have these facilities, I think I would learn better in a smaller school, I love science and think I want to be a scientist and working with employers would be a great (opportunity).' The parent indicated that the daughter would need to travel for an hour each day to attend the UTC but that it would be well worth it – 'they do not have homework as they do all their work during school time.'

A second 17-year-old student was dressed in her scrubs and indicated that she was currently on work placement at the local hospital. She spoke about what she had done in the day before attending the open evening. She had worked on the wards alongside nursing staff, helped to feed patients and chat with them. She also took temperatures and blood pressure readings and completed the patient notes with the details. She felt she was better at learning this way. The researcher noted the student was very motivated and keen to share her learning from her day's experience. She was an impressive role model for the UTC.

- **The importance of working with the life science ecosystem** – part of a regional strategy to support the evolving economy and creating of high-quality jobs. This model relies on the interconnectedness of the region and key stakeholders working together to offer their expertise and access to resources.
- **The importance of workplace practices** – learning about the industry practices – the curricula offered a blend of general academic and vocational qualifications together with industry recognised technical qualifications such as Good Laboratory Practice which supports the development of industry standard laboratory skills from the outset.
- **A range of delivery methods were utilised** – for example, a resident professor creates the projects and experiments for students, provides links with

higher education, arranges work placement programmes, a mentoring scheme, industry masterclass series, visits to companies and places of interest.

- **The importance of location** – preparedness to travel, access to local hospitals and workplaces, strategic local government support with local transport
- **The importance of professional identity** – students commented on being treated as a professional not as a pupil; use of scrubs at work placement in hospitals, laboratory coats in lab lessons, and a school uniform suit to wear in all other lessons helped to promote a sense of professionalism.

The focus on the region and the life science sector and its support of the UTC spurred ideas of what could potentially be created in the local region. The researcher considered the UTC model and the key features that could be used as an ideal solution to the regional talent issue. Liverpool as a region is considered a life science hotspot and has a well-developed ecosystem with local and multi-national brands. The principal made reference to the time it had taken to establish and build strong networks of industry support. The UTC engaged the support of key stakeholders in Liverpool John Moores University, and the sponsorship of Royal Liverpool and Broadgreen University Hospitals NHS Trust. The researcher understood that the replication of the UTC model would not be politically viable, as responsibility for education in Wales is devolved to the Welsh Government and their interest in a new school system would not be entertained. Additionally, the size of a project of this type would be too onerous for a study within the timeline available.

Some early ideas and thoughts began to resonate with the researcher and questions began to emerge:

- Could the UTC model be of value in the south west Wales context?
- What elements of the model would be transferable and key to addressing the talent issues?
- How would these elements be configured into existing education-provision?
- What actions or changes would be needed to implement this?
- Is this feasible within the research timeline in parallel to working fulltime?
- What skillset would the researcher need to conduct this as a research study?

- What were the available resources the researcher could draw upon to support her?

  The researcher assimilated a summary of the notes from the visit to Liverpool with a presentation to the Scientia PhD group. This was a University scholarly support group that convened weekly to discuss progress and issues relating to student's research or about developments taking place across the region or issues of topical interest from elsewhere. The feedback was positive and encouraging and focused on the most viable and transferable elements that could support a proposed intervention study. The presentation was also presented to the Principal of the host FEI to identify the level of interest to pursue a project that could use the UTC model but bespoke to the regional context and need. Agreement was granted for a formalised proposal that would address the recommendations for the FE sector and presented to the FEI governing body for approval.

  The UTC model had further examples in other geographical parts of England. The researcher planned to visit three other locations identified with a life science focus. These visits were conveniently arranged over the course of 12 months. The objective of these visits was to showcase the Principal and senior leaders from the host FEI to view the UTC model and to also provide insight into other models, generating ideas and to better understand the organisation and implementation processes. These included:

- UTC Cambridge (opened 2014) – specialising in Biomedical and Environmental Science located on Cambridge Biomedical Campus adjacent to Medical Research Centre, Cancer Research UK, and Papworth Hospital.

- Sir Charles Kao UTC, Harlow (opened 2014) named after its namesake, Nobel Prize winner for his pioneering work in fibre optics in telecommunications, specialising as a STEM Academy with a focus on Medical Technology and Engineering.
- Health Future UTC, Birmingham (opened 2015) - specialising in Healthcare and Health Sciences sponsored by Wolverhampton University and West Midlands Ambulance Service and Mid-counties Co-Operative Pharmacy Group.

These reconnaissance visits generated useful data that the researcher could analyse and build an understanding using specific themes. The summary planning of this phase is illustrated in Table: 10.

Source Location	**Stakeholders**	**Purpose of the Data**	**Time Period/Cycle**	**Data Collected**	**Data Analysis Method**
University Technical College (UTC) Liverpool Cambridge Sir Charles Kao – Essex Health Futures	a.Educationalists + b. Employers + c. Learners	Understand and view best practice models relating to sector specific skill requirements and educational provision and organisation to address these needs	Reconnaissance phase -various dates	Interview notes with Principals, Vice Principals, employers, teachers, and students Observations Photographs	Analysis of literature, notes Photographic imagery Observations

Table 10: UTC visits and overview of information gathering

These are visually represented using wordle software to illustrate the key qualitative data. Research conducted by McNaught and Lam (2010) concluded that word clouds provide a quick but brief overview of the data and can reveal the frequencies and strength of use of different words that appear in an interview transcript or piece of text. Comparisons can be made between the different word clouds generated from different texts and can quickly reveal differences and similarities between ideas and therefore it can be a useful method for qualitative analysis of text. In an education context, Ramsden and Bate (2008, P.2), suggested that ‘word clouds could assist in the analysing of survey responses providing teachers with visual depiction of responses within a minute’. In research conducted by McNaught and Lam (2010) identified the value of a word cloud as a preliminary or supplementary tool for analysis. They suggested the wordle could quickly highlight the key differences and potential risk themes or points of interest and a direction of travel for further detailed analysis in subsequent stages of research. In addition, their work suggested word clouds could be a valuable validation tool to further confirm findings in addition to supporting visual interpretations of findings.

Five categories are illustrated in the following word clouds categories using word cloud software

- Specialisms of Focus
- Requirements from Talent
- Programme Delivery
- State of the Art Facilities
- Programme Support

Figure 15: Thematic Analysis Category – Specialisms of Focus Wordle

The UTCs visited specialised on key curricula areas relating to life sciences or sub-categories of life science and health. The specialisms were defined by the regional ecosystem and the type of companies within the locality.

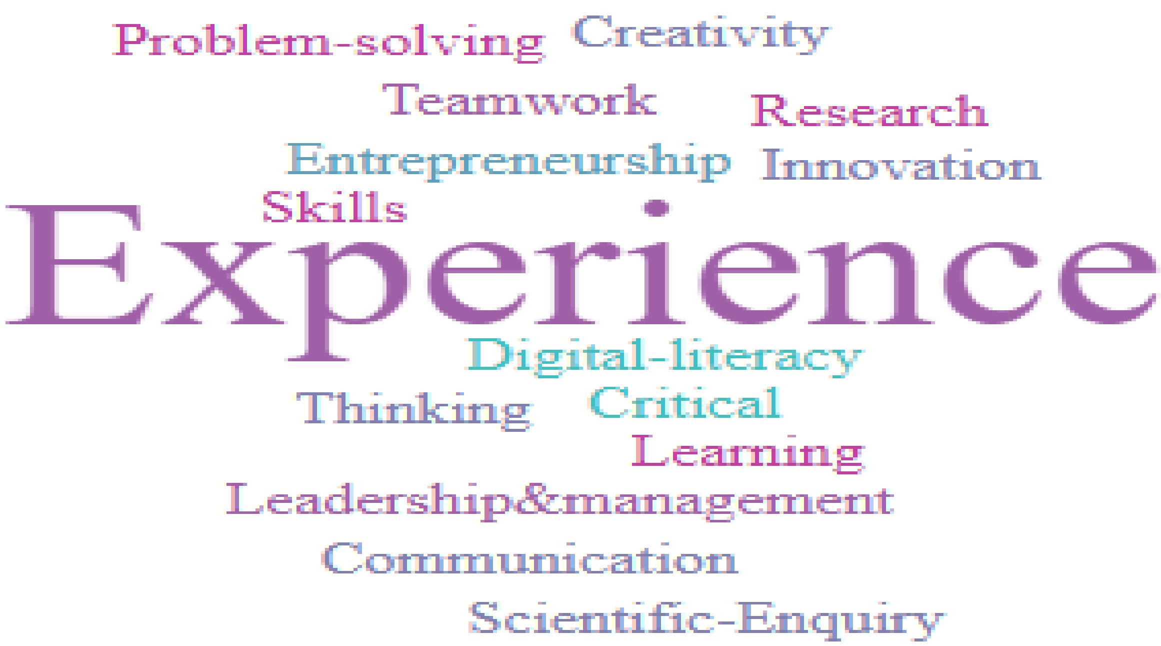


Figure 16: Thematic Analysis Category – Requirements from Talent Wordle

Several skills sets needed in future talent were identified. Many soft skills and core skills are identified as in demand by many professions and transferable across sectors.

Figure 17: Thematic Analysis Category – Programme Delivery Approaches Wordle - used with employers to develop technical capabilities of students

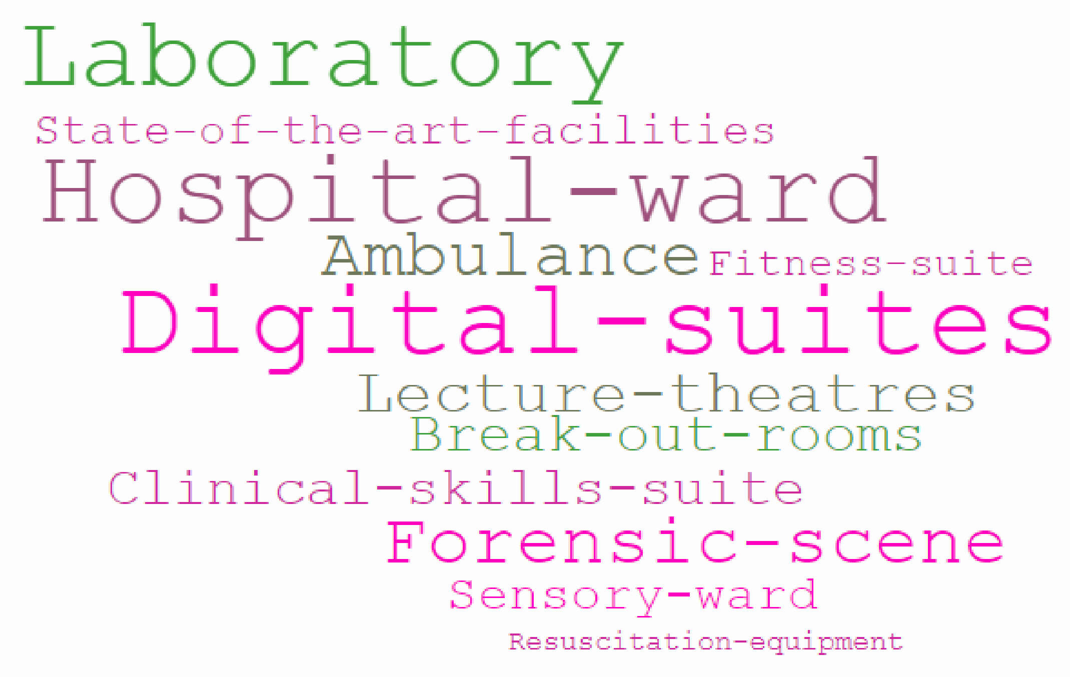


Figure 18: Thematic Analysis Category – State of the Art Facilities Wordle help to showcase to potential recruits to visualise the workplace environment and the approach taken to learning

Figure 19: Thematic Analysis Category – Programme Support Infrastructure

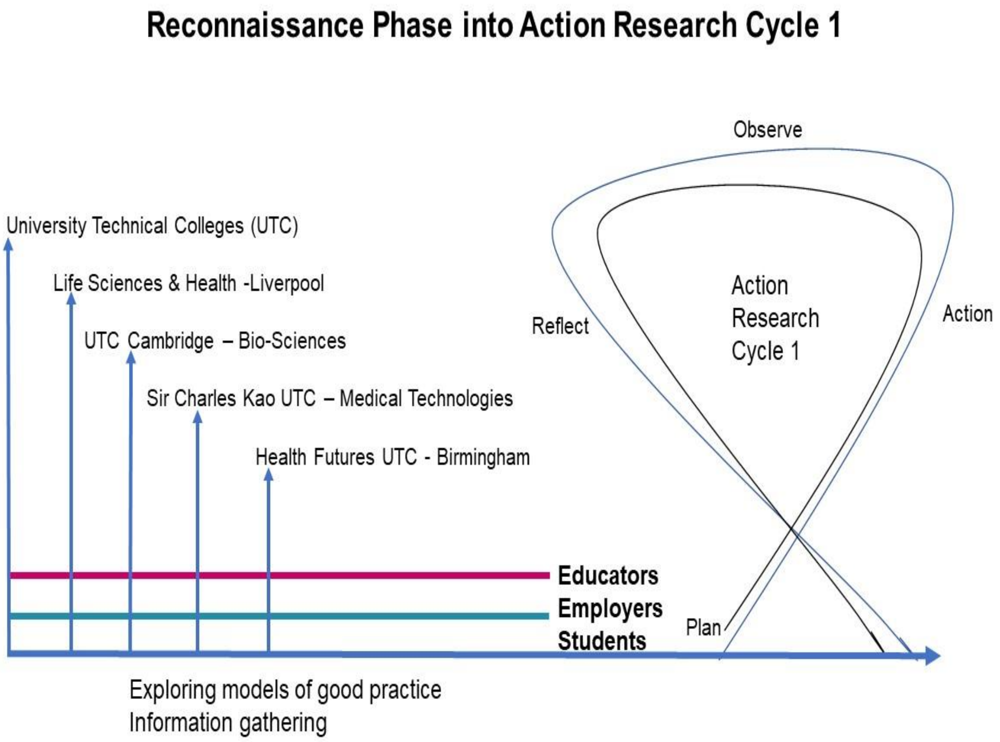
Photographic Images 1: Four images of state of the art facilities at UTCs

Photographs 2: Images from UTC visits in reconnaissance phase

The reconnaissance phase is essentially the starting point and diagnosis of the issue or problem. The researcher is better equipped with an insight and understanding of the situation that leads to the formulation of research questions that matter. It is the questions that link the reconnaissance into the action research spiral of planning, actioning, observing and reflecting (Kemmis and McTaggart, 1998).

The purpose of reviewing the literature and gathering information in the reconnaissance phase is to support and guide the researcher into defining and limiting the problem. The process assists in the development of an appropriate research design with applicable data collection instruments to collect the required forms of data to answer the research question(s) (Mertler, 2008; Parson and Brown, 2002). According to Johnson (2008) this process also enables the action research process to link existing theory and research to the actual area of practice under investigation. Three key areas are considered in the regional study as a consequence of the reconnaissance phase:

- What aspects of the UTC model can be transported to the regional context?
- How can the perspectives of different stakeholders be used to collaborate and design an intervention programme that address the recommendations and resolves the regional talent issue?
- How supportive would the regional life science ecosystem be in the curricula development and delivery process?
- What elements need to be included in an intervention study in order to address the talent issues within the research parameters of time and budget?



Reconnaissance phase leading into first action research cycle

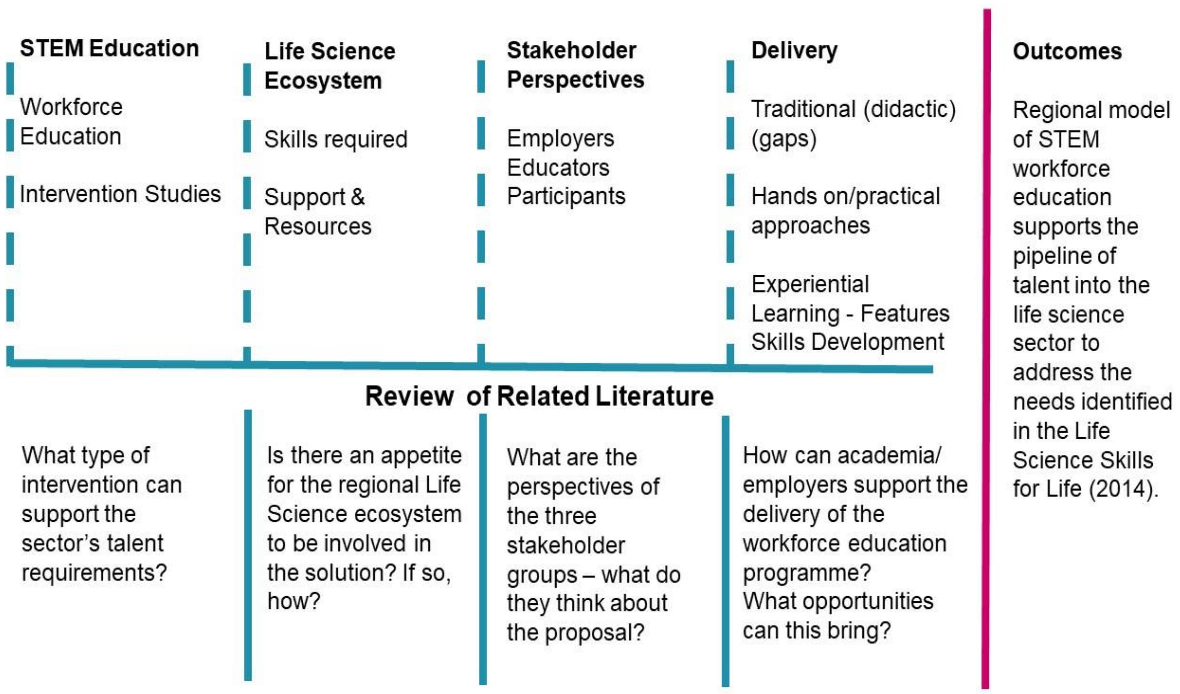


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Figure 20: The reconnaissance phase that led to initial research questions and scope of the study.

4.2.6 **Research Question**

An umbrella research question addresses the topic in focus including the key words and phrases to help guide the research and approach to database and library searches (Ellis, 2004). It references an appropriately complex question the researcher wants to know the answer to, as the purpose of the study is to gain new knowledge. The researcher has determined qualitative action research as the most appropriate to reflect the perceptions of the stakeholders. 'The single most important component of a study is the research question. It is the keystone of the entire exercise' (Bordage and Dawson, 2003, P.378). It will address gaps identified in the existing literature and the contribution to the field, provide a clear focus for the research process, influence how data is collected and the type of questions to ask and how to think about how others will argue against it (ibid).

These processes derive several lines of inquiry over the same period, which the researcher assembles or crystalises into a research paradigm with a focus and a set of initial question(s).

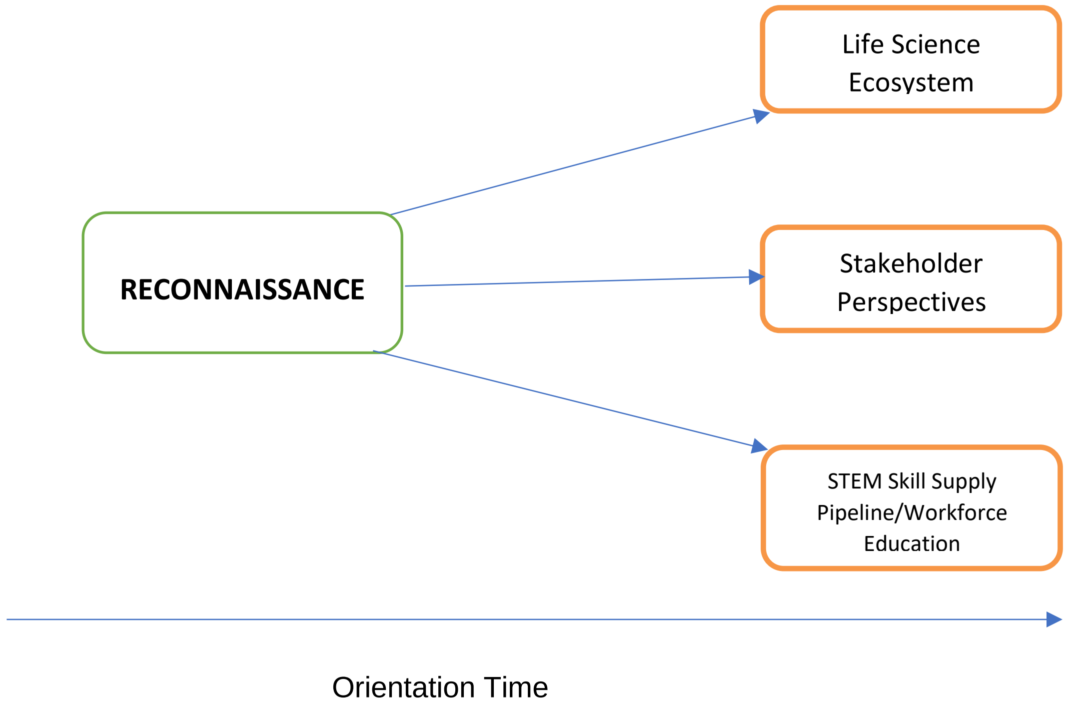

Figure 21: Initial Lines of Inquiry

A key aspect of any research study is determining the key focus. Practitioner initiated action research combined with professional development requires a topic of genuine interest and of personal value that one would like to examine in detail (Mertler, 2008; Johnson, 2008). The goal of action research is to bring about change, implement and test ideas, create improvements for the better or correct an area of practice that is not working so well (Fraenkel and Wallen, 2003). A further consideration to selecting the topic of focus is the part-time nature of the researcher and her availability of time and its constraints on the study (ibid).

The aim of the research study is to advance an understanding of how a STEM intervention programme through action research can facilitate the development of high calibre talent whilst increasing awareness and potential interest in careers in the life sciences within an evolving regional economy of the southwest region of Wales?

The research question collates the key elements of interest in the study as identified through the reconnaissance phase. These are:

- The perceptions of three stakeholder groups – employers, educators, and students to collaborate and co-create a solution. Are there differences in perspectives between stakeholders?
- The approach to creating a STEM workforce education intervention programme to complement existing educational provision in the FE sector which develops future talent in line with sector needs.
- Tests the willingness of the regional life science sector and its ecosystem to support the design and delivery of the programme.

The researcher sought to address the study's research question through a series of three action research cycles. Its aim is multi-faceted as it seeks to address change in relation to the regional problem, its relationship to practice within the further education sector and alignment with the needs of the life science sector. The approach taken also considers the prior experience and professional development of the researcher in the capacity and role as a Regional Advocate. Sub questions that may be subordinate to the main research question (Mertler and Charles, 2008) are important and can alter according to earlier findings and re-direction of the plan. These are found in every action research cycle and provide a focus for the key areas of action according to the stakeholder group:

Action Cycle 1: To identify the knowledge, skills and attitudinal requirements of young talent required by the region's life science sector and to understand employers' perspectives on a proposed approach. (Employer Stakeholders).

Action Cycle 2: To design and develop a STEM intervention / workforce education programme and to assess access to support from the region's life science ecosystem (Educator Stakeholders).

Action Cycle 3: To implement a pilot intervention and evaluate its effectiveness in preparing young people for careers in the life science and associated sectors. (Learner Participant Stakeholders).

The action research plan is initially developed identifying the stakeholders who can provide the data, a consideration of how these individuals can be accessed, where and when (Creswell, 2005).

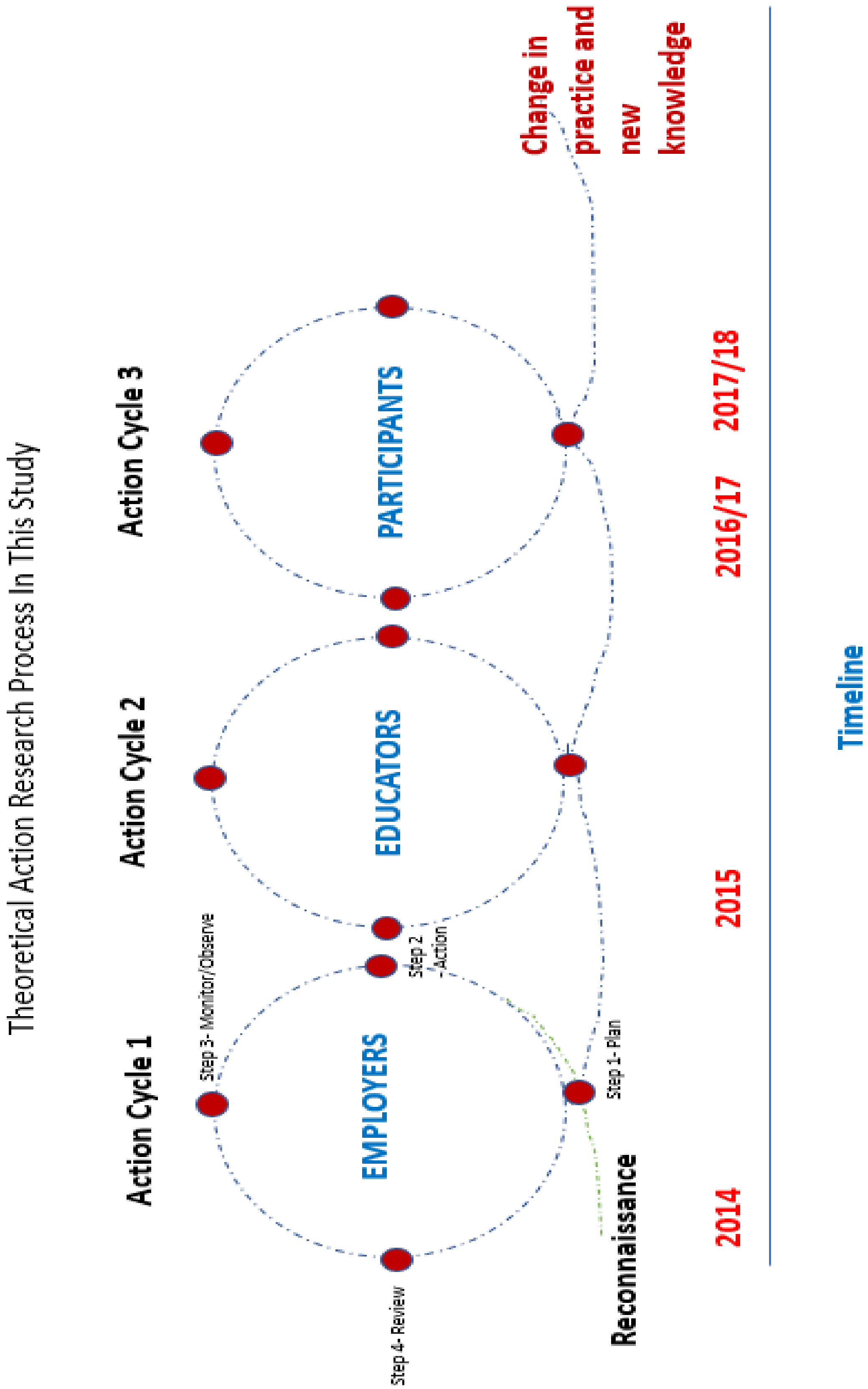

Figure 22: Three Action Research Cycles with three stakeholder groups

4.3 Overview of Action Research Cycle 1

Action research can be seen as a simplistic and cyclical process to conducting research. It is a systematic inquiry since it is conducted in a spiral of cycles. The researcher reflects on every stage in addition to the reflecting step as the process does not follow a linear path. This is because action researchers face real life issues that are seldom direct or linear (Whitehead, 2016).

The research-practitioner starts by identifying the problem and ascertaining its potential causes. A brainstorming process is followed to identify potential approaches to mitigate the problem or to find a resolution. Following this, the researcher is likely to identify with an approach and makes several judgements based on her prior knowledge, experience or that gained from reading the literature, as to the best way to proceed. This may generate several areas requiring further understanding which help to shape the questions for the action cycle as an approach is selected for planning a specific solution. This plan is developed into a series of actions which help to implement the approach and then to observe and evaluate its effectiveness. However, if in one of the phases, information is received that necessitates modification or change to the actions planned, then these plans may need to be abandoned or iterated, requiring the researcher to refocus and re-plan. This can be similar to the analogy of conducting medical treatment which begins by monitoring symptoms, diagnosing the disease, prescribing a remedy, treating the patient and monitoring and evaluating the results. If the medicine the patient has taken does not make him get better, the doctor needs to repeat monitoring of symptoms and diagnosing the disease, before prescribing a more appropriate medicine.

Pardede (2016), showed that many action research experts have independently designed their educational AR process without knowing about other versions. Consequently, the literature uses various terminologies to describe similar action research processes. Despite the different terminology used in the various versions – all models listed in the Table illustrate the same intent with an action research approach to conduct a systematic study to solve a problem or to present change and improvement through a systematic process of planning, actioning, observing and reflecting. These four main steps occur in each phase or recurring action cycle until a solution is found, the timeline is reached, or the researcher feels it is time to stop (Burns, 2010, P.7).

Stage	Kemmis & Taggart (1990)	Sagor (1992)	Mertler (2008)	O'Leary (2004)	British Council (2015)	Bakowska-Waldmann and Kaczmarek (2019)
1	Planning	Problem Formation	Planning	Observe	Notice of a problem and plan	Planning – identifying, preparing, deciding, organising
2	Acting	Data Collection	Actioning	Reflect	Teach/Act	Acting – testing, implementing, promoting
3	Observing	Data Analysis	Observing	Plan	Observe	Observing – monitoring, analysing, reporting
4	Reflecting	Reporting of Results	Reflecting	Act	Reflect	Reflect – revising, summarizing, evaluating

Table 11: Steps in An Action Research Cycles from Different Researchers

Through this process, the researcher practitioner learns more about the practice and action inquiry. Through each step the researcher implements intended actions to improve reality whilst also creating a change in practice.

The researcher has adopted the method used by Mertler (2008) to structure each action cycle into four key steps:

- Step 1 – Planning – includes gathering information, reviewing the related literature and developing the research plan.

- Step 2 – Actioning – refers to implementing the research plan and collecting the data. This step may be a stand-alone process or coincide and simultaneously occur with step 3 – Observing.

- Step 3 – Observing – refers to analysing the data and making sense of it from patterns or themes that emerge.

- Step 4 – Reflecting – refers to looking back over the whole process, when everything has been collated, and then critically examining and identifying the key learning aspects. The reflection may influence the researcher's next decision or further research steps. This may include planning of a new action cycle or communicating the results with the education community or stakeholders.

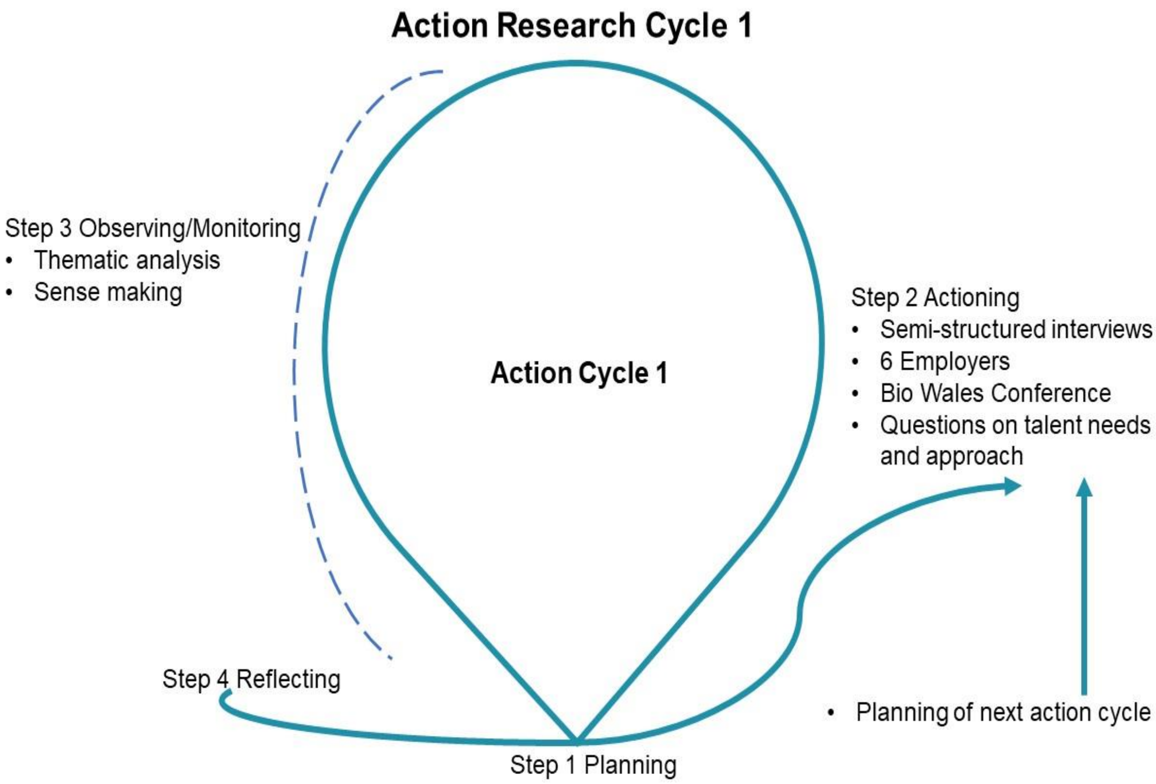

Figure 23: Action Cycle 1 – four step approach to action research

4.4 Step 1: Planning

Cycle One focuses on the orientation phase as the researcher began to absorb and understand the context, environment, key actors, and potential for a solution to address the regional talent problem related to the life science sector. A focus on the region and its available resources spurred ideas of what could potentially be created. The researcher created a first proposal that had been discussed and agreed with the principal and leadership team of the host FEI. The outline proposal was developed using a PowerPoint presentation with the overall research intentions of Action Research Cycle 1 as planned in the summary card in Table 12.

The first step was to understand the context of the problem and to assess the suitable approaches to address the talent issues identified. This would require seeking the perspectives from employers within the life science sector. A data collection opportunity arose when the researcher attended the Bio-Wales Conference and Exhibition; an annual Life Sciences event hosted in Cardiff Bay, sponsored by the Welsh Government. The researcher planned her visit to the conference and set up a series of six interviews with employers and representatives from across the life science sector. Pre-planned questions were devised seeking views from employers of the early model devised from ideas generated from the literature and visits to the UTCs. The appointments were made as part of the conference facilities. Delegates were given opportunities to meet with company representatives in a scheduled agenda session as a means of networking within the conference proceedings. Six prospective interviewees were selected from the attendance list of the day from a cross section to represent the sector.

Phase of Research and Focus	Cycle 1 March 2015 **To identify the knowledge, skills and attitudinal requirements of young talent required by the region's life science sector and to understand employer perspectives on a proposed approach**.
Stakeholder Groups	Employers
Background Activity **Location** **Key Areas of Questioning**	The researcher identified the questions that need answering. The Life Science Skills for Life Report (2014) identified key skills required of young talent. Are these identified skills appropriate for FE students? What do employers think about the proposed approach to resolve the talent issue? To identify what aspects if any can be incorporated into a bespoke programme. Identify the perspectives of employers on a collaborative solution. **Bio-Wales Conference, Cardiff Bay** What are the skill requirements for the life science sector and how do they relate to 16-19-year-olds? What are the views of stakeholders on the key elements of the STEM workforce education model proposed? What type of approach can be successful in addressing the talent problem the industry faces?
Data Collection Locations	Bio Wales Conference Cardiff – targeting 6 attending employers
Data Collection Instruments	Semi-structured Interviews (Audio Transcriptions) with range of Employers x 6

Table 12: Action Research Summary of the activity for the first action research cycle.

4.5 Step 2: Actioning

The actioning step within the action research cycle is concerned with taking actions or implementing activities as identified in the plan. The first action research cycle is concerned with identifying the requirements for a proposed education intervention as articulated by employer stakeholders.

4.5.1 Participants

The employer stakeholders were identified ahead of the conference. An outline of the subject and nature of the proposed interview and the proposed use of any data generated as part of a PhD action research study was conveyed to each stakeholder. The participants agreed for use of their individual comments and that they would be noted as such 'not necessarily representative of their organisations.' Their personal details were provided for use in the study but in line with the anonymity of other participants their individual identities have been protected and their job role has been used as the key identifier.

The interviews were held with the following job role holders:

1. An anaesthetist from an NHS hospital
2. A managing director of a recruitment agency specializing in finding life science talent for organisations
3. An employee from a private sector design innovation centre with interests in medicine, health and life science and strong links to academia
4. A European representative whose company is involved in clinical trials.
5. A Medical Director for an NHS University Health Board
6. A Chief Executive of a large government agency which funds innovation projects in life sciences and other sectors

4.5.2 Location

The interviews of six individuals representing the sector were held at the Bio Wales Conference held at the Millennium Centre in Cardiff Bay in March 2015. A designated area for business-to-business meetings was used to conduct and record each meeting.

4.5.3 Data Collection

Semi-structured interviews were conducted with the six employers for an approximate duration of 15 minutes. The interviews were audio recorded in agreement with the participants. The researcher introduced herself and outlined the process of the interview, the expected length of the process and confirmation that all responses would be anonymised. The interviewee was also given the option to decline to respond to any given question if they deemed it too ethically sensitive or if they felt the risk of an adverse reflection on their organisations. The researcher introduced the background to the interview with the findings and recommendations of the Life Science, Skills for Life (2014) report and an overview of the UTC models in England. A set of three questions as identified in the plan were utilised in each interview with the opportunity for further questions depending on responses. The schedule acted as a checklist of topics or prompts that the researcher wanted to explore and were listed in a table where the researcher could add notes of written responses or prompts for further questioning and probing.

4.6 Step 3: Observing and Monitoring

Collecting data occurred at the same time as the action step was conducted. The observing and monitoring stage of the action cycle refers to the recorded data collected that captures the effects of the actions. It is also the step that involves organising and analysing the data.

4.6.1 Data Analysis

The process of data analysis in action research can be quite complex. According to Dictionary.com (2016) the definition of analyse is “to examine carefully and in detail so as to identify causes, key factors, possible results, etc”. As an action researcher, it is important to embrace this definition and follow only where the data collected leads. Whilst the data analysis techniques used may be selected at the discretion of the researcher, the approach selected should be consistent with the type of data collected. According to Mills (2007), “data analysis is undertaken when researchers want to summarize and represent data that has been collected in dependable, accurate, reliable, correct, and “right” manner. Researchers interpret data to make sense of the research findings, to answer the questions “so what?” In the dual role as an action researcher and researcher-practitioner the intention is to respond to Mills’ “so what?” question by clear, concise, and well-thought-out techniques for data analysis. The answers to “so what?” will hopefully be revealed as the inquiry deepens with each subsequent action cycle into the interpretation and implications of the research data.

The interview data was transcribed into text following recording to aid analysis. Written notes were recorded in the question table. Demographic data relating to each interviewee was collected such as name, gender and occupation, as this type of information can be of value when contextualising responses (Bryan, 2008). However, to maintain complete anonymity, which was guaranteed at the outset of each interview, this information is omitted from the interview records. The data collections are reported by stakeholder group and colour coded to aid comparisons to be made between groupings and cycles.

The researcher transcribed the recorded interviews, capturing what was said in response to the set questions. A copy of the transcriptions was analysed and reviewed. The analysis of all respondents revealed the multiple use of key terminology and phrases. To validate the content of the transcription, the researcher used the process called member checking by which, a copy was sent to each participant for them to review by editing or adding to the transcription and finally confirming its content as a true reflection of the interview. This serves to support the trustworthiness (Birt, 2016) and validity of qualitative research (Creswell and Miller 2000; Carlson, 2010). An amendment was received during this process, not for the accuracy of the account but for the clarity in conveying the participant’s intended contributions (Doyle, 2007).

The total transcription of the interviews was processed in preparation for first analysis using word cloud tools. A word cloud tool such as wordle is an application which analyses text to provide an illustration of key terms and their frequency. The cluster of words or word cloud derived shows larger scaled words as ones used most often within the given text. The wordle software rendered the large amount of text and analysed for the most frequently used terms eliminating the most common English words such as ‘the, and, is’ etc. The tool produces a fast and visually rich way to enable researchers to have some basic understanding of the data in hand. Each of the six transcriptions were fed into the wordle system and analysed using the software resulting in six word-clouds as outputs. The researcher considered the variations between the six individual word clouds. From the word cloud analysis, the number of words that appear, refer to words or phrases used in the actual interview discussions and comments made. These are more detailed in interviews 2, 4 and 6 where the respondents had more to say but there are also consistencies between all six respondents illustrating the association and need for action and change from the further education sector. The tool can quickly visualise general patterns in text and provides the researcher with common themes or views or where there are differences between the sets of responses. The researcher recognised some limitations i.e., that words retrieved from full transcriptions can be taken out of context and each word is treated as a single word or unit of analysis. The initial word cloud process ignores key phrases and can create some ambiguity, for example, negative connotations i.e., not convenient.

4.6.2 **Thematic Analysis**

The researcher proceeded to analyse the data more closely using thematic analysis steps (Braun and Clarke, 2006). The study of the transcriptions in full is a very time-consuming process and required detailed coding of the types of interactions and comments voiced in each of the six interviews. The audit trail from the questions asked, to the responses transcribed and the key quotations from participants support the credibility and trustworthiness of the data (Guba and Lincoln, 1994). Patton (2002) suggests that informants views captured through their spoken word also aids in determining how the researcher has been led to their interpretation and understanding. Therefore, including the quotations could be viewed as part of the validation process (Matt, 2004). A summary of the key notes and quotes are highlighted for each employer:

Interview 1 - responses from the anaesthetist

'Requirements of day-to-day jobs' 'idea of a new model is a fantastic idea' 'similar to reverse technology – identify the end product to teach the skills you need the talent to have' ' educational system needs to change' 'life science sector not linked to education system' 'it would be a good idea to interact and focus on what is needed' 'collaboration means you will blend and get the result much quicker' 'mentoring is an important side'

Interview 2 - responses from the innovation design researcher

'this is long overdue' 'many talk about industry academic link but not many deliver to the required standard' 'it seems essential to me' ' my work blends across academia and industry but the education needs to be applied' 'parts are good but parts are not' 'the challenge is that the life science sector is very diverse' 'there are lots of skill sets but the life science industry is constantly changing so you need a large spread of skills' 'many haven't heard that life science is an option' ' I think the support needs to be enhanced for academics and practitioners' 'education today is different' ' I was educated with access to people from industry when learning product design' 'the reality of finding jobs is very competitive' ' show a particular employer a portfolio of evidence of what you can do' ' spending a compulsory week in industry alongside A levels is challenging – difficult to find places' 'quality of work experience is low – babysitting as opposed to learning development week' 'challenge is to convince industry that it is not babysitting for 7 days'.

Interview 3 - responses from employer representative of clinical trials company

'work with clinical trials industry' 'this is critical, look at countries in Europe like Germany, industry works closely with universities and students are ready for the world of work with the skills required by companies' ' this is critical for the success of the country' ' we have too many art graduates, we need to link student degrees with industries and employment opportunities' 'if wales are thinking like this – they are already ahead of the curve' 'I think there is room for improvement' 'An integrated curriculum model blending academic and technical work based provision is vital' 'experience of work through internships, shadowing and getting on with people is important' 'it is critical to understand work through industry and mentoring support and career guidance' ' we always say it is universities responsibility but there is a massive responsibility for

employers to make sure students are produced with the right skills – Germany gets it but we should too'

Interview 4 - responses from medical director at NHS hospital

'the nature of health and life sciences has changed over recent years and it is important that young people who are going into these professions have the right skills needed' 'it is important to have close relationships between those employing and the people providing training' 'there is a breadth of opportunity in health and life science to create the skills in our young people for our future work force' 'there are areas where a greater relationship between the health sector and the FE sector would be really important' 'exciting things like ARCH (A Regional Collaboration for Health) can bring together stakeholders to design curriculum and education programmes that are fit for the future and provide the workforce needed by the sector' 'we have a very traditional FE sector at the moment' 'the idea of masterclasses is important first of all it give purpose to education and people can see what is being done to solve problems' 'opens eyes to challenges that are being faced but were never thought of – I think it is an important part of the programme'

Interview 5 - responses from the specialist life science recruitment director

'run a recruitment business exclusively for the life science sector' ''people need to be fit for purpose when they leave the education system' 'if people could understand what industry or employability looks like in the real world outside academia' 'more can be done to support the life science sector' 'more real life insight is needed into – what are jobs like, what is my career going to look like' ' the reality at the moment is that the academic system is more interested in keeping people in education and not making them fit for purpose of going into industry or preparing them for their life beyond that'

Interview 6 - responses from the chief executive of innovation funding body utilised by innovation projects with life science and other sector companies to assist in their growth.

'important that young people as they grow up have an understanding about what work is really like' 'I think students at school need to know this as soon as possible …what the world looks like is so important ..so that they can understand what it is they really want to do' 'sometimes it is not obvious' 'getting

some context of how things work is important' ' work in the future is going to be multi-disciplinary so helping young people to grow and not cutting their choices too early will help them guide their choices' 'education is still quite traditional in the way it is segmented' 'Life sciences is really multi -disciplinary now' ' never enough women applying for job roles' ' we do not explain enough about the opportunities that exist and the clean and dirty jobs within the sector' ' we don't show the creating, innovating and design that can build new products that work' 'when you get to the world of work they realise it is much more fluid and open than they realise' 'industry challenges, master classes and blending academic with technical experience is important' ' giving students opportunity to work on challenges experienced by industry – you will be surprised with what they come up with, it's not an experiment, it is a really good use of talent'.

The researcher worked through the transcript in a secondary phase to identify key sentences or phrases that were pertinent in each interview. The data collected varies from one person to another and includes opinions, attitudes and knowledge. The interviews conducted in the study for employers were planned as one to one, face to face and were semi structured in nature i.e., the researcher asked the same questions to each participant to eliminate issues of bias or potentially leading the interviewee. This defined structure also supported the reliability of the data when extracted to support interpretations and explanations (Yin, 2011). However, the researcher deemed it necessary to allow flexibility to uncover detail and deeper understanding with additional questioning where conversations allowed for further probing on information provided. Semi structured interviews provided the ideal compromise through an interview schedule with the freedom of direct participant interaction and deepens the understanding by means of using the informant's voice (Corden and Sainsbury (2006). The blend of options makes the method highly suitable for small scale research projects. The choice to utilise semi structured interviews is also aligned to the philosophical position of the researcher and the given context and type of information required. According to Thomas (2015), most people want to assist and provide their views and opinions unless the focus is on issues sensitive to them. The direct line of enquiry with employer interviewees and researcher enabled a flexible method of data collection and to pursue modified lines of questioning following interesting responses in a way that is not possible from questionnaires alone. Researchers have the freedom to veer off interview schedule if the conversation seems of value (Bryan,2012). In contrast to the methods with observation, interviews can provide the researcher with an obvious shortcut to their research questions because they can directly ask about what is going on in a situation rather than interpreting an implied meaning from what they see (Robson, 2011).

The thematic analysis of the qualitative data using Braun and Clarke's (2006) six step approach, the following broad themes emerged in response to the three main questions:

- **What are the skill requirements for the life science sector and how do they relate to 16-18-year-olds?**

  Employer responses suggest a need for young talent to have a range of knowledge, skills and experience related to the sector. They believe an understanding of the types of careers and job roles and what would be expected of them in the workplace are important insights. Some indicated that young talent needed to be aware of expectations in the workplace, be fit for purpose and that employability was an important aspect of their development. Some employers identified the need for a wide spread of skills and others offered examples of skills needed including work experience, multidisciplinary skills, creativity, design and innovation, technical skills. One employer suggested a portfolio of evidence to record skills developed over time.

- **What are the views of stakeholders on the key elements of the STEM workforce education model proposed?**

  All employers indicated a positive view on the proposal of a STEM intervention to address the talent needs of the sector – some suggesting it was long overdue and that change was imperative and urgent.
  Some employers suggested elements that should be considered including internships, work experience, work shadowing, industry challenges dealing with real life problems, experiments, careers guidance on job roles.

- **What type of approach can be successful in addressing the talent problem the industry faces?**

A collaboration between further education and industry was welcomed particularly linking the life science sector to education. Close relationships would be important to addressing the issue. The life science sector would be open to collaboration. Reversing the model of starting with what industry seeks in talent would be a good approach. Collaboration was identified as an important approach and its importance for success. The change dynamics of the life science sector was highlighted against the more traditional further education sector that needs to change. An employer suggested participants being involved in the collaboration as they could offer some surprising insights. One employer commented on the need to attract diversity into the sector particularly increasing female participation. Some criticism against the further education sector suggest that it is not interested in preparing young people for future employment.

The researcher reaches the following conclusions from the employer stakeholder interviews that inform the action research cycle 2.

- There is a definite and urgent need for change and a collaborative response involving different stakeholders including employers/educationalists and participants or students. The preparedness of employers is assured by those interviewed that the life science ecosystem would be supportive of any intervention. Although the researcher would need to test this hypothesis.
- The identification of needs of talent such as knowledge, skills, experience and professional competencies should be embedded into the intervention. As the sector is dynamic and constantly developing, any intervention design needs to provide assurance of ongoing alignment and updating in the education provision to reflect the life science sector's dynamic demands.
- The need for young talent includes knowledge, skills and experience linked to STEM and or the life science sector. Reference is made to the importance of changing work practices and that of future work and the importance to be attributed to work experience, mentoring, masterclasses, and a skills portfolio. The design of learning experiences should aim to make use of expertise, facilities and resources the regional ecosystem has to offer.

4.6.3 **Data Merging**

The researcher considered the conclusions drawn from the employer stakeholders and further assessed them in combination with data from the reconnaissance phase, earlier practice, and prior knowledge. The process reveals the variation, duplication and frequency of key terms and supplies an illustration of the provisional list of categories or themes. These themes were aligned to the first research recommendations and the initial questions whilst also supplying an additional focus for further in-depth enquiry and understanding.

Perceptions on Recommendations from Life Science Report	Features of an Intervention	Potential Outputs
Industry & employer interface Life science sector Collaboration Blended academic provision, schools, universities, and industry knowledge Evidence based Shared resources Regional networks Change in education system	Exciting programme Excellent idea Shared resources Mentoring Work experience Internships Placements Industry challenges Educate, train, apply skills Masterclasses Skills portfolio	Professional Motivation Positive Attitude Talent Expertise Skills Employability Careers Future workforce Recruitment University enrolments Apprenticeships

Table 13: Clustering of key themes

The clustering of the key themes as illustrated in Table 13, provide the researcher with an understanding of what employers are looking for in the design of any subsequent intervention and the typical capabilities they seek from talent and therefore the outputs of a programme. These themes provide a starting point from which to consider the approach to design. In addition, the findings of the reconnaissance phase and action cycle 1 show consensus of the need and clear appetite for collaborative action between further education and employers, as identified in the recommendations made in the Life Science Skills for Life (2014) report.

The last step of Bakowska-Waldmann, E and Kaczmarek (2019), action research cycle focuses on the processes of summarizing, evaluating and revising the data collected to identify the areas of focus and questions for a deeper understanding to take forward into the next action research cycle. It provides the researcher the opportunity to revisit the plan for the cycle and the questions set and to establish any gaps or to consider new areas of focus following the analysis of the data collected. To reflect upon the cycle, it is pertinent for the researcher to review the plan set out at the commencement of the research cycle particularly regarding the questions set to establish if the data collected supplied the insight required or if further probing is needed.

4.7 Step 4: Reflecting

The duration of the first action cycle was three years. During this time, the researcher led on the initial research and publication of the Life Science Skills for Life report which was published in 2014. From the presentation in May 2014 to a group of over 50 key strategic stakeholders from across the region with a personal stake in education and the life science sector, the focus of the researcher transferred to the recommendations set out in the report. The researcher developed a research proposal and would take the next two years to work on a part time basis to develop the study and groundwork in what is considered a reconnaissance phase of her action research.

During the time, the researcher worked to build contacts across the education and life science sector. Reflecting on this period, the researcher acknowledges the messy nature of action research and the multiple lines of enquiry being developed and processed simultaneously. Some lines of enquiry generate valuable insight and data whilst others take time to develop and can often lead to a lack of response or commentary that lacks any significance to the research questions. From this early phase of the study the researcher begins to learn about the craft of action research but recalls doubting her choice of research approach. At the commencement of the research, the researcher did not envisage the enormity or scale of the challenge but looking back she was able to proceed to the second cycle of research with greater clarity of what the focus would be. The scope of the research became clearer and is illustrated in Figure 24.

The researcher begins to reflect on the outcomes of the reconnaissance and employer stakeholder group and starts to make sense of their perceptions and specific requirements proposed for an intervention programme which could widen participation of young people interested in pursuing a career in the life science sector. Any new understanding or areas of focus i.e., key features of an intervention programme are sought in existing literature to support the next stages of the research. New questions arise - what are the key features of an effective careers or employability intervention programme, what studies have been undertaken that relate the regional STEM sectors and further education? This understanding from the literature is used to help inform and plan for the next iteration or action research cycle.

The researcher considered the perceptions of three stakeholders' groups in relation to the recommendations and the manageability of working with multiple stakeholders as one of the key strands within a proposed study. The idea of gathering and identifying multiple stakeholder views could add value in shaping the change programme, assist in understanding perspectives and how they may contribute to the alignment of the gap between FEI provision and the needs of the sector.

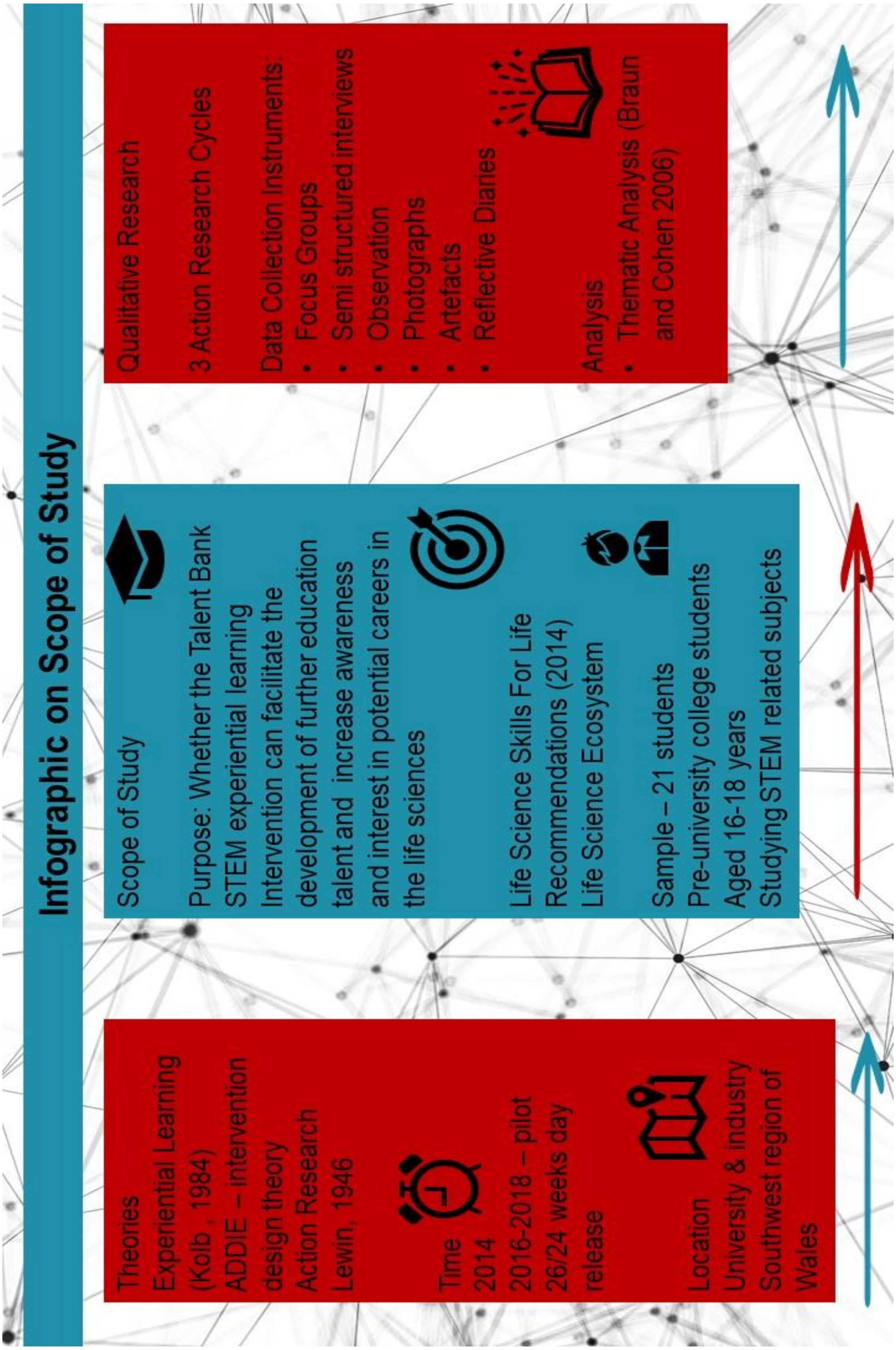

Figure 24: Scope of the Action Research

To the researcher's knowledge at the commencement of the research design, there was no record of prior literature relating to a collaborative model of stakeholders involved in a FE study on workforce education for the life science sector.

4.7.1 Problem Revisited

At the time, the research landscape was continuously changing. News of regional development projects such as A Regional Collaboration for Health began to circulate, and such ambitious infrastructure plans would certainly require talent resources. When the Life Science Skills for Life report was released with its recommendations in May of 2014, it made no reference to these innovative developments and so it was deemed important to understand the nature of these to make a considered view on their potential impact regarding talent and skills needs. In conclusion, the data gathered through AR cycle one, confirms that the sector's situation was a genuine and real issue. One that if left unresolved would continue to see potential opportunities for young people pass by from a lack of awareness of these career chances. In addition, there is a likelihood of further negative impact on the growth of the regional economy due to the lack of talent pool exacerbated by additional regional developments in the life science sector across the southwest region.

4.8 Endpoint

The starting point began with a reconnaissance period to enable the researcher to understand the context and nature to the research problem. An analysis of the issue, the regional situation and a review of the literature identified a range of gaps and opportunities that led to a first course of action. Following this course of action, the researcher devised ideas for an intervention programme and a series of research question relating to whether the programme would address the industry's needs and provide a resolution. These questions were put to a group of employers a from across the life and health science sectors suggesting scope for s proposed model to meet the talent needs. The end of this action cycle has helped to determine the focus of the study and developed an understanding in the researcher of a way forward. The ideas and learning from the action cycle will be incorporated into the planning for the next action cycle.

4.9 Conclusion to Chapter

The chapter has outlined the activities conducted by the researcher in the reconnaissance phase and how these influenced the researcher's choices in focusing the direction of the research study. The first action cycle considered the perspectives of employer stakeholders on the prospect of a collaborative solution to the regional talent issues as reported in the Life Science, Skills for Life (2014) report. Responses to the questions in a semi structured interview identify a range of key features that could be used to support an industry facing education intervention. Following the analysis of the data collected and the emerging themes within the first AR cycle, the researcher assimilates, revises and prioritises the key areas of focus for the next cycle. The next chapter will outline the second action research cycle and its focus on the design of the intervention and assesses the perceptions of educators on their views to the approach to tackle the talent problem.

Chapter 5

ACTION CYCLE 2

5 ACTION CYCLE 2 - Design of an Intervention

5.1 Introduction

This chapter outlines the second action research cycle. It focuses on the intervention design process, the underpinning learning theory and the subsequent creation of the Talent Bank STEM intervention programme. It illustrates the Talent Bank model and its various features and delivery approach. The intervention programme forms the basis for data collection from a focus group of educators, with the aim of eliciting their perspectives on the experiential learning model and its potential to resolve the regional life sciences' talent issue. The findings are briefly discussed and compared with the employer stakeholder group findings from action cycle 1. Finally, an overview of the planning preparations for the third action cycle is outlined before summarising the chapter and introducing the third and final action cycle.

5.2 Starting Point

The reconnaissance phase focused the researcher to explore the broad field of STEM intervention programmes for the FE sector. Literature on studies were identified that focused specifically on links between STEM education and sector demands, including any that raised awareness of STEM careers, addressing the technical skill development and employability requirements related to career opportunities offered by science and other STEM related sectors. A further focus sought vocational and technical education studies or where curricula was developed where critical thinking, creativity and innovation and problem solving are outcomes of learning.

A plethora of research studies report of the empirical evidence of STEM curricula and interventions as transformative learning theory (Taylor, 2016). STEM curricula is used to prepare students with higher-order capabilities and habits of mind to deal positively and productively with complex problems and global challenges they may face in society (ibid). So, et al., (2018) suggests STEM increases engagement and understanding whilst developing students to become the science and technology leaders in an experiential learning environment. There have been many attempts and approaches to increase student interest in STEM through educational intervention programmes, Thibaut et al (2014). in their systematic review of STEM education, they make reference to the integrated STEM intervention as an emerging approach with potential to improve students' interest and motivation in STEM. The literature illustrates a spectrum of STEM curricula that vary based on diverse ways of integrating the STEM disciplines. An integrated STEM intervention refers to what Moore et al. (2014, p. 38) describes as "an effort to combine some or all of the four disciplines of science, technology, engineering, and mathematics into one class, unit, or lesson that is based on connections between the subjects and real-world problems." The lowest level of integration that involves combining two or more S-T-E-M disciplines is called multi-disciplinary, where a topic is explained from the perspectives of two multiple disciplines (Dugger and Fellow, 2011). The next level is termed interdisciplinary, where there is an overlap of concepts using different disciplines with a focus on problem solving (ibid). The highest level of integration is termed transdisciplinary where there is a blur between the discipline boundaries and where problems are viewed and integrated below a main subject. (ibid). Thibaut et al., (2018) in their review of STEM interventions developed a framework of five key principles: integration of STEM content, problem-centered learning, inquiry-based learning, design-based learning and cooperative learning. The proposed framework has several benefits, including its applicability in the classroom and the possibility to describe integrated STEM on multiple dimensions. In curricula development, Beane (1991) criticized the use of multidisciplinary and interdisciplinary approaches, emphasizing the importance of transforming students' learning and the advocacy for the transdisciplinary integrated STEM approach. This is further supported in recent literature, according to ElSayary, (2020) that states STEM education can transform students' perspectives, change their habits of mind, support diverse interests when appropriate pedagogies are intertwined with appropriate content and use of technologies. The integration of STEM disciplines enables learners to make better and more connections between the disciplines (Guyotte, et al., 2014).

As a result, the researcher considered the development of a transformative and integrated STEM intervention, which according to (Furner and Kumar, 2007), provides 'more relevant, less fragmented, and more stimulating experiences for learners.' The proposal would develop an integrated STEM intervention as an additionality programme for students who would already be studying STEM related qualifications in FE. The hybrid model aims to prepare participants with higher order skills and development to positively deal with the complex problems of society that they are likely to face in the future (Taylor, 2016).The reasoning behind this approach to building on the gaps in existing provision rather than creating a competing programme is further supported by (Pearson, 2017), suggesting that 'integrated STEM should support the individual disciplines by connecting ideas across them and should not inadvertently undermine students learning in these subjects.

So et al. (2018) emphasised the importance of using experiential learning as a process to design activities and guide students learning in STEM curricula development. Experiential learning is a theory of education that builds on social and cognitive constructivism theories of learning. Kolb (1984) stated that true knowledge is created through learners' experiences; whilst Dewey (1933) states the importance of enriching experiences to change learners' ways of how to be and how to view in a transformative world, but that this transformative understanding can only be acquired where learners learn by reflecting on their own experiences (Dewey, 1938). The experiential learning theory developed by Kolb (1984) provides a structure to designing learning programmes that focus on more hands-on and interactive experiences. The learning philosophy requires participants to engage in direct experiences and focused reflection to construct knowledge (Li et al., 2019). The various applications of experiential learning include different learning forms by doing, such as project-based learning, problem solving learning and inquiry-based learning (ibid). Participants experience learning in cycles according to Kolb (1984) through the four steps of DO, OBSERVE, THINK and PLAN. According to ElSayary et al., (2015) STEM curriculum tends to be an innovative curriculum that requires learning by doing.

To assess progress, participants need to have as many learning check points throughout the learning programme where they receive feedback and reflect on their learning experiences. According to Kolb's (1984) experiential learning model, reflection is the essential process that transforms experiences gained from the experiential activities and course materials, building new understanding based on previous knowledge into understanding and genuine learning. In order to transform students' learning, three key elements need to be considered: the design of the integrated curriculum, the curated learning experiences within each experiential learning cycle and feedback and reflection on all aspects of learning (Li et al., 2019). Greenhill et al., (2018) states in previous studies that the use of experiential learning with an integrated STEM curriculum leads to transforming students' habits of mind.

The first action research cycle focused on identifying the perspectives of employers from the health and life science sectors. The data identified a set of three key themes that provide a foundation to the intervention design:

- Theme one identified a strong need for a collaborative intervention design supported by FE and industry in order to ensure currency and relevance.
- The researcher continually reflected on her observations at the UTCs. A recurring thought resonated from the initial visit to the UTC Liverpool, focused on utilising the existing life science ecosystem to build and design the support to a programme for young people in the community using the surrounding life science industry, its resources and expertise. Theme two, therefore, identified that employers from the life sciences were likely to support the initiative and share expertise and resources. This support could help shape the learning opportunities and aid the programme delivery.
- Theme three identified a set of key features or learning opportunities that could utilise and apply the theoretical perspective of Kolb (1984) and his Experiential Learning theory. These features would aim to fulfil the knowledge and skills development of individuals through specific learning experiences that were identified as lacking in existing learning

provision. The approach would aim to promote pedagogy to support talent development in response to industry needs. These features would include work placements and internships, company visits, masterclasses, mentoring, and industry challenges or authentic, real-life problem-solving projects. Critical reflection would form an integral component to experiential learning connecting the learning from the experience. This critical reflection process would be developed and instilled in participants throughout the course of the programme delivery. A reflective practice process will be developed to aid participants to practice this skill as part of the programme.

The combination of data collected from the reconnaissance and the action cycle provided the researcher with a deeper understanding (Yin, 2014) to inform the foundations for an intervention model and the next phase of action which documents the study's journey and unfolding story.

5.3 Overview of Action Cycle 2

The second action research cycle is concerned with two key areas of researcher activity. Firstly, utilising the knowledge gained from the first action cycle into the design and creation of the Talent Bank model and secondly seeking the perspectives of the model with educators. The planning phase provides an overview of actions that culminates in the model, centred on learner experiences curated to develop talent that is aligned to industry requirements. Figure 25 illustrates the steps involved in the second action cycle against a timeline between April 2015 and end of July 2016.

Action cycle 2 planning also incorporates the planned approach of a focus group to collect the viewpoints of the educator stakeholders. The action plan template used in action cycle 1 provides the same framework identifying the stakeholder group involved, the data collection instruments, and the processes used to identify answers to a set of questions. The cycle concludes with the reflection stage, utilising the feedback and knowledge gained from the educator focus group and its implications for the implementation phase.

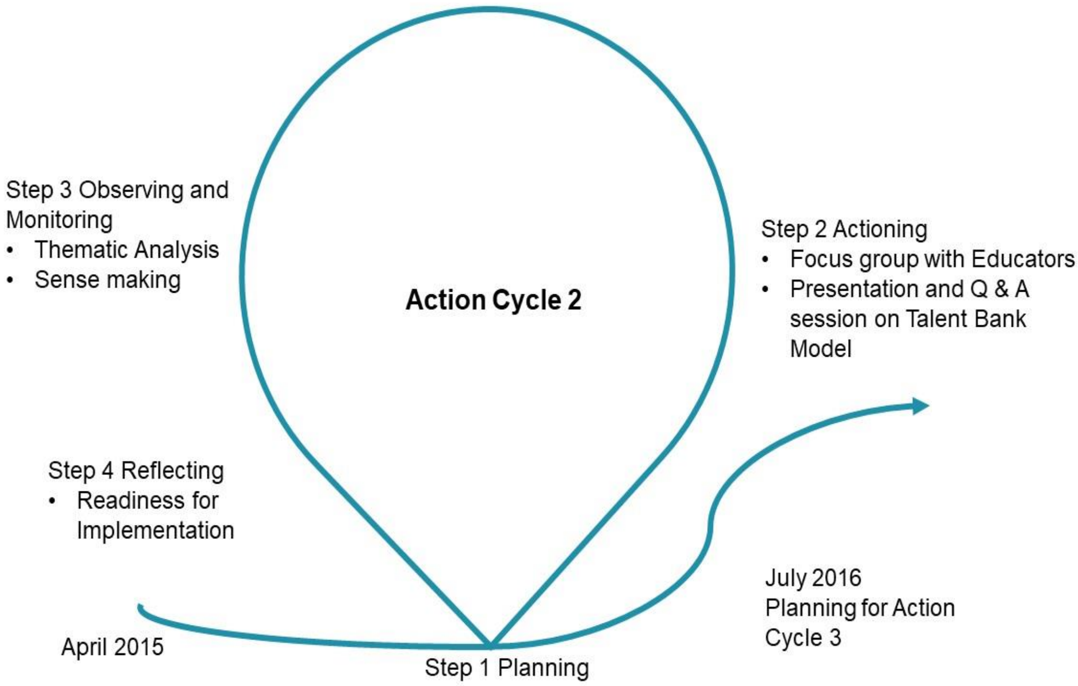

Figure 25: Action Cycle 2 (Two threads – design and focus group

5.4 **Step 1 – Planning**

A review of the existing procedure to curricula development within the FE institution identified several key areas that could be changed or enhanced to develop better outcomes and alignment with stakeholder and industry needs.

5.4.1 **Designing the Intervention**

An intervention can be defined as a new programme, course, curriculum, pedagogical technique, or the action taken to improve or reform an older system or practice (Berdanier et al., 2015). In the context of education, this may refer to a totally new programme, or one that is specifically created to update, or fill a gap in learning to address any identified deficits or targets of academic need. Intervention research is distinguished by its emphasis on the design and development of the intervention to inform practice. This process is both creative and evaluative as it requires blending existing research and theory with other knowledge. This may include details of the setting, existing practices, knowledge of areas that need change and creating intervention principles and action strategies that can blend to formulate specific outputs. Interventions are implemented change strategies purposely aimed at disrupting existing practices.

The transdisciplinary and integrated STEM curricula model and experiential learning theories are used to underpin the development of the Talent Bank intervention. The curriculum development process is based on a blend of two models; the widely used ADDIE framework created by the Center for Educational Technology at Florida State University (1975) and an updated iteration, the Community Intervention Design Framework from University of Kansas (2014).

5.4.2 The Talent Bank Model

In recognising that talent is the engine of economic growth and can propel the drive towards a knowledge-based society (Billet, 2012)., the researcher considered the requirements of a programme to create an additional education choice in post compulsory education. The intervention would provide future talent equipped with skillsets for the 21st century to develop the next generation of scientists, technologists, engineers, medical and health care practitioners, and entrepreneurs who together will help to solve the global, regional, and societal challenges that lie ahead. The outputs of the Talent Bank programme intentionally could serve local health boards and businesses with highly qualified and specialised workers to help plug the technical skills gaps currently evidenced in the region. The philosophy to support the achievement of this vision means ensuring learners are at the heart of all decision making and that this guides the stakeholder model in a dynamic approach to collaborative design, co-location, and co-delivery (www.nesta.org.uk/report/by-us-for-us-the-power-of-co-design-and-co-delivery,2013).

The Talent Bank name is derived from the desire to create a talent pool for the south-west region, particularly from the skill supply pipeline from schools and colleges. With associated links from similar names such as ‘blood bank’ and ‘nursing bank’ the term Talent Bank seemed a suitable title for the intervention model. A logo was developed and attributed to the developing presentations and literature as the intervention model evolved and interest and publicity around the programme began to rise. A tagline of ‘distinctly different’ was also created to accompany the Talent Bank model. The intended purpose is to raise awareness of the value the programme can provide, for those young people wishing to enhance their prospects and to stand out in the field of competition. The programme offers a unique opportunity in the region for those interested in STEM to be inspired, gain valuable experience and achieve success beyond the norm of their current college experience. The programme combines existing qualifications with skills and learning experiences designed and curated to enhance student individual profiles. The intention is to support the development of high calibre talent, highly valued in the global, regional and evolving knowledge economy.

The model is purposively co-created with the employer sponsors and partners from across the life science eco-system with the added intention that educationalists and learner participants stakeholders can also share in shaping the features and content of the intervention. The steering board of representatives help guide the project through its development and checks progress against the plan. The programme would continue to evolve and change from the reflection and review steps during and after each programme is delivered. This aims to ensure the programme is dynamic and continually seeks improvement based upon the needs of the learner participants and the operating environment of the industry itself. The researcher considers this practice to provide a continuous strive to close any gap between what is delivered with what is demanded in a progressive sector.

The intervention is designed as an innovative evidence-based programme of contemporary STEM education targeted at young people, set in the context of a priority or emerging sector in life sciences, medicine or health. The essential elements embedded into the design of the Talent Bank programme include:

1. Co-located learning context
2. Progressive pedagogy
3. Access to ultramodern facilities

4. Engaging Areas of interest
5. A focus on practical skills development
6. Digitally native learners
7. Insight into potential careers
8. A professional identity for participant

The Talent Bank model is illustrated in Figure:26. The programme is created with a framework of learning experiences set within the context of the university and what the life science sector has to offer. The essential elements embedded into its design aims to reflect as many of the features identified by employers in action cycle one as well as responding to the recommendations from the Life Science Skills for Life report. These features are drawn from the themes identified in Table 13 in section 4.6.3 and will be tested with participants as part of the pilot programme. The themes highlight specific learning experiences or features, multiple skill sets employers seek in talent and a range of approaches for the delivery of the intervention. Whilst these features can be considered ambitious, particularly for an action research study, the researcher made a conscious effort to explore and test a blend of as many of the ideas identified by employers in the design of the intervention. Furthermore, the literature referred to many studies exploring gaps relating to single experiential intervention features (Smith, 2016 and Hawtrey, 2007), such as work experience, industry challenges (Koponen et al., 2012 and Lee et al., 1994), industry visits (Carbone et al., 2020), internships or mentoring (Crisp, 2018), particularly in the context of higher education. However, the literature also identified gaps appertaining to studies related too multiple experiential learning features. At this point, the researcher considered designing an intervention that could incorporate as many of the experiential features put forward by employers. The programme is also purposefully designed to be dynamic in nature and not prescribed upfront to provide the greatest alignment with the sector and to accommodate individual learner needs and the flexibility required to gain industry support.

The model identifies a range of the sectors in **Row A** as new and emerging areas where this model could be applied. However, it should be stressed that the model has only been designed for the needs of the life sciences and that this would require engagements with stakeholders within each relevant sector.

Row B highlights the main stakeholders with an identified personal stake in the study. Employers, Students and Academia are stakeholder groups where perspectives are sought as part of the study.

Row C highlights the three main pathways learners can select to reach their career destination. For this study only General academic and vocation STEM qualifications are considered. This is because of set criteria outlined by the host institution and to confine the study to a set group of participants.

Row D – identifies the key sectors of Science, Technology, Engineering and Math which affects most aspects of the life science sector and interests of targeted learners.

Row E – Requirements/ capabilities from talent: A set of skills and competencies identified by employers looked for in new recruits. These skills were identified and included in the framework as five skills strands that are developed through the various learning experiences and include:

- Scientific Curiosity and Research skills – these skills set considers the need for young talent to understand the value of research in pushing the barriers of knowledge. Skills in conducting, applying and understanding the findings of research are beneficial for many organisations and for those progressing to university.
- Problem solving, creativity, enterprise, and innovation – these are universal skills included in the 21st century suite of skills. Employers suggest many graduates do not have strong problem-solving capabilities and the life science sector focuses on being at the vanguard of change and solving some of society's most important challenges.
- Digital literacies and skills in Emerging Technologies – the sector is changing by the dynamic influence of technology. Awareness and an interest in the digital landscape and associated skills are areas of prime need.
- Leadership and Self-management – as a substantial proportion of the current workforce is planning to retire, a replacement workforce is

needed that can assume early leadership responsibilities. Self-management skills and initiative as opposed to supervised management is required.

- Communication – English literacy, presentation skills, selling, etc. are generic and transferable skills for most sectors.

In addition, a set of delivery features **(Row F)** were identified as vehicles for delivering awareness, knowledge, skills and learning from experiences. These five original features are:

- Masterclasses
- Industry challenges
- Work experience/ internships/ voluntary work
- Workplace visits
- Mentoring
- Health and Wellbeing (added to model in 2017)
- Bespoke Career Plan (added to model in 2017)

A presentation document of the Talent Bank model was created as a useful aid to the researcher to support the recruitment of support from the regional ecosystem (Appendix U). A plan of action was devised to contact employers and academics that were working in the life sciences that would be prepared to collaborate (Appendix K) and offer support of the learning opportunities as identified in the features table. Promotional materials were also developed to help show the intended professionalism of the Talent Bank programme and to assist in the recruitment of employers.

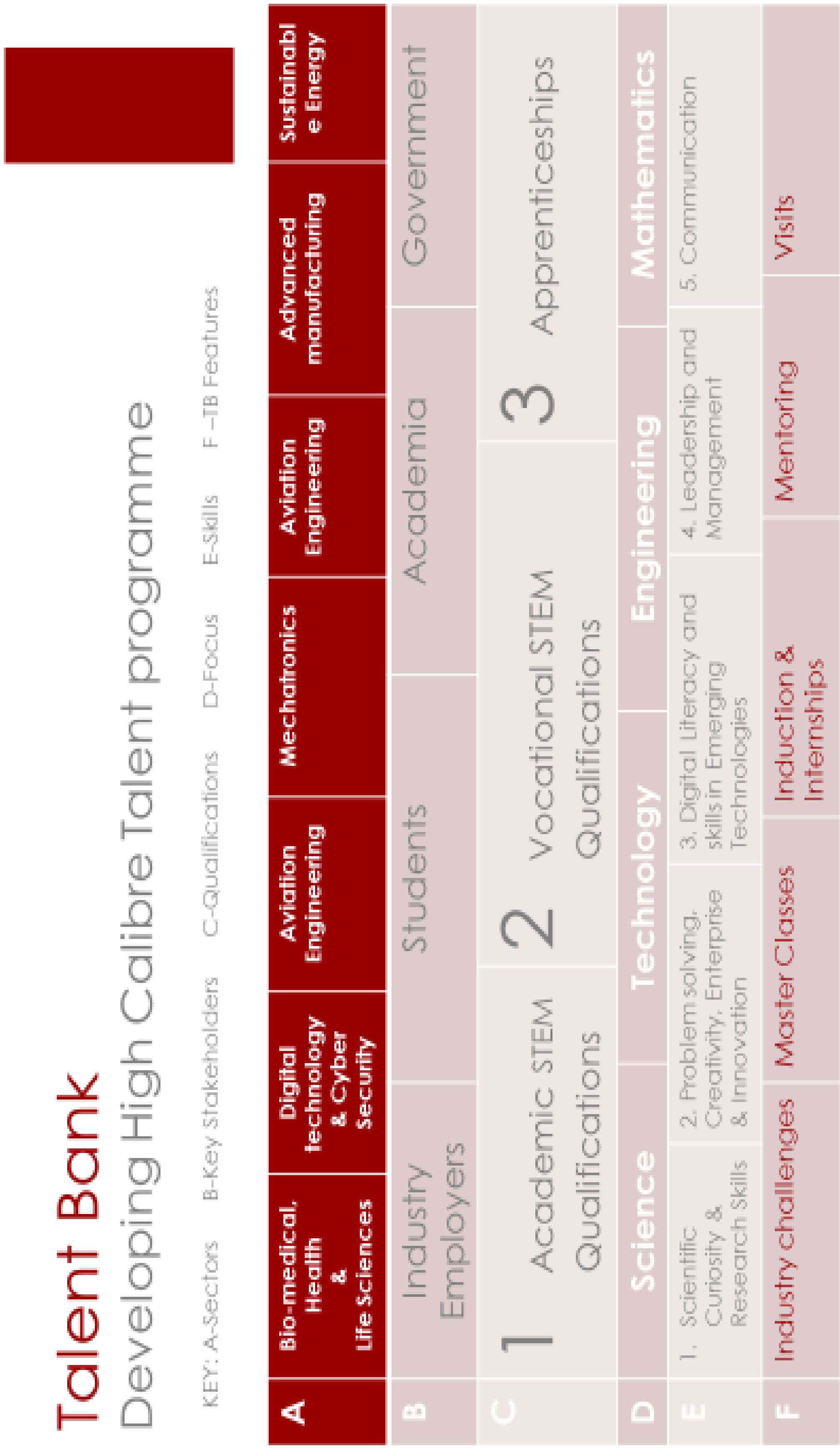

Figure 26: The Talent Bank Model

5.4.3 **Partnering with Employers.**

Employers' relationships are forged and built over time. Initially employer interviews are hosted to support the identification of sector needs in terms of future talent. Many of the individuals involved in the initial action cycle one interviews have progressed to providing ongoing support to the programme. This has taken many forms from sponsoring equipment and providing accommodation, to presentations master classes, to hosting of company visits and supplying access to equipment, workshops etc, to taking part in interview panels etc. Each employer support is valued and welcomed whether this is monetary support or time. The employers are often based in the locality within the existing eco system and range from large multi-national organisations with bases in Wales to local one person SMEs. Relationships built with employers took considerable time to establish and built over the duration of the research.

The first employers involved included the following:

- Abertawe Bro Morgannwg University Health Board

  (now known as Swansea Bay University Health Board)
- Swansea University – Medical School
- Institute of Life Sciences
- Life Sciences Hub, Cardiff Bay
- Fujitsu
- The Mullany Fund
- Glaxo SmithKline
- Cellnovo
- GE Healthcare

5.4.4 **Action Cycle 2 Plan**

The action plan template used in Action Research cycle 1 provides a similar structure to focus on the key areas of work, the questions to be answered and the corresponding timeline available (Figure 14).

Phase of Research	Cycle 2 - April 2015 - August 2016
Stakeholder Groups	Educators from schools, FE college and university sectors
Background Activity and Key Areas of Questioning	To design an integrated STEM intervention programme (Talent Bank) with delivery protocols. To host a focus group with educator stakeholders to identify their perspectives of the following: What are your views of the proposed Talent Bank vision? What are the perspectives on the learner experiences being a focal point of the programme? What are your views on the delivery methods selected and utilising the region's life science ecosystem to support the STEM intervention programme? What barriers or challenges do you envisage in implementing the intervention with a pilot cohort?
Data Collection Methods	Focus group
Required Outputs	Perspectives of educators on the Intervention Model in relation to: The Talent Bank aims and objectives to address regional talent problem. An Intervention model with key design features Delivery methods and protocol Barriers/issues relating to implementation phase.

Table 14: The Planning Card for Action Research Cycle 2

5.5 **Step 2- Actioning**

The step 2 – actioning of the cycle focused on collecting the perspectives on the proposed programme and its implementation from educators prior to testing the programme with participants in the final action research cycle. The focus group with a range of educator stakeholders was arranged in April

2016 and held in the Hub, a communal meeting room within the Institute of Life Science 2 building at Swansea University. The focus group was designed to gather perspectives from educators from secondary schools, further education and higher education on the Talent Bank programme ethos, its design, delivery plan and considerations for implementation. A set of questions was drafted to explore these areas with opportunity for educators to ask specific questions. The focus group arrangements were shared by the FE institution via the principal's office and promoted by the Regional Learning Partnership inviting interested parties and partners to attend the lunchtime event.

5.5.1 Participants

Fifteen educators were in attendance representing the university, college, school and private training sectors.

- 9 Further Education lecturers
- 3 secondary school Teachers (1 Sixth form teacher)
- 2 University lecturers
- 1 private company training officer (links with schools and colleges)

Of the participants in the sample, 80% (n= 12) were female and 20% (n=3) were male. The participants were specialised in a range of disciplines including Biology, Chemistry, Physics, Math, General Sciences, Research Methods, Technology and Careers Education.

The researcher introduced the purpose of the focus group as part of a larger research study and indicated that practitioners' perceptions, comments and views would be recorded anonymously. A presentation summarised the Talent Bank concept supported by aspects viewed at the various UTCs visited and the key elements that were considered exciting and transferable to the local context were shared. The educators were made aware of the context of the programme as a transdisciplinary STEM intervention that supports the traditional delivery of individual STEM disciplines. The group was informed that the model proposed was to address gaps in learning opportunities not readily available in the existing learning provision including work placements, masterclass series, project challenges and company visits. It highlighted that the FEI sector traditionally did not have links with the life sciences sector and that the research would aid in developing and nurturing positive relationships to strengthen a more collaborative approach in support of better alignment of provision to meet industry needs.

5.5.2 **Data Collection Instruments**

Following the presentation, a set of questions relating to the programme design and its intended delivery were asked. Responses from the educators were recorded by a scribe onto flip chart paper. The core questions were:

- What are your views of the proposed Talent Bank model and its design?
- What are the perspectives on the learner experiences being a focal point of the programme?
- What are your views on the delivery methods selected utilising the region's life science ecosystem to support the STEM intervention programme?
- What barriers or challenges do you envision in implementing the intervention with a pilot cohort?

A "Q and A' session at the end of the focus group session identified several queries raised by the educators. These questions were also recorded onto the flip charts with responses as applicable. Some questions sought definitive answers about student numbers, teaching hours, training etc. The researcher was not able to respond to these questions as they were at that point not confirmed but informed the group that these would be noted, and answers would be provided in the future as the institution made certain decisions.

5.6 **Step 3- Observing**

Step 3 of the action cycle involves analysing and making sense of the data collected. The primary form of data collected through the focus group instrument with educators was qualitative in nature. The questions involved collecting views, opinions and perspectives on the programme, its design and intended implementation for the researcher to better understand alternative perspectives from educators. The responses from the focus group recorded on flip charts were later transcribed into an excel spreadsheet. Several questions were raised by employers seeking clarification on more detailed aspects of the model which were also recorded. The scribe tried to identify each of the educator responses by the individual's sector to try to distinguish any differences in sector views, however, this became too overwhelming. The responses that were able to be identified by sector are shown in brackets. The data was then analysed and collated using Braun and Clarke's (2006) thematic analysis steps, groupings responses into categories of any common emerging themes.

5.6.1 **Findings**

The researcher identified two main categories:

- Interest and strengths of the Talent Bank model and its vision
- Negatives/Weaknesses/Considerations and Challenges

The transcribed comments captured from the flip charts in response to the questions are categorised below with the questions raised by educators highlighted in bold:

Interest/Strengths

- I think lots of students would be interested especially if they want to get into medicine'(FE)
- Definitely something students would engage with (FE)
- I think it's really exciting.
- **How can our students get involved?**
- **who would the partners be? (University)**
- I think schools would think it's a good idea and be interested (School)
- my school would be interested (School)
- this would be amazing for our students (FE)
- I have students who would like to visit different organisations and learn about job opportunities (FE)
- this is like the Seren programme for talented and gifted students
- students would be better prepared for university
- **where would it be located (School)**
- **who would organise the programme? (University)**
- **who would the programme belong to? (FE)**
- **how will it be promoted and how would students be selected? (University)**
- **where would it be delivered? (FE)**
- I think the skills challenges or projects could be beneficial.
- work experience is so important but really difficult to arrange (FE)
- masterclasses and mentoring would be great.
- good to have employer support (FE)
- Access to state-of-the-art resources
- **How can we get involved? (FE)**
- Located at the university….they can see first have what university life is like (FE)
- Rich learning opportunities (FE)
- Welcome skill opportunities - access to the resources would be nice (FE)

Negatives/Weaknesses/Considerations and Challenges

- the problem is the lack of funding.
- I don't think it's FE's role to prepare students for the world of work (FE)
- Duplicates the work we do as teachers.
- it will attract talented students and impact our numbers of A levels – and we will lose hours
- employers don't offer work experience opportunities for our students (School)
- we would like to work with industry but we need time (FE)
- our students wouldn't be interested
- they are too busy with their A-levels and they have exams to focus on (FE)
- some students will find the travel too much
- A level student don't need this they can find their own placements (FE)
- There's not enough time in the timetable to do this (FE)
- **what about our hours? (FE)**
- they need to focus on their A levels at the moment (FE)
- **who would deliver the curriculum? (FE)**
- its competition for our 6th form (School)
- we don't have time to work with industry
- Conflict with timetables – **how will this be managed? (**FE)
- **what are the costs involved?**

A developing phase occurs following the data collection and analysis in which interpretation of the data guides thinking and future actions (Mertler, 2004). The thematic analysis of the educators' responses gave rise to the researcher considering the following aspects in the programmes' development and implementation:

- The focus group explored and explained the perspectives of educators on the Talent Bank model. It showed that some educators think differently on aspects of the intervention and have some contentious perceptions compared to the employer stakeholders. This is an important finding as (Yiu and Law, 2012) pointed out in their review that for the most successful and effective models of experiential learning, cooperation of employers, educators and students is required. The researcher considered what if any, of the barriers and threats could be mitigated and if not, how could they impact the implementation of the programme?

- The question of whether teachers involved needed to have prior STEM expertise. Studies suggest that teachers are often requested to support STEM intervention initiatives without experience of teaching the subjects. In these instances, teachers become facilitators of the learning process rather than deliverers, but this also raises the issue of professional development to support the teachers involved (Diefes-Dux, 2014).
- The importance of scheduling the programme to coincide with existing timetabling and the need to complete the programme before external exams.
- The view that students already have too much to do without the burden of an additionality programme – therefore it needs to be optional and may have a limit to the number of subjects undertaken.
- Need to ensure assessment is manageable as students already have a heavy workload and exam commitments.
- Will create a lot more work for teachers - monitoring, UCAS (technical) forward thinking! Need to consider how statements would be gained for each student.
- Logistics issues for some students who travel from west.
- Programme not likely to result in employment in the sector as most students targeted will likely progress to university.

The results show the importance of listening to stakeholders on the issues raised as their insight not only deepens the researcher's understanding of the issue but also of their thought processes and the lenses they use to interpret. If the researcher had hosted a mixed stakeholder focus group, it may have been difficult to make sense and understand any underlying issues. As a consequence of hosting a separate focus group with educators, the researcher began to understand some of the concerns raised by the educator community. The questions raised demonstrated a need for further information amongst the stakeholder group and may have contributed to some of the negative feedback as the information was not readily available to share. If these concerns or issues were overlooked there is a likelihood that the programme would be affected either by negative publicity or word of mouth from lecturers with their students which may impact on the ability to recruit students to the pilot.

The results also highlight the number of questions raised by the educators seeking clarity on the minutia detail. The researcher acknowledges the difficulty in judging when to disclose and share information on the practicalities of the intervention particularly when final decisions have not been made. From the educator's perspective this may be viewed as the researcher having a hidden agenda or a defensive mechanism that could affect any trust in the researcher or the project. An alternative view could be that by asking questions on the project that there was genuine interest to find out more information. Finally, some of the barriers and challenges identified by the group were not surprising. Some had been considered by the researcher, however several, particularly around the pre-implementation phase, gave the researcher impetus to further consider the issues against potential implications to the success of the project such as an implementation checklist and a Frequently Asked Question information sheet.

5.7 Step 4- Reflecting

Following the focus group, the researcher met with the principal of the institution to discuss the findings and responses of the focus group. The concerns raised by the teachers specifically from the FE institution centred around concerns relating to change and impact on workload and job role. The principal would assure staff that the programme was in response to community need and posed no threat to existing provision. The findings identified a few questions that needed confirmation from the principal from suggestions put forward by the researcher, such as the confirmed location, the cohort sizes, the timings etc. Despite the clear concerns from FE lecturers regarding the proposed programme and its potential impact on single STEM subjects, the principal agreed to go ahead with the plan to test the model with a group of participants in action cycle 3. A few key points were agreed to move the study forward into the implementation phase with participant students.

Several changes and refinements were discussed about eligibility and promotion of the learning opportunities with students. The importance of continuous update and communication of the project was noted. The researcher would supply regular updates to the principal's office for inclusion in online newsletters. The prospectus had advertised the programme for students with an interest in STEM related subjects. A limiting factor was introduced to allow only students studying a maximum of 3 A levels or a STEM related vocational programme could be considered following the feedback from the educator's focus group on work balance and burden of assessments. Letters would be distributed by the principals' office targeting students within this criterion to apply for a maximum of twelve places on the pilot programme. Teachers who expressed an interest in supporting the intervention pilot would be interviewed by the researcher for a secondment opportunity to support the programme one day a week. It was further decided to devise a checklist of pre-implementation considerations which would be discussed in preparation for the implementation alongside a budget.

5.8 Endpoint

The second action research cycle concludes with the understanding that the educator stakeholder group held mixed views on the Talent Bank model. Whilst some educators were positive about the possibilities the Talent Bank could offer and agreed with the employer stakeholders, others were observed as protectionist of their own STEM programmes and viewed it as a threat. Figure 27 highlights the key areas of consensus and differences in perspectives between the two stakeholder groups. The key areas of concerns focused on the potential impact the intervention could have on existing programmes. The researcher noted and acknowledged these concerns and on reflection understood their perspectives. It would be important for the host institution to consider these teachers' views, providing assurances as they had potential to be obstructive if they were not engaged with the programme and understood its vision. The researcher needed to consider how this could impact the implementation and recruitment for the pilot and where her energy would be needed to mitigate any potential arising from the negative influences. A range of other considerations or barriers were identified by the educators. Some were anticipated by the researcher, but some valuable views were shared that assisted the researcher to consider other risks to the implementation process

A Frequently Asked Questions (FAQs) sheet (Appendix I) and a checklist of implementation actions and considerations stemmed from the focus group to enable the change process (Appendix J)

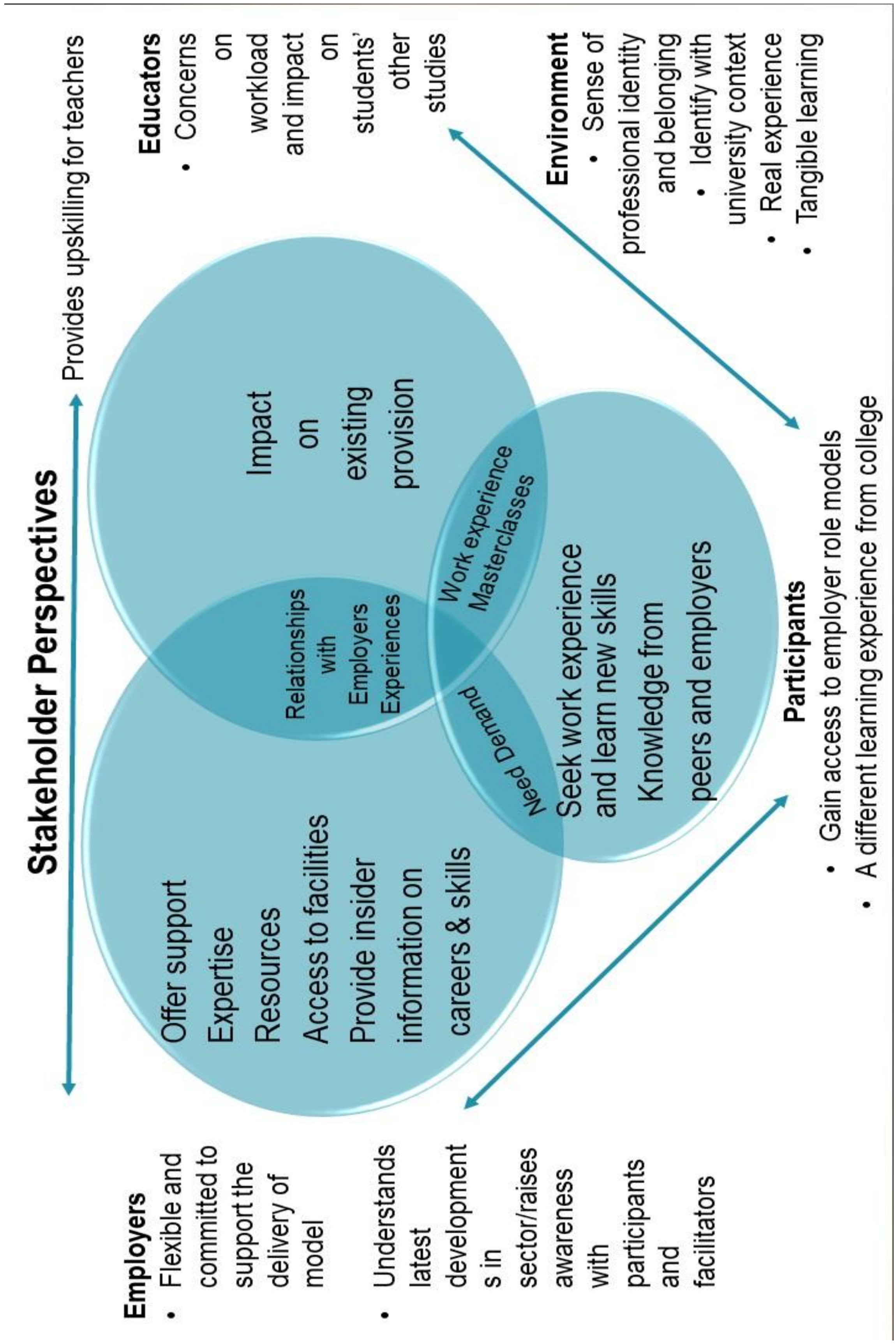

Figure 27: Differences in Stakeholder Perceptions

5.8.1 **Action Plan and Checklist for Implementation**

A pre-implementation checklist to support the process of piloting the Talent Bank was devised in response to the findings from the educators focus group and presented to the institutional leadership along-side an estimate of the costs of the required resources. A meeting was convened with the principal to agree the various elements and a small budget was approved to support the pilot testing phase. However, in the event that the programme be mainstreamed, further work including a detailed costing plan would be needed to calculate and assess its economic viability.

Recruitment and staffing were identified as key processes that needed to be led by the host institution. The Talent Bank concept was presented in the college prospectus as a new curricula intervention to be piloted in September 2016 with a small cohort of students. The recruitment process was designed and approved by the college student services team. Success of a change in practice or process according to Fullan (2019) is highly dependent upon whether the change can become sustainable within the curriculum planning process. For this reason, regular meetings on updating progress on the action research and the pilot were conducted in conjunction with the principal of the FEI, curriculum team leader and student services manager. Updates were also provided on a monthly basis to various regional committees with an interest in the project and its progress.

The value of piloting of the intervention from ‘outside’ enables the change plans to be realised without being suppressed by the existing bureaucracy of the existing practices of the host organisation

Kemmis and McTaggart, (2008) suggest this leads to collaborative actions creating change that are justified by the forces of better arguments rather than justified by authority. This said, it is important that the leaders value practice-based knowledge in such situations of change (Fullan, 2011). This process helped to identify early issues surrounding competition of the intervention programme with existing provision and where teaching staff were opposed to the introduction of changes and the potential impact it could have on themselves as well as their students. In response to these early issues the researcher was requested to present the Talent Bank concept to the whole Science and Math department and to provide clarifications to issues raised and to ensure the lecturers understood the model and its intended implementation process. The scheduling and duration of the programme was influenced by these discussions which led to the agreement of a day release on Wednesdays, as this is considered the enrichment day and for a duration of 26 weeks so that it did not impact on A level students starting their revision in April.

5.8.2 **Delivery Protocols**

The intervention programme will be structured according to a day release model that supports learner participants undertaking the learning experience alongside their existing qualifications. The programme will be offsite and held between 9am and 4pm for a 26-week period. This will allow easier timetabling for the host organisation and clear logistical challenges for travelling to the off-site location for participants. The programme will look to utilise the expertise and resources within the life science ecosystem and university departments and require minimal additional financial resource. However, a budget will be made available for the pilot of the designed intervention in the first instance.

The intervention focuses on creating learning from experiences and the development of skills identified and prioritized by industry. There are no plans to accredit the programme.

The delivery site will be at both the University campuses where suitable accommodation has been arranged. In addition, several sessions will take place at industry places of work.

Teaching staff and support has been agreed with the host FEI, the University and the work has been developed in collaboration with the middle management of the host organisation. A team of four lecturing and one administration staff have also been financially supported by the host together with a small budget for resources.

Qualifications were not the priority of the programme design however two key qualifications were identified that would add value to the learner prospects and their individual profiles. These are the Extended project Qualification which supports the development of an individual's research skills and their ability to communicate their findings. This is validated by OCR – a recognized awarding body and the qualifications is valued by University's and awarded UCAS points. The second certificate recognises the development of research methods skills created by the University to develop the research understanding and application of skills in the conduct of research. This would culminate in a research paper and the award of the certificate at the end of the programme.

5.8.3 Intervention Programme Aims and objectives:

The pilot programme aims to combine and complement existing STEM disciplines taken in the traditional FE context by participants to create a holistic, hybrid integrated STEM learning experience.

Objectives: at the end of the programme participants should be able to:

1. Explain what the life science sector is about and how it relates to medicine and health through a range of learning experiences.
2. Identify a range of occupations or careers within the life science sector from a range of employer supported activities and be aware of the opportunities proposed within the region Identify and explain the STEM talent needs of the sector and associated skills strands and expectations of employers when recruiting talent.
3. Apply skills developed as a team member and as an individual in an industry challenge project to investigate a global problem over a set period. The development and practice of reflective review following each learning experience will enable participant
4. Create an individual profile in the form of a UCAS (Universities and Colleges Admissions Service) application or CV (Curriculum Vitae) to illustrate experiences from participation.

5.8.4 Institutional and Ethical Approval

The programme was presented to the FEI Governing Body and offered for pilot testing with a small cohort of students from September 2016- April 2017. Approval was granted by the Principal and Governing Body with a provision that only a small cohort of learners undertaking a specific range of qualifications would be eligible. The Talent Bank Pilot programme would provide information on the value of its design to enhancing the individual profiles of young people with an interest in future careers allied to medicine health or life science. The aim of the intervention is to create an additional skill supply pipeline of regional talent to expand the existing graduate talent pool.

As the learner participants targeted would be between the ages of 16 and 18 years old, ethical approval would be required from the Ethics Committee at the School of Medicine (Appendix E). In line with BERA guidelines (2004) the best interests and rights of the child participant was of primary concern. The proposed methodological tools were considered appropriate and would not show any obvious risk to the physical or psychological wellbeing of the participants involved (Anderson and Morrow 2011. Participants were informed at frequent intervals that they could withdraw from the study without reason at any time during the data collection process.

The teaching team comprised of two qualified teachers – one seconded from the Math department at Gower College who considered the study and new intervention programme to be of value and interest. Applications were invited from teachers at Gower College and the researcher conducted interviews with nine teachers from science and math disciplines. A final candidate was selected to be seconded each Wednesday to support the programme delivery. A seconded teacher was interviewed from Swansea university Post Doctorate scholars programme to join the team. A qualified teacher from a primary perspective but with an interest in how technology could aid learning. An application was made for an updated DBS (Disclosure and Barring Services) which was subsequently granted and allowed the seconded teacher to support the programme delivery. All three members of the practitioner team held the necessary DBS checks and accreditation.

5.9 Conclusion to Chapter

This chapter has focused on the second action research cycle and its focus on the design and development of the Talent Bank model, in response to the identified requirements of an industry focused intervention as identified by employer stakeholders in action cycle 1. It explains the positioning of the STEM intervention programme as ‘additionality’ to sit alongside existing A level and vocational curriculum programmes. The key features and main skills sets are explained together with the delivery protocols. The model was presented to a focus group of educators from across the sector. The main questions centred on the perceptions of the new model and the potential barriers and considerations for implementation. The data was analysed using thematic analysis and identified several themes relating to strengths and areas of weakness and potential barriers from the implementation and delivery challenges. The findings were compared with results from the employer stakeholders and several interesting differences in perspectives were identified. These differences in the main, related to the need for the programme as overwhelmingly positively viewed by employers in the sector, whereas some educators revealed some disagreement with this view and the motivation for the intervention. Additionally, contentions were raised on the value of the programme and the perceived negative impact of change for change-sake. The researcher acknowledges these perspectives and is mindful of their implications. These results will be discussed in more detail in relation to the research aim and objectives as part of the discussion in Chapter 7. The nature of action research involves defining a problem and the redefining that problem through a series of iterative processes as more insights and understandings are gathered. The purpose of the study was to explore and evaluate how a particular intervention programme could address the region’s lack of an indigenous talent pool to support an evolving life sciences sector. As the study was designed as a dynamic and interactive qualitative research, the next action cycle focuses on the testing of the intervention with learner participants. Before the intervention model can be implemented and considered for mainstreaming within the FE institutions’ curriculum portfolio, it must be piloted in terms of ‘fitness for purpose’ and value from delivery, content and outputs. To provide a more in-depth and balanced understanding of stakeholder views, the next and final action cycle in Chapter 6 will focus on the planning and organising of the Talent Bank intervention programme as it is implemented and experienced by a pilot cohort of participants.

Chapter 6

ACTION CYCLE 3

6 ACTION CYCLE 3 – Implementation of Model

6.1 Introduction

This chapter details the main actions involved in implementing the pilot intervention programme with a cohort of students. Action cycle 3 is structured into the four key steps, in keeping with the structure of previous action cycles including an overview of the starting and endpoints. Firstly, the planning of action cycle 3 outlines the intended actions of the implementation phase of the Talent Bank intervention model. Step 2 – outlines the actioning phase which occurs in tandem to Step 3 and the data collection strategy devised to collect perspectives on the intervention model as experienced by student participant stakeholders. The data collection instruments collect a range of data across the timeline of the programme which is categorised using thematic analysis. The reflecting stage looks back at the whole cycle and findings are compared with the other stakeholders in action cycle 1 and 2. The key findings are summarised before introducing the next chapter. Further discussion of these findings will occur in chapter 7 alongside an evaluation of the intervention programme and its processes.

6.2 Starting Point

The reconnaissance phase identified innovative industry-focused education models called UTCs that have been established to address the STEM skills shortages and talent needs of innovative and growing industry sectors. The researcher identified key aspects of the UTC programme that could be relevant to the south-west region of Wales, as part of a solution for Further Education to address the lack of young talent for the life science sector. Semi-structured interviews conducted in Action cycle 1 with representative employer stakeholders generated data on the perspectives of employers and identified key aspects of skills, knowledge and experiences expected from future talent. Employers overwhelmingly suggest a real need for such an intervention and encouraged the researcher to work collaboratively with the life science eco-system within the region to deliver the programme in the implementation phase.

The research utilised the findings with reflective processing to further iterate the Talent Bank intervention programme. Action Cycle 2 sought the perspectives on the Talent Bank intervention model with a focus group of educators. Questions probed the views of educators on the programme design and the proposed learning experiences for prospective students. The responses from the group of 15 educators were mixed on a number of issues. The findings suggest a mixed enthusiasm for the programme and its appropriateness for the targeted students and their needs. Other perspectives gave a sense of reluctance towards any change, particularly, FE lecturers who shared concerns about the intervention and how it may affect their job roles, subject numbers and student outcomes. Many questions were raised on the operating details of the programme that had not been finalised. The learning from the process indicates that the researcher should have anticipated that these types of queries may have arisen. A simple fact sheet of what is known and what decisions are yet to be decided would have helped the communication. Following the focus group, the researcher initiated a communication strategy using a periodic newsletter together with a Frequently Asked Question Sheet (FAQs) (Appendix K) to provide clarity on the programme and its vision. A further outcome gained from the educator focus group was the suggestion of a checklist for implementation (Appendix L). The FEI decided to move forward with the implementation of a pilot programme in September 2016. The third action research cycle focuses on the perspectives of participant stakeholders as their experience the intervention across its timeline.

6.3 Overview of Action Research Cycle 3

Action cycle 3 is concerned with the implementation stage of piloting the intervention with a cohort maximum of twelve students. The study was initially planned to gather data on the perspectives and experiences from one cohort of participant stakeholders during the academic year September 2016 – April 2017. It would evaluate the effectiveness of the intervention on its design of learning experiences to raise awareness and interest of careers in the life sciences from the participant perspective. The action cycle 3 is illustrated in Figure:28. The perspectives of participant stakeholders are gathered over the programme's timeline using a range of data collection instruments. A second cohort is added to the action cycle phase following approval for a follow up cohort in September 2017 - April 2018. For the ease of analysis and representation, the data collection instruments have remained the same and the data merged to present an overview of the participant perspectives. The instruments used include:

- Pre-programme focus groups
- Weekly observations
- Reflective diary accounts
- Photographic evidence
- Artefacts
- Post-programme focus groups.

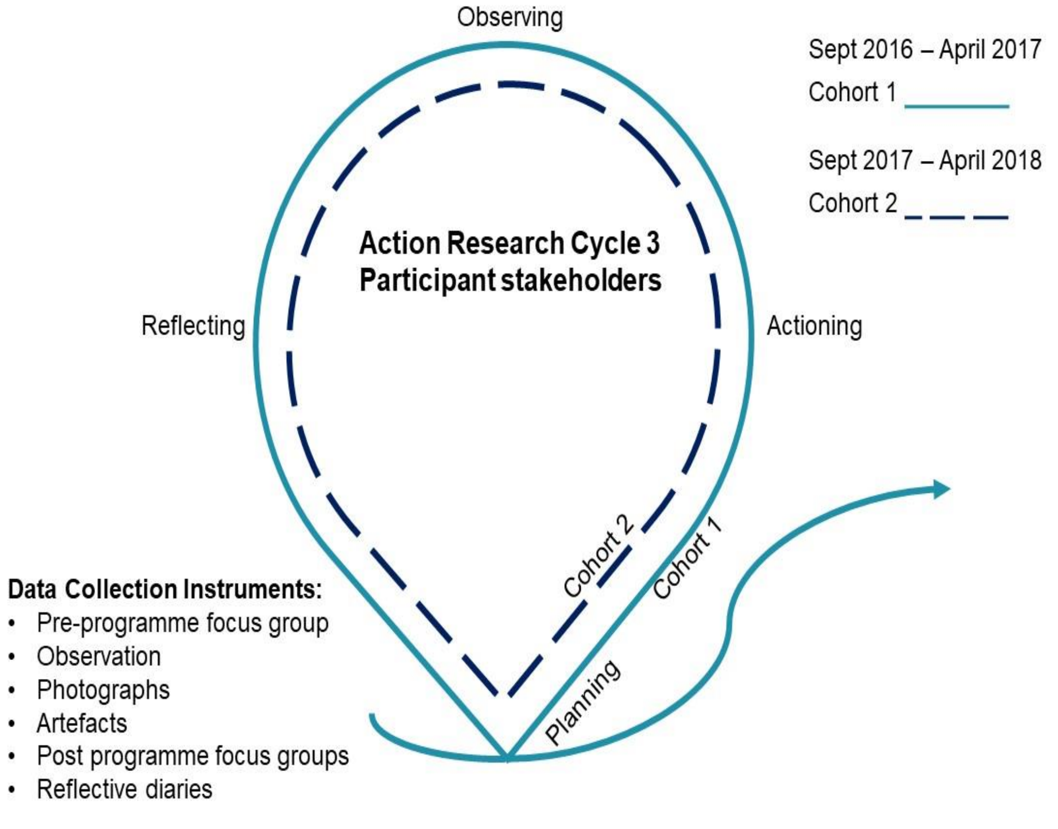

Figure 28: Action cycle 3 – gathering perspectives from two cohorts of participant stakeholders

Supplementary data collected from employers and educators following their involvement on the programme are also summarised at the end of the action cycle, however, whilst this data was not planned as part of the original action cycle it is supportive of the participant perceptions and therefore deemed of value. A summary of the key findings from the three stakeholder groups is illustrated at the end of this final action research cycle illustrating the areas of difference and agreement.

6.4 Step 1 – Planning

The planning phase of action cycle 3 focuses on raising awareness of the Talent Bank programme to support recruitment. A set of materials to promote the Talent Bank pilot programme to attract and recruit a cohort of participants was devised and distributed using the FEI Student Services Department. A poster advert to market the pilot programme (Appendix G) and a FAQ sheet (Appendix I), were designed and published to raise awareness of the FE institution's new pilot STEM additionality programme. The action cycle planning card summarises the key areas of focus in the implementation and data collection with participants in Table:15.

Official permission was sought from the FEI to conduct the pilot alongside the action research study (Appendix D). Approval was granted to proceed from the Institution's Governing Body and principal in a study approval letter (Appendix E). Following the approval to proceed, the appropriate approval was sought from the School of Medicine and Health Ethical Committee to conduct the study as the intended participants would be under the age of 18 years. A checklist of documentation was prepared to support the ethical approval (Appendix E). A pre-implementation checklist was devised in preparation for meetings with the FEI principal on resourcing and support needs (Appendix J). Agreement was reached on the resourcing and the researcher was able to begin the implementation phase of Action Research Cycle 3 in August 2016. Changes to these original processes between cohort 1 to cohort 2 are summarised at the end of this section titled as Alterations.

6.4.1 **Implementation**

A set of key decisions and actions were undertaken to plan the implementation of the Talent Bank programme before any data collection could be initiated. Whilst implementation actions occurred prior to the initiated programme, many considerations came to light throughout the programme delivery period which commenced in September 2016

Phase of Research	Cycle 3 – Implementation Phase Cohort 1- August 2016 Cohort 2- August 2017
Stakeholder Groups	Learner Participants,
Background Activity – key actions	• To market and recruit a cohort of participants studying STEM disciplines to the additionality Talent Bank programme • To identify employer support from the region's ecosystem to support the delivery of the programme • To implement and deliver the programme • To identify perspectives on the following areas: What reasons are attributed to joining the TB? What are the perceptions of participants on the design and implementation of the Talent Bank programme? What learning experiences/features were of most value? What areas could be improved? Would the Talent Bank programme be one that you would be recommended to others?
Data Collection Methods	• Pre-programme focus groups (Participants) • Observations (Educators, Employers, Researcher) • Photographic Images and Artefacts (Researcher & Participants) • Reflective diaries (Participants/Researcher) • Post-programme focus groups (Participants)
Significant Iterations	• Presentation on Talent Bank intervention programme / alterations • Marketing and recruitment materials – poster, prospectus, employer recruitment, FAQs • Video creation – Talent Bank

Table 15: Action Cycle 3 Planning Card – gathering data on perspectives of participants

The areas of focus included:

- Marketing
- Programme design
- Location
- Timetable/scheduling and timeline
- Leadership and management
- Life science ecosystem and employer recruitment
- Programme delivery
- Assessment
- Identity
- Alterations

6.4.2 **Marketing**

In order to attract interest in participating in the Talent Bank intervention programme, it was important to raise awareness of the pilot and its proposed value to prospective participants and their parents. Several meetings were scheduled with representatives from the Marketing and Recruitment team within the Student Services department of the FE institution. With the support of the team, the researcher-practitioner devised a set of marketing materials that would target the particular- type of student the programme was designed to attract. The principal defined the target group participants could be drawn from. The stipulation set out required any applicants to have a GCSE profile of at least grade C grades in Maths, English and Science and to have selected to study a maximum of three Maths, Science A levels in Maths or Science (Biology, Chemistry, Physics, Computer Science) subjects or a vocational science programme. These stipulations were considered to ensure participants would be able to balance their commitments of the Talent Bank programme alongside their existing qualifications.

As the programme was in its pilot phase and linked to research, it was important to offer the opportunity to all grade 13 students who met the criteria i.e. utilising the college database a list of over 130 prospective students were identified. A letter was drafted advertising the opportunity alongside the commitments to the study and distributed in late August 2016 (Appendix C). A3 posters were created and displayed around the common rooms and subject accommodation corridors to raise awareness of the pilot programme and aid recruitment

(Appendix G). Any interest in the programme was directed and managed through the Student Services department. A list of prospective applicants was compiled which the researcher interviewed over a series of 3 weeks. A group presentation to the BTEC National Forensic and Applied Science students about the Talent Bank programme was also delivered in the first week of September 2016.

An information open event was publicised in the local press and held at the Institute of Life Science at Swansea University's Singleton Campus. The introduction outlined the programme in detail to prospective participants and parents and provided a one-and a half hour taster session. The session involved a masterclass on the life journey and work of an Accident and Emergency Doctor, a session from a Psychology Practitioner on memory, displays of typical challenge projects as well as artefacts linked to medicine, health and life science. The event provided an ideal opportunity to present the aims of the programme to the participants' parents and to increase the potential for consistent messages to filter to the home environment and how it would integrate with existing A levels and vocational qualifications. Over 55 parents and their children attended the event, indicating a sizeable level of interest.

Each applicant who expressed interest following the Open Event was interviewed by the Student Services team to assess suitability and details shared with the researcher to arrange follow up interviews. The interviews took place at both campuses of the FE institution to ensure convenience for the students. Each interview lasted approximately 15 – 30 minutes with a focus on assessing initial interest in future careers in the sector and motivations for joining the programme and their suitability against the entry criteria. The final eligibility of each student was checked by the Student Services team and any changes to their enrolment noted. Successful students were subsequently notified by the Student Services team and issued with a set of consent letters. Parental consent and participant consent forms (Appendices H and F) were distributed alongside the information sheet and a Frequently Asked Questions sheet.

6.4.3 **Programme Design**

A final summary of the Talent Bank model is shown on p. So et al., (2018) attributed importance to planning and teaching STEM using an experiential learning environment as a process to design activities and guide students through the transformative learning process. A schedule of activities was not prescribed up front, rather the dynamic programme was planned with two weeks in advance drawing on the support available from the academic and life science ecosystem reflective of the workplace realities. For learning to occur from the experience, effective reflection practice was initiated and promoted to amongst the participants to identify learning, receive feedback that would lead to improvement and enhanced knowledge (Strange and Gibson, 2017).

6.4.4 **Location**

Talent Bank was granted space at Swansea University's School of Management at their Bay Campus and at the Institute of Life Science at the University's Singleton Park Campus. Participants travelled from the west of Swansea to the locations of the programme in the east to both campuses of the University. Some students reported catching buses at 7am in order to arrive for a 9 am start. There were no direct public transport routes to the Bay Campus although connections were available from the central Quadrant bus station. The significance of this is that some participants were prepared to travel up to two hours to attend the programme. The map illustrates a radius of 10 miles highlighting the distances participants were prepared to travel from.

Figure 29: Location map of Swansea and distances travelled by participants:

Location of FE Institution's A level Campus in SA4

Location of FE Institution's Vocation Programmes Campus in SA2

Location of Institute of Life Science at Swansea University in SA2

Location of Talent Bank at Swansea University Bay Campus in SA1

The accommodation used for the programme was a purpose-built suite sponsored by Fujitsu, Intel, Brocade and Kyocera industry partners. The suite provided a professional learning space to host the weekly programme with access to state-of-the-art computer facilities. A series of photographs illustrate some of the facilities at the Talent Bank Hub (Appendix P). Supplementary accommodation was provided at the University's Singleton campus within the Institute of Life Science shared with the School of Medicine. These facilities provided opportunities for the Talent Bank programme to schedule visits to the nearby Singleton Hospital as well as university facilities, such as laboratories.

6.4.5 **Timetable, Scheduling and Timeline**

The student timetable was set between 9am and 4pm each Wednesday on a day-release basis over a 26-week period delivered from September to April. The scheduling of learning activities was not pre-determined aside from the initial weeks but flexibly curated normally with one to two weeks in advance. This approach would test the support that could be gained from employers in the life science ecosystem.

Learner participants were facilitated through five different session formats. Generally, the first hour of the participant's schedule was structured with a practical activity followed by a formal session with a masterclass speaker. The participants would be given time to research the speaker and their organisation and to devise questions of interest. The speaker would introduce their organisation, their job role and share their own career journey and talk about a specific topic of interest. A Question & Answer session would follow providing participants the opportunity to ask questions on any aspects of interest. Following the masterclass, the group would conduct a reflective Q and A session discussing the key learning points, followed by their own personal feelings towards what they have gained from the experience. An example of the reflective template used is located in Appendix N. Other activities included lectures for the Research Methods module, practical workshop sessions or laboratory sessions, the industry challenge project and mentoring using the Mullany Fund e-mentoring platform. The Mullany Fund is a charitable organisation offering an e-Mentoring online programme of support for students aged 14-19 years, who may have aspirations of a future career in the life sciences. Students are matched up with a dedicated professional mentor who provides tailored advice and guidance (the mullanyfund.org, 2021). The Industry Challenge (Appendix L) is a problem-based inquiry focused on the diabetes disease and its impact on the NHS in Wales. This was a topical project designed as a skills development vehicle for group work at the outset. The learner participants could demonstrate their knowledge, understanding and application of their learning from their research methods module to develop their problem-solving skills and creative skills in creating a research poster. The first six weeks of the Industry Challenge enabled participants to work as part of a group. This was followed by individual research pathways depending on the interest of each learner. These sessions became more student-centred and problem focused enabling participants to apply their own approaches and focus on their individual interests.

Aligned with the aims of the pilot intervention, no official control group was used. The researcher evaluated her delivery, via reflective practice and by polyangulation of the data collection, rather than an experimental comparison to determine the efficacy of the programme.

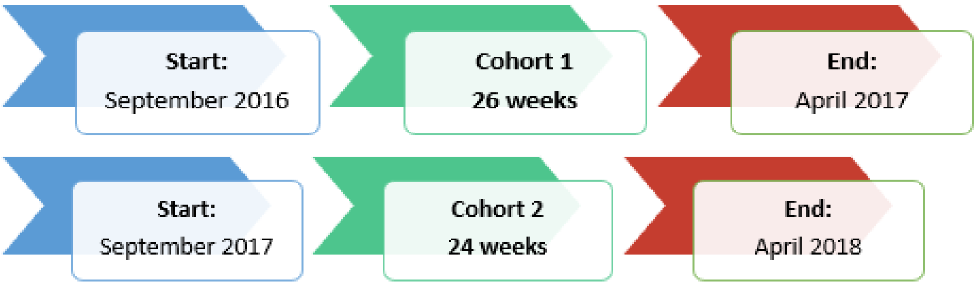

Figure 30: Timeline of each Cohort

6.4.6 **Leadership and Management**

The researcher assumed the responsibility for leading the programme in conjunction with the study. A Programme Area Manager collaborated on a month-by-month basis to provide and receive updates from the FE institution and the Maths and Science departments. The Programme Area Manager supported any student or staffing issues. The researcher was given autonomy to operate week to week and report monthly to the principal. Periodic updates were presented to the Governing Body and the Senior Leadership team. Some monthly administrative reporting was also completed for funding received to pilot the programme.

6.4.7 Regional Life Science Ecosystem

The Talent Bank intervention was designed as an industry-led intervention to ensure relevancy and currency of learning experiences that reflects the reality of the life science sector in Wales. Following the employer stakeholder findings in action cycle 1 and the visit to UTC Liverpool, the researcher placed a reliance on the region's ecosystem drawing upon existing and new relationships to test the delivery of the programme in collaboration with a team of educationalists from the college and university setting. Whilst a small budget for delivering the pilot was made available by the host institution, part of the research was to identify if the ecosystem could be utilised minimising the need for excessive delivery costs often associated with new educational programmes.

The researcher needed to build contacts from across the regional life science ecosystem using university colleagues to make initial introductions. With the passing of time and publicity attributed to the Talent Bank programme, the researcher found it much easier to make connections and develop her own network of contacts. The importance of establishing relationships with employers is particularly important especially when their expertise on specific aspects of knowledge development, such as careers and industry practices are needed.

Employer relationships were continually sought, forged and built over time. Support for the delivery of the Talent Bank could take many forms, from sponsoring equipment and providing accommodation, to presenting master classes, to hosting of company visits and providing access to equipment, workshops etc, to participating in interview panels etc. Any employer support was welcomed whether this would be monetary support or through employer time. The employers were often based in the locality within the existing eco - system and range from large multi-national organisations with bases in Wales to local one person or small, medium sized enterprises (SMEs). Relationships built with employers required an investment of considerable time to establish and build over the duration of the research. Figure 31: illustrates some of the supporting organisations involved with the Talent Bank programme.

Figure: 31 Sponsors and Partners

6.4.8 **Programme Delivery Method**

The research practitioner worked with a small team of two seconded teachers, one HE lecturer and an administrator to plan, arrange and facilitate the weekly programme. Whilst the programme organisation changed week-on-week according to the availability of organisations and speakers from the region's life science eco-system, some fixed delivery sessions were included most weeks. The university provided a lecturer to deliver the research methodology unit and the seconded college teacher supported the industry challenge project. The industry challenge project was designed as a skills development vehicle, the outcomes of which also formed part of the Extended Project Qualification that would provide additional UCAS points as well as evidence and application of research skills for the Young Scientific Journal.

6.4.9 **Assessment**

The assessment within the programme was considered within the educationalist focus group and purposefully kept to a minimum to ensure no extra burden of work was placed on learners and their existing study commitments. However, key elements were designed to demonstrate learning outputs based on work completed within the schedule - this included the Research Methods module delivered by University staff for which students worked to generate a research paper for submission to the Young Scientific Journal – an online journal established for students aged 12 to 18 years to share their research worldwide. A certificate of completion would be awarded on completion and secondly the OCR Extended Project Qualification (EPQ) which required the completion of a research project. The module and industry challenge on diabetes was mapped to bring together a real-life problem which participants could research and investigate and report their findings. This streamlined the assessment process and linked up key elements of the programme into a whole theme and area of focus. Observations were conducted each week and notes gathered on participants' level of interest, interaction and understanding of the activities alongside their general progress.

6.4.10 Identity

The importance of professional identity was first identified by students at the UTCs. The students attributed great value at being treated as adults and acting as trusted professionals. They understood that they were entering a profession where their behaviour needed to match the expectations of the profession. The wearing of appropriate clothing such as scrubs and lab practice coats provided a sense of identify and a feeling of being part of a community and not just as a school student. To support a professional identity, a uniform for each student was provided for certain Talent Bank activities. For work experience in the hospital, a set of scrubs were issued to each student and a laboratory coat was provided for experiments conducted in the lab environment. A lanyard with an identification card was issued to each participant which, needed to be presented if requested for time spent at the university. Sweatshirts with the Talent Bank logo also enabled the students to be identifiable amongst university students. The participants became aware of the interest in the project and the associated publicity from the organisations involved, such as the BBC news and local press releases. The Talent Bank identity assisted in showcasing their efforts and heightened the value of their participation, as opposed to just being part of another programme offered by the college.

6.4.11 Alterations

A summary of the main changes of the programme and its delivery between Cohort 1 and Cohort 2 are outlined below:

Marketing: A full page advertisement for the Talent Bank programme was included in the FE institution’s main prospectus for academic year 2017 -2018. In addition, an Open Day event was planned and co-ordinated with the Student Services Recruitment Team, hosted at the Institute of Life Science at Swansea University’s Singleton Park Campus adjacent to Singleton Hospital. The twilight session attracted over 50 potential students and parents. The aim of the event was to showcase the learning experiences participants would enjoy and the criteria set for their acceptance on to the programme. Participants from the previous cohort were in attendance to speak about their own experience alongside some employers and sample artifacts from Cohort 1. A Talent Bank website was created to support the profile of the programme, raise awareness and to share its distinct vision. A video showcasing how the Talent Bank would support the broader skills agenda and development of the regional life science sector was initially developed by students and then professionally created to coincide with the prospect of the Talent Bank as part of the regional ARCH programme and Swansea Bay City Deal. https://vimeo.com/221551648?ref=em-share An Instagram page was devised by participants to capture and showcase the programme. https://instagram.com/talent_bank_?utm_medium=copy_link

Intervention Design: Recommended additions to the Talent Bank programme included a focus on participants learning about the importance of looking after their own self-health and planning future careers via a bespoke career action plan and interview skills. These additions were suggested recommendations from the post programme focus group from Cohort 1 and endorsed by some employers.

Delivery Method: An emphasis on inclusion of more practical activities and WOW workshops (a term used for the extra special activities supported by an outside agency) introduced by the educational team, drawing on their experience and the expertise and resources from employers and academics in order to create more variety within the programme. This also provided a further opportunity to explore support from other employers and academics that had not contributed their support with Cohort 1.

Scheduling: A revision of the schedule was made with the second cohort, reducing the duration of the programme from 26 weeks to 24 weeks. This revision is attributed to feedback from teachers and learner participants in Cohort 1, requesting to complete the Talent Bank programme earlier than scheduled to commence college-based revision sessions for external A level exams in May.

6.5 **Step 2 – Actioning**

The actioning phase of the action cycle is concerned with the implementation and delivery of the Talent Bank intervention programme. The following flow chart illustrates the key actions taken throughout the programme and the associated time and data collection instruments used. Step 3 – Observing and monitoring occurs in tandem to the action.

6.6 **Identification of suitable candidates**

Figure 32: Flow Chart of Participant Pre-Programme Activity

6.6.1 **Consent to Participate in Study**

Once students were interviewed and offered a place on the programme, a set of letters providing an overview of the pilot programme and the study, consent forms and fact sheets were distributed for parents to give consent to their son/daughter to participate and contribute to the research process. The consent forms were received and maintained by the FEI to ensure compliance with data protection protocols.

- Information Sheet (Appendix C)
- Participant Consent Form (Appendix F)
- Parent Consent Form (Appendix H)

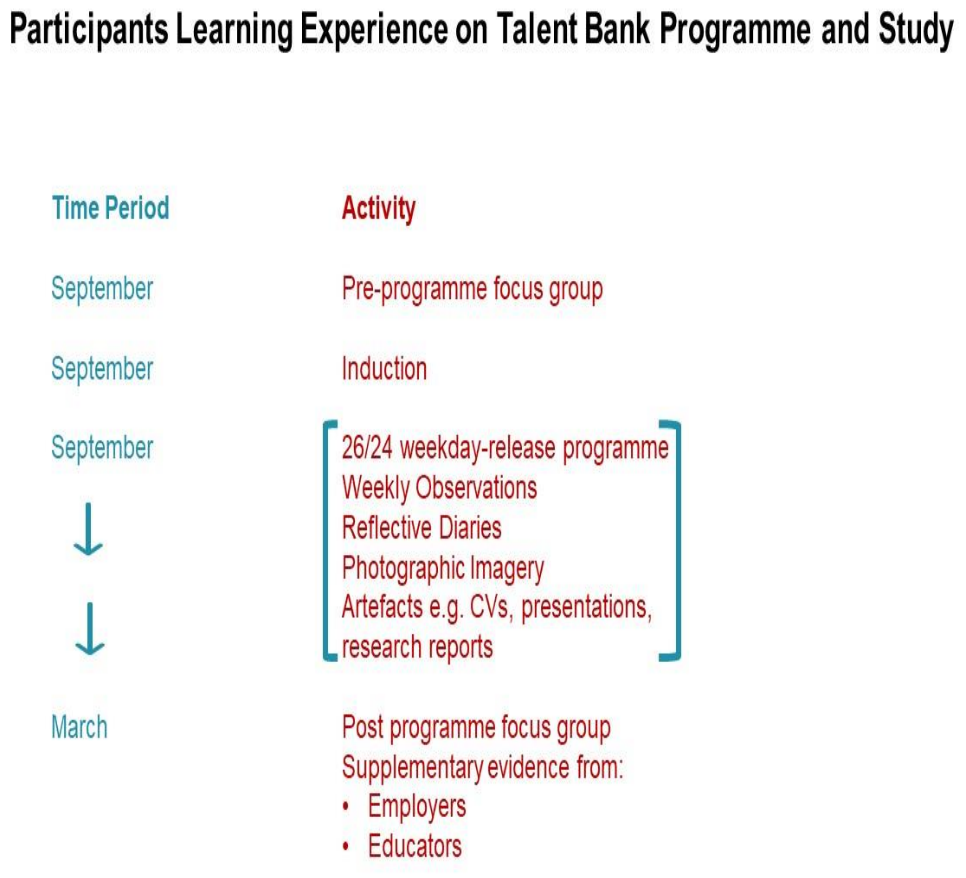

Figure:33 Flow Chart of Participant Activities through Pilot Study

6.6.2 **Recruitment of Learner Participants**

Cohort 1 - 12 places

A cohort limited to 12 adolescents ranging in age between 16-22 years took part in the first pilot of the intervention between September 2016 – April 2017. Participants were studying A levels or vocational science and came together as one group. Ordinarily, these groups of students do not mix and are taught on different campuses at the FE institution.

COURSE	TOTAL STUDENTS	FEMALE	MALE
3 A Levels in Maths and Sciences	5	2	3
BTEC National Diploma in Forensic and Applied Biology	7	4	3

Table 16: Participants by STEM Qualifications – Pilot – Cohort 1

6.3.2 Cohort 2 – 9 participants /12 places

Cohort 2 recruited 9 participants aged between 16 and 17 years old to the Talent Bank programme in September 2017 – April 2018. The breakdown of their data is shown in table below. A reduction in recruitment levels in the second cohort is attributed to conflicts with college timetabling and inability to release students from their General subjects.

COURSE	TOTAL STUDENTS	FEMALE	MALE
3 A Levels in Maths and Sciences	6	3	3
BTEC National Diploma in Forensic and Applied Biology	3 (-2)	3 (-2)	0

Table17: Participants by STEM Qualifications – Cohort 2

6.6.3 **Pre-programme focus group**

Notification of the pre-programme focus group was discussed in the induction week with its purpose outlined. Each group of students were invited to attend the pre-focus group to gain an understanding of motivations for joining the programme. Consent to participant involvement in the programme was checked as part of their completed Participation Consent. The homogenous focus group of learner participants had limited previous knowledge of each other as they had just started college following their GCSE qualifications. The session was organised by the researcher-practitioner during the second week of their day release from college, set within the Talent Bank Hub at the University's Bay Campus. The session was hosted by an independent academic moderator and an assistant moderator. The planned event was scheduled for a period between 45 – 90 minutes. The purpose of the focus group was to gauge the participants' qualitative reactions to specific questions on their reasons for joining the programmes, identify their expectations and career aspirations. The recording of the session was not permissible under the terms of the Ethical Approval and therefore the responses and comments were captured on a flip chart and sticky notes. A focus group narrative sheet outlines the structure, flow and set of pre-determined questions (Appendix M). Participants were informed of the use of their answers in the research study and assured of their anonymity. The responses were transferred to a spreadsheet and visual overview.

6.6.4 **Induction**

In the first two weeks of each programme, an induction session was held to outline the Talent Bank model with the recruited participants. This covered the vision of the model and key areas of focus, including the elements within the study. The participants were provided with an overview of the research and their role in the study and the contribution expected alongside the other stakeholder groups. Participants were informed of the data collection instruments that would be used and that they would have an opportunity to review information at the end of the programme. The initial session also focused on team building, helping the participants get to know each other as they came from disparate groups and backgrounds.

6.6.5 **Communication**

A WhatsApp group was established for the participants and leadership team to ensure effective communication on the ongoing organisation of the programme. Since the programme was hosted once a week and was dynamic in nature, and participants came from disparate courses within the college, there was no one way to ensure effective communication. It was deemed important by the researcher that information was distributed, and feedback received efficiently and in a timely manner. The WhatsApp group enabled multi-way communication between all members of the group throughout the duration of the programme.

Communication between the programme leadership and management team and leadership from the college was recorded over email. Monthly meetings were scheduled between the researcher and the Curriculum leader and separately with the Principal, to update on progress with the programme and students, as well as any issues arising.

6.6.6 **Programme Delivery**

The programme of delivery was developed a week in advance drawing on the availability of employer and university expertise, facilities and resources. Cohort 1 (September 2016 - April 217 – 26 weeks) programme activities and learning experiences are illustrated in Figure 34. Cohort 2 (September 2017-April 2018 – 24 weeks) activities and learning experiences are illustrated in Figure 35.

The actioning phase of the action research cycle is where the planning steps become implemented. Whilst the programme is delivered, the data collection is also conducted in tandem depending upon the collection strategy.

6.6.7 Participation Debriefing Letter

Following the post-programme focus group, the participants received a session summarising the findings of the action research and the Talent Bank programme. A presentation was shared with each group followed by a Q and A session to elicit feedback and any further comments. A participant debriefing letter was issued indicating how their contributions would be used and to record an end to their involvement in the study. Appendix O illustrates a copy of the debriefing letter issued.

6.6.8 Celebratory Presentation

A final celebratory event was hosted at Morriston Hospital in April 2017 and in 2018 with employers and parents to showcase the Talent Bank programme and to present certificates and awards for participant accomplishments. Employers and teachers involved were invited to offer any ancillary feedback which was also collated and merged with the other forms of data.

Figure 34: Cohort 1 Learning Experiences and Activities

Figure 35: Cohort 2 Learning Experiences and Activities

6.7 **Step 3 – Observing**

The observing and monitoring steps collect the data related to the study's identified issues. Since this step is conducted throughout the course of the intervention programme it is likely a number of adjustments may be required. Early data collected and analysed will be used 'to inform future data collection often enabling the research to know what to look for" (Johnson, 2008, p.63). Frankel and Wallen (2003) and Johnson (2008) point out the importance of collecting multiple measures on the variables of interest in a study. This encourages the polyangulation of the data collected to support their quality and accuracy.

6.7.1 **Data Collection Strategy**

The data collection strategy for Action Cycle 3 draws upon five data collection instruments identified in the research design and methodology. The instruments have been selected to draw on data collection opportunities identified at certain times in the schedule that may assist in determining any change, patterns or trends (Johnson, 2008).

Data Collection	Participants	Employers	Educationalist	Researcher
Pre-programme focus group	√		√	
Observations	√		√	√
Reflective Diaries	√			√
Photographic Images and artefacts	√			
Semi-structured interviews		√	√	
Post-programme focus groups	√			

Table 18: Data collections strategy by stakeholder

The main focus of the cycle is in gathering the views of participant stakeholders and their perceptions of the Talent Bank programme at specific timings within the learning schedule.

6.7.2 **Pre-programme Focus Group**

A pre-programme focus group was hosted before each programme commenced usually lasting for an average of 60 minutes. Following the introductions and overview of the focus group format, the participants were asked a series of questions which the scribe recorded on a flip chart or the participants were asked to write their answers on a post-it-note which were collected and stuck to the flip chart. The focus group was designed to identify qualitative views on the programme, career aspirations, the key reasons for participation and what was hoped to be gained from participating. An independent researcher conducted the focus group with a secondary support member for checking the process and accuracy in recording the responses. A framework of questions and process is outlined in Appendix M.

6.7.3 **Observations**

Observations were conducted throughout the weekly programme of activities. Teachers made note of participants and their interpreted levels of learning and understanding, interaction, motivation and enjoyment. Information was discussed each week as a team and noted by the researcher. Notes were recorded on experiences that were highly engaging and those that were not so valuable. Photographic images were also taken to record specific activities and to provide evidence of engagement.

6.7.4 **Reflective Diaries**

Reflective diaries were completed by participants after weekly activities. This was a reflective process that began with participants being asked to reflect and submit their views prior to the following week. This was not so successful with many participants not completing the necessary actions. A decision was then made to incorporate the reflection into the daily programme, and which needed to be completed before the session finished. The process took time to initiate and to get the participants to habitually complete. Group discussion and Q and A sessions supported the sharing of experiences amongst peers as part of the reflective process. Appendix N illustrates an example of the template used to structure reflection on activities and how they relate to individual learning and progress.

6.7.5 **Photographic Imagery**

Photographic images were taken of the group and individuals to support the reflective process and journaling of the participant journey and Talent Bank story. The images provide a rich tapestry of learning experiences and were used to present the range of Talent Bank activities engaged with at a Celebratory presentation with employers and parents. A gallery of images is illustrated in Appendix P.

6.7.6 **Artefacts**

The artefacts refer to tangible materials anticipated from participants on the programme. These could include such items as research papers, university application statements, personal reports, Curriculum Vitaes, student presentations, laboratory experiment logbooks etc.

6.7.7 **Post-Programme Focus Groups**

At the end of the programme students were asked to attend a post programme focus group for up to 90 minutes to understand their views of the programme, their learning experiences and if the programme met their expectations.

A post-programme focus group was designed with a set of questions to follow up and enable comparison with pre-programme responses focusing on the skills developed, the range of learning experiences and career aspirations following involvement. Typical questions include:

Exit Questions

- What are your views about the Talent Bank programme?
- What were your most enjoyable elements of the programme?
- What were your least enjoyable elements of the programme?
- Did you achieve the outcomes you expected from the programme?
- Would you recommend the programme to others?
- What word would you use to describe your experience on the Talent Bank programme?

6.7.8 **Data Analysis**

The data generated from the five types of planned instruments were categorised and sifted from digital and written notes whilst being inputted into an excel spreadsheet. The analysis of action research data is typically less complex and detailed than in other more formal research methods (Fraenkel and Wallen, 2003). The data collected from all collection instruments was analysed separately in accordance with the timeline. Following the completion of all data collection further analysis was undertaken, and the data merged into a set of themes or categories in accordance with the process with other action cycle groups. The findings highlight several interesting perspectives relating to the main purpose of the study which is to advance an understanding of whether a STEM intervention programme (Talent Bank) can facilitate the development of high calibre talent whilst increasing awareness and potential interest in careers in life sciences within the evolving economy in the south west region of Wales?

6.7.9 **Findings – Participant Stakeholder Perceptions**

Key highlights within the qualitative data are illustrated from the various data collection instruments.

6.7.10 Pre-programme focus group

The pre-programme focus group collected data on a series of crafted questions to gain an understanding of the perspectives of participant stakeholders with regard to the Talent Bank intervention.

Icebreaker question – to engage the learner participants

- **What do you think about the new University campus?**

  Participants indicated positively about the new campus and its facilities. 'It's nice' "really like it'.

Exploration Questions

- **What subjects are you studying?**

  Participants provided information regarding their individual STEM A level subjects (various permutations of three from: Biology, Chemistry, Physics, Maths, Computer Science) or vocational BTEC Biological (Forensic) Science as their main programmes of study.

- **What attracted you to apply for the Talent Bank programme?**

  The majority of participants commented on access to work experience and working with employers as the main attraction to the programme. A secondary choice was because their friends had joined and the opportunity to see university and support their university application. One student in the second cohort indicated that his family had suggested the course would be good to check out careers in medicine and health.

- **How did you hear about the Talent Bank programme? A list of options was provided as prompts:**

  The main responses indicated the college as the main source, with others referring to Open Evening event, parents, careers teacher at school, the Elevate conference (a day conference hosted for Grade 11 students with an interest in Medicine, Health and Life Sciences) Maths's teacher at college, school, or friends. The second cohort responded to most of the options from previous cohort - an additional comment indicated that one person had heard about the programme from a student on the previous cohort.

- **What are you expecting from the programme?**

Responses of participants on their expectations ranged from gaining experience of work, working with employers, improving their Curricula Vitae, developing skills and gaining extra qualifications that supported their university application and 'seeing if STEM' was a suitable career for them. A single response related to seeking support for the MCAT (Medical College Admission Test).

- **What knowledge do you have about the life science sector?**

A few students referred to the life sciences as concerned with pharmaceutical, drug development, cures for diseases and testing. Most participants indicated that they were not aware of the region's life science sector, the companies, or the range of careers available.

- **What do you think are the benefits of the programme?**

Several participants valued the chance to attend the university and to see what it offered. Responses included meeting employers and gaining work experience in a hospital which was difficult to find.

- **Do you have a Curricula Vitae or a careers plan/use LinkedIn?**

This question was inserted into the second cohort pre-programme set of questions following the feedback from cohort 1 and the request for some learning experiences relating to interview preparation and techniques, as well as writing personal profiles and CVs. All students indicated that they did not have CVs or career plans. Students had previously heard of LinkedIn but did not have an account or use it.

- **What career aspirations do you currently have? (If any).**

A few participants identified career aspirations in nursing, midwifery, forensic science. One student had a range of aspirations but was unsure as to which one to pursue – surgeon or a paediatric doctor or GP. Two students expressed an interest in engineering. When probed on why they thought the Talent Bank programme was of value as it was focused on life science and health science – one participant responded about an interest in medical engineering and another in the second cohort indicated that his mother thought the course experience would be beneficial. Several responses indicated that participants had no firm ideas on what they would want to do but were open to new opportunities.

Further Participant Quotes:

- My timetable clashed with Wednesdays so now I have to go to other math's classes on a Tuesday do that I can come on Wednesday (P8)
- My teacher doesn't think I should come (P3)
- Sometimes we have really good events planned by Talent Bank, but I have to attend uni talks at the same time (p2)
- It would be good to have a plan so that we know what is on each week (p15)
- [....]I think I have benefited from the TB by learning more about the careers in life science - I didn't really know about these types of jobs to be honest. (P3)
- [....] Yes I did benefit from the programme - Employers told us about the importance of skills and work experience alongside our qualifications (P5)
- [....] I've met lots of employers and learnt about different careers. I've learnt about the role academics at universities play in conducting research to push innovation and create new knowledge. I've studied Research methods which will help me when I go to uni (P9)

The responses were transcribed from the flip chart and post it notes into an excel spreadsheet for analysis and categorisation.

6.7.11 Reflective Diaries

Question areas of reflection included:

- Tasks and activities undertaken - rate the best and the worst session and indicate why?
- Skills developed today
- One new thing you have learnt today
- What worked well?
- Areas for improvement

The feedback was designed to gather participant reflections on the activities to enable their reflective practice to determine the learning from their experiences and to identify if they would recommend the sessions to the next cohort of participants.

The reflective diaries identified a range of experiences that were perceived as most enjoyable and valuable to individual learning. These included the masterclass sessions with employers. Participants like the personal career journeys and the sharing of advice. Two such sessions were highly referenced for their impact: an entrepreneur in the life sciences who identified with failure at school and who has succeeded in life following his own interest rather than a career; and a session on STEM skills led by the STEMNET partnership that works with schools and students and aims to increase participation in STEM careers through a range of practical workshops and presentations. The reflective diaries also identified favourable feedback for the Collaborate conference at Swansea University – an annual regional conference on the life sciences. Participating as a delegate provided the participants with an insight into the region's various projects and how research pushes the boundaries of knowledge providing the linking between their research methods unit and academic masterless speakers. The WOW activities such as the Operating Theatre Live dissection and death workshop, practical resuscitation skills with Welsh Ambulance Trust and the development of clinical skills with Graduate Entry medicine students from Swansea University were all identified as highly engaging and enjoyable experiences. One participant identified that she definitely did not want a career in surgery or medicine following the dissection workshop which highlighted the value of ruling out careers as an alternative learning point.

Some sessions delivered by university academics focused on really interesting aspects of research and provided a real insight into the work of the university in pushing forward on the knowledge and innovation frontier. Most participants were not aware that universities played this significant role until they began their Research Methods unit. A few presentations with technical content were pitched at too high a level and not appropriate or accessible in parts for the younger participant audience, and this was reflected in feedback.

6.7.12 **Observations**

Observed references made by teachers, employers and researcher:

- Observation records highlight positive changes in participants' motivation and confidence across the timeline of the Talent Bank programme**.** Most participants displayed inhibitions and shyness in their behaviour at the outset as they felt out of their comfort zones, new to the environment and invariably did not know each other.
- During masterclass sessions and engaging with employers, participants became more active over the initial weeks as they were trained to conduct research on the speaker and to formulate questions. Once a process was adopted a pattern of behaviour became established and observation notes highlight participants enthusiastically asking questions relating to employer organisations, job roles or their career journeys.
- In the Industry Challenge weekly activity, participants from A levels and Vocational programmes were able to work together as a team and appreciated each other's contributions.

- All participants enjoyed the practical aspects of the Talent Bank programme particularly the NHS induction and the session in the Clinical Skills Suite with trainee doctors from Swansea University's Graduate Entry Medicine programme and the Health Board. Participants dressed in professional attire such as scrubs and lab coats enabling participants to demonstrate their professionalism with doctors, nurses and laboratory staff that interacted with them.
- A focus on career planning and interview skills was introduced to the second cohort – all participants took the mock interview training session seriously participating through the one-on-one interview process. Teacher observation notes identified some participants that were prepared to make mistakes and others that were very shy and needed coaching and encouragement to proceed. Their reflective accounts indicated that most valued the session despite not enjoying aspects of the experience and they felt they had learnt from the process.

Some of the teacher observation notes referred to increases in:

- Curiosity and interest
- Motivation
- Confidence
- Knowledge acquisition
- Skills development
- Personal growth – e.g. overcome nerves when presenting
- Enjoyment

6.7.13 **Photographic imagery**

Hundreds of photographic images were taken to record the learning journey for each cohort group. These have been curated into the key elements of the programme and also as a timeline of key moments to illustrate the distance travelled throughout the participation in the study.

PowerPoints of each cohort's participation highlight the key experiences and create a record of learning experiences and outcomes.

6.7.14 **Artefacts**

Artefacts. - one student shared their personal statement in application to study medicine at university. The document refers to several key experiences organised by the Talent Bank programme that the individual has considered to add value and strengthen their application. A second artefact refers to a case study written by a participant for Fujitsu, a key Talent Bank sponsor. The case study illustrates the way in which the programme and its many learning experiences has supported his individual development and a copy of this statement is contained in Appendix Q.

6.7.15 **Post – programme focus group**

The post focus group was hosted at the end of the programme for a duration of 90 minutes. Questions were asked to each cohort and their responses transcribed on to flip chart paper or post it notes and stuck to the flip chart. The responses were transcribed and analysed into themes.

How would you rate the Talent Bank programme overall?

- **Headline: 100% of participants rated the programme as excellent or good**

To what extent has the Talent Bank helped to prepare you for the world of work?

Significantly or adequately

- **Headline: Most students feel the programme has significantly prepared them for the world of work**

What skills do you think you are better at because of your time on the Talent Bank programme?

Problem solving / critical thinking / time management /being professional/ communicating/ networking/ researching / reporting/ presenting/ interviewing/ listening/ computing/ confidence / work experience.

- **Headline: Students could highlight at least 5 examples of skills when asked about the range of skills that they feel they have developed whilst on the programme**

Further Highlights:

- More than half of participant's indicated the Talent Bank had influenced their future career choice.
- Only two participants remained unsure but were more informed about opportunities in the life science and health sector.
- Many participants indicated that the Talent Bank had helped to confirm their career choice or rule out options.
- Most participants indicated that they have decided to progress to university because of their participation in Talent Bank
- Several participants indicated that they would consider entering the workplace if suitable jobs in the sector were available.
- The most beneficial aspect of Talent Bank - ranking 1st - masterclass speakers, ranked second - work experience/ volunteering, ranked third company visits, ranked fourth - extra qualifications, ranked fifth- skills development
- The least valuable experience identified by participants was the online mentoring.
- All participants indicated they had grown in confidence because of their involvement.
- All participants rated the Talent Bank as a programme they would highly or would generally recommend to others.

- **Additional Quotes from Participants**

'The sessions were wonderful and amazing'.

‘To be honest, all the sessions were good. I liked the entrepreneur masterclass the best - he showed you could do anything really even without qualifications if you put your mind to it’

‘The pathology lab was the best - I would like to work in a lab now that I know what it’s like’

‘The best part was in the skills suite in the hospital - we learnt how to take blood from a synthetic arm - the doctors were training - they also showed us how to resuscitate a patient’

‘The best for me was being interviewed by the BBC about the Talent Bank and what I wanted to do in the future - I have never been on TV before - I’m famous now!!!

‘it was a great experience that helped me learn new things each week’

‘it was cool to meet employers and ask them questions about their jobs’

Part of the virtual mentoring programme:

‘I am paired with a doctor on a cruise ship - he told us about his career and how he got his job. He deals with all sorts of emergencies on the cruise ship - some of the guests have had to be airlifted to hospital. He talked to us about the importance of reading - he reads articles on research to help him keep up to date in his field’

‘To be honest I want to be an Engineer - but I’ve learnt so much - nano technology and its role in medicine, artificial limbs and medical engineering - I don’t know if I would want a career in this but the lecturers and the presentations were amazing’

‘I really enjoyed the course - you’re treated as an adult not like a child’ I like wearing the scrubs at the hospital - it makes you feel as if you are part of the team and not like a student’

‘I’ve learnt more on this course than I have in all my A levels’

6.8 Step 4 – Reflecting

Reflecting on the whole action cycle with participants, a great deal of data was collected in comparison with other action cycles. The researcher reflected on the entire process and considers the value of a mixed method approach with quantitative data and how this may have added more detailed understanding and measurement of the success of the programme. That said, the qualitative data indicates success in many areas that address the recommendation set in the Life Science, Skills for Life (2014), The next step is to draw together the findings from all three action cycles and determine the overall understanding that can be gained from the analysis. The endpoint will consider the findings from all three stakeholders.

6.8.1 Supplementary Evidence

Brief interviews were conducted with the employers in the masterclasses and workshops immediately following each session or by phone (according to the convenience of the employer) and lasted approximately 10-30 minutes according to the individual. The questions focused on the feedback of their own session, their perceptions on participants' reactions and whether they believed the participants would be of value to the sector and any additional impressions overall. The data was collated, and thematic analysis of the responses identified a range of themes and sub- themes that emerged:

The employers' perceptions were that there is an identified need for an intervention programme to support regional life science sector. Several references were made on the assertion of the need for such an intervention:

- .... this is something we definitely need for young people in the region. (E3)
- …. wish there was something like this available when I was at college... (E2)

- ...it’s great that students are so engaged with the programme... I speak to many under-grad groups and they don’t have the same level of energy ... (E27)
- ...I really enjoyed the session with them (students) .. the Talent Bank has such great potential for the region. (E24)
- ... I think the Talent Bank compares better than our UTC model ... you are integrating and utilising the regional stakeholders to provide a really unique learning experience (E18)

The professionalism and maturity of the participants

- - wow ... they are a great group of kids - I can’t believe how mature they are for their age .... I’ve worked with university students and some of them don’t compare... (E7)
- They look so professional in their uniform - you’d think they already work with us ... and they are only 16... (E27)
- You would think they were under grads... amazed they are just 16 years old ... (E15)

The level of curiosity amongst participants and keenness to ask questions and the benefits of developing skills and experiences

- I was amazed at how enthusiastic they were ... the detailed questions they asked ... really impressed with their level of knowledge ... a real testament to the programme (E5)
- .I was meant to be here for just an hour but they just kept asking me really great questions. I was taken aback by their confidence, knowledge and level of interest in diabetes...I hope they found the presentation useful for their project (E24)
- It’s amazing how curious they are... (E19)
- I was worried at first that they wouldn’t engage with my personal story (as an entrepreneur) but they were really interested asking lots of questions . (E9)
- .. it was rather surprising to me that they weren’t aware that industry looks for experienced and skilled talent in addition to qualifications. I

think the emphasis on professionalism and developing skills is an important one... (E16)

- I don't believe it's industry's responsibility to educate ..that's the schools, colleges and universities role …. but we've complained for years that young people are not being prepared for work … they are not equipped with the skills and attributes we need. This programme could change that particularly where employers are involved. I really think this approach can benefit everyone – the region, employers and young people. It's a win-win.

The value of working with employers and their willingness to support the programme

- I really enjoyed myself this morning ... they were an amazing bunch ... I would be more than happy to present again or if I can help you in any other way .. just let me know (E8)
- It was a good session... the students had fun in the resuscitation workshop - if you are interested in a talk about the .... let us know... (E11)
- Sorry we had to cancel this week but as I said it was an important week for us but if you can reschedule or you need us to support you with a visit for example. you have my number ... you only need to ask...
- we have an educational programme co-ordinator - I can put you in touch with her if you are interested in company visits or work experience ...(E10)
- we value the collaboration with yourselves... let's keep in touch .. if you think we can support you in other ways.... (E8)

The potential for talent from the TB to be recruited by the industry

- ..they are a credit to you .. they are our future ... we would definitely consider recruiting them. (E6)
- ...They are an asset that the life sciences sector desperately needs... (E13)

- ...Your students are better prepared (for work) than some university graduates that we see... (E22)
- The company offers apprenticeships that your students may be interested in ... they are a real smart group. (1)
- My company would welcome the opportunity to interview these students (E16)

6.9 Endpoint

The summary of the findings highlight that the TB intervention model can enhance young people's awareness of STEM careers, skills needs and opportunities within the region's life science sector from participating in employer led learning experiences such as masterclasses and skills workshops. Participants learned that employers seek experience and skills as well as qualifications and grades in new talent they are looking to recruit. The TB programme provides opportunities for learners to learn in a professional manner and be treated as adults, which they welcomed. Employer contributors remarked positively about the enthusiasm and professional capabilities of the participants and indicated that they would be a value source of talent for the sector. Participants also enjoyed learning on university campus and viewing what it would be like to be an undergraduate student from actual students. The opportunity opened their eyes to university life and provided a positive impression about applying to university.

Masterclasses, research methods, industry challenge and work experience were identified as the most valuable and enjoyable elements of the programme. The opportunity to undertake work experience or voluntary work was an important consideration to join the programme as it was difficult to secure work experience in a hospital setting and to undertake a NHS induction. The opportunity to work with employers was cited by participants as one of the most important features of the programme

Employers, educationalists and participants alike who took part in the research agreed the TB programme was an exciting and dynamic provision that could contribute to the individual participants and their profiles; contribute to the FE organisation and their curriculum design practices; and for the ultimate benefit although this may not be known for years, but there is potential for the programme to create a new inflow into the skill supply pipeline that supports the regional life science sector.

Participant perceptions on the content of the programme were generally positive and recommendations of the programme to other students was a unanimously positive response. There are many learning takeaways from the study and the Talent Bank model:

- Rebalancing of participant profiles. A surprising outcome was that some participants were able to compensate previously average GCSE scores with learning experiences from the Talent Bank programme to compete for highly competitive places at medical school. Whilst this suggests value placed by Admissions Tutors on the kind of experiences deemed difficult to fulfil, more research is needed to ascertain if this is a contributory factor rather than a singular factor that led to the success for two participants. This could suggest that Talent Bank intervention can re-balance individual's profiles with distinctively different experiences that enable participants to gain advantage from writing and relaying their experiences at interviews.
- Differences with students who did not participate in TB was not a focus within the study however, many students indicated to teachers and friends that they wished they had opted for the opportunity instead of selecting a fourth A level subject. A control group may have been able to make a detailed comparison which would be beneficial for comparison purposes.
- Finally, the data suggests that a dynamic and iterative programme can be developed with stakeholders so that provision is more aligned to meet the talent needs of the sector. A gap is identified in existing provision particularly with A level participants who are looking for a range of

experiences to supplement their qualifications. This was not identified by vocational students. All participant groups referenced the value of collaborating and being involved in the programme.

- The researcher confirmed the willingness of industry to support the TB programme. All employers approached, offered and contributed to the programme. The involvement of employers identified a range of support mechanisms that could be offered including access to resources and equipment, expertise, delivery support, company visits, marketing, sponsorship, awards etc. These areas should be explored to identify the reality and potential cost of sustainability of this support.
- Sustainability and mainstreaming / The TB is a novel approach to talent development in response to regional need. FE providers are limited in their ability to support such financial commitments to trial new programmes in a way as this study has, particularly where numbers are small. Research needs to assess further the associated costs of mainstreaming such a provision into the FE portfolio with an understanding of future likely demand. The adjustments to change in practice in curricula design also need to be assessed for its costs in policy development, re-training of practitioners and involvement of employers in the future design praxis of relevant provision that supports regional need.
- Findings showed that there were not hugely significant differences in perspectives between the three stakeholder groups. The key stakeholder differences show misalignment between the needs of employers and what participants thought employers were looking for and a difference of perspective from some educators to the value of the programme. Stakeholders provided different perspectives which were valuable in shaping the iterations of the Talent Bank programme. Ultimately, all stakeholders have a universal desire for the best learning opportunities that create the desired talent outcomes for high quality employment within the regional economy.

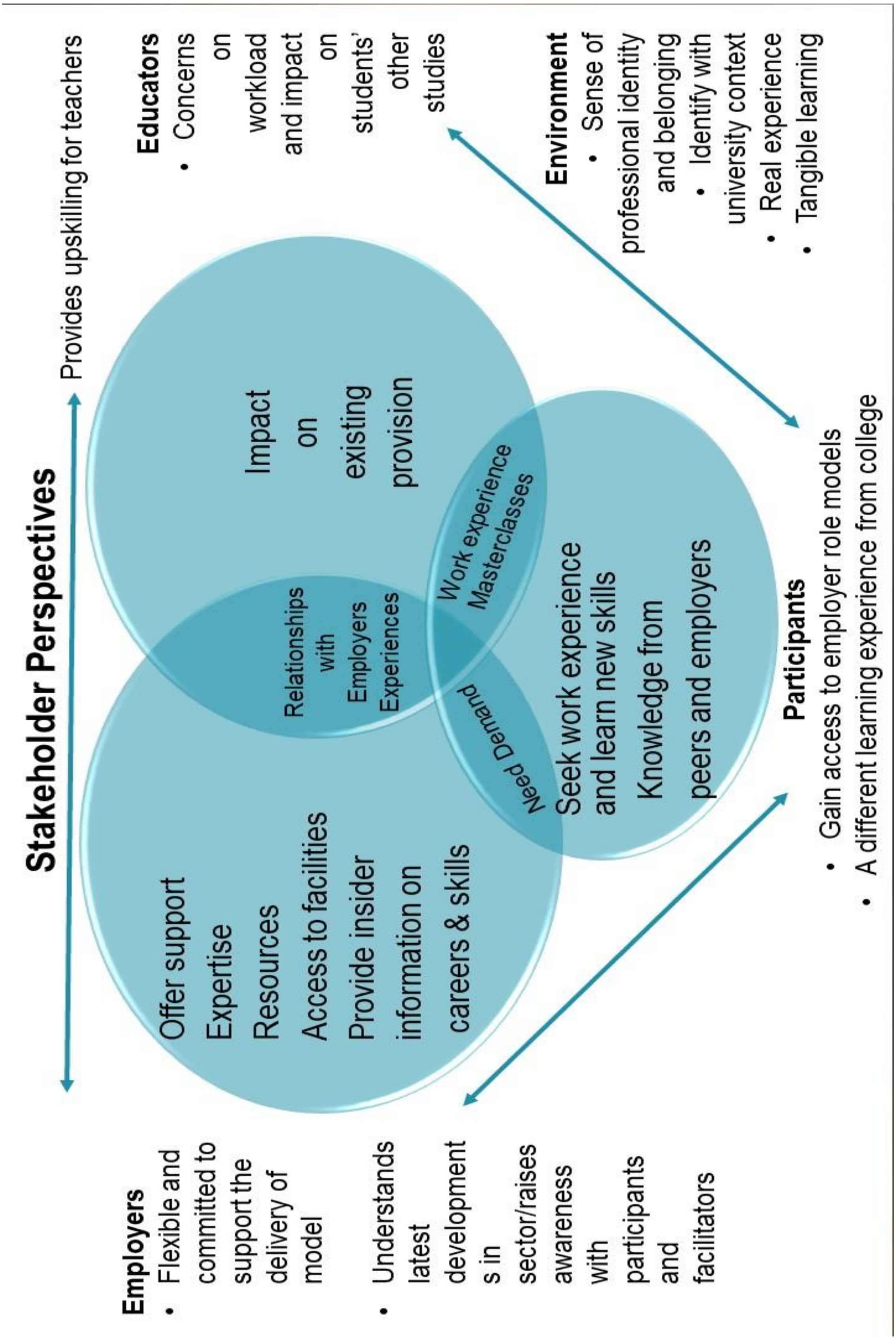

Figure 36: Venn Diagram of Stakeholder Perspectives

The outcomes from any action research study provides a foundation for the next course of action. As this study has been completed the next stage is for the FEI to consider the programme and its value to their education portfolio. Since the completion of the study, some features of the Talent Bank model have been adopted into existing provision such as masterclass series and the use of the EPQ research qualification. The networks and relationships with employers from across the life science ecosystem will remain but require other practitioners to be appointed to nurture and continue to develop these important contacts, in order for the FEI to continue to draw on their valuable contributions. Aspects of the programme have already been mainstreamed into exiting STEM education provision and changes to curricula design may also be implemented by other FEI managers following approval from the Governing Body board. The study makes an interesting contribution on a number of fronts. The documented journey of participants and their destinations and presentations have been shared and communicated with others so that the benefits from the research can be taken by other practitioners.

6.10 **Conclusion to Chapter**

This chapter has presented the third and final action research cycle with the implementation of the pilot Talent Bank intervention with two cohorts of participant stakeholders. This phase of the research was conducted between August 2016 and April 2018. The data collection utilising five instruments collected multiple datasets. The analysis led to identifying the value of the Talent Bank programme and a range of strengths as viewed by participants from the reflections of their learning experiences. The findings identify a number of areas for further development including the logistics for participants to attend, the value of the online mentoring feature, potential for longer period of work experience and the need to explore further reflective practice habits to enable participants to monitor and review their learning and development.

The chapter concluded by drawing the data strands from all three stakeholder groups to provide an initial overview of the stakeholder perspectives. The findings provide a valuable insight into the differing perspectives and where challenges can or did occur in implementation. This research has shown the importance of translating theory into practice in order to inform deeper understanding of pedagogical design and its impact for the three stakeholder groups. A discussion of the stakeholder perspectives and the other aspects that underpin the study and address the research aim and objectives are discussed in more detail in Chapter 7.

Part C
Difference

'You try to listen to what others aren't saying……

And write about the silence'

N.R.Hart (n.d.)

Chapter 7

DISCUSSION

7 DISCUSSION

7.1 Introduction

Chapter 7 draws the main summary of findings from the three action cycles and examines the results in the context of the overarching research aim and objectives. The primary intention of the action research study was to advance an understanding of whether a co-created STEM intervention programme designed through change in the existing FE curricula development praxis, could facilitate the development of high calibre talent whilst increasing awareness and potential interest in careers in the life sciences within the evolving regional economy of the southwest region of Wales? The study is interpreted and discussed through the lenses of three stakeholder groups and the willingness of the region's life science ecosystem to support and be involved with the design and delivery of the Talent Bank intervention programme. The chapter includes a discussion of the study in relation to existing knowledge of literature on experiential learning and integrated STEM interventions and what implications may be of value to curricula developers, practitioners and other stakeholders involved in workplace STEM education.

The background to this study arises from employers and their call for greater development of student skills and capabilities from academic provision that are more aligned with and supportive of workforce needs. Criticism is levied at educators and governments for failing to prepare students as future employees and the decline in STEM talent (Thibaut et al., 2018). However, the increasing variability and evolvement of sectors particularly in fast changing and dynamic sectors as in the life sciences, make it difficult for FE providers to keep pace and to deliver up to date STEM content. The FE sector is already stretched by greater student numbers and declines in government funding and therefore any solution needs to be cost effective. Given these circumstances there is a need to understand employer perspectives of the current and future STEM talent requirements from further education students studying STEM disciplines.

Regional research in Life Science, Skills for Life, (2014) highlighted the need for STEM talent with abilities to contextually apply and develop knowledge. Regional employers identify the need for generic skills such as communication, critical thinking, problem solving, digital literacies and leadership to support business growth. In addition, working collaboratively as team members or independently on one’s own initiative, holding a professional attitude and an interest and willingness to learn and adapt were viewed as significant credentials sought by the life science sector. Technical abilities were also cited but directed at graduates from the higher education sector (Thibaut et al., 2018).

The recommendations of the Life Science Skills for Life (2014) regional report suggest that the FE sector should address many of these criticisms by collaborating with industry to devise a resolution to meet the regional talent deficiencies. The report recommends that the further education sector which focuses mainly on general qualifications should work with stakeholders to create STEM learning programmes to meet the needs of the sector. This would entail curriculum development of new provision that would complement existing provision to provide STEM students with opportunities to apply their knowledge in real life, authentic based contexts with employers in the life science sector.

The purpose of the study, therefore, is to also generate a collaborative industry led education solution that addresses the needs of stakeholders, whilst addressing the gaps identified for further research in experiential learning design of integrated STEM interventions, particularly in further education contexts. The intention of the research is to improve relationships and dialogue with stakeholders and with the regional life science ecosystem, in order to inform and enhance the curricula development praxis within FE. Through such initiatives STEM knowledge, skills and professional attitudes can be better inculcated in FE students for the benefit of FE outcomes, the life science sector and the region as a whole.

7.2 Summary of Findings

The most important findings from the study are summarised:
The findings from the data analysis indicate that the overall effects of participating on the Talent Bank programme are both positive and beneficial for participants. This supports the findings of earlier research conducted by STEM studies utilising experiential or hands-on-learning activities (Clark and Ernst, 2007; Guzey et al., 2014; Riskowski et al., 2009; Stohlmann et al., 2012). Several studies have shown that experiential learning activities enhance employability of students (ibid).

7.2.1 Perceptions of Employers

The perceptions of employers identified a real and urgent need for an industry and education skill solution and outlined the importance of a talent pool with a combination of knowledge, skills and experiences alongside qualifications as the requisite sought in young talent. Employer stakeholders indicated a preparedness to collaborate with educators to devise an appropriate solution to address the life science sector's need for talent. STEM employers place considerable value on vocational skills such as the ability to apply and develop knowledge relevant to the job role. The acquisition of discipline related experience has been shown to provide a strong basis for future employment and a necessary foundation whereby skills can be developed and enhanced (Toner, 2010). These findings are consistent with studies on vocationally related skills (Heijke, Mebg and Risk, 2003), despite the popular belief among educators that genetic skills are most paramount (Leakey and McGuigan 1997).

Employers commented favourably following masterclass and workshop support on the participants of the Talent Bank complimenting their knowledge, capabilities and level of professionalism. Many employers commented that their organisations would consider the participants as suitable talent for future recruitment opportunities. All employers spoke positively about the level of motivation and confidence exhibited in the group when presenting at the celebration event. The employers commented that the participants would be worthy assets to any future organisation if they maintained their commitment and interest in gaining experience and knowledge similar to the previous 26/ 24-week programme.

The potential benefits of employers from the Talent Bank intervention include the potential to preview the development of young indigenous talent as an inexpensive recruitment source. Other advantages included in other studies refer to the benefits of strengthening relationships with the FE sector and being involved in new collaborative regional projects (ARCH, 2017). Some studies reference the value of graduates and their qualifications but criticise graduate skill sets and the lack of real work-related experience specifically in lab environments (Bryan, 2015). According to Bryan (2015), the 21st century skills which includes creativity and innovation, critical thinking, problem solving, communication and collaboration should be considered within the design of student-centred pedagogies such as problem centred learning and inquiry-based-learning which advocate the use of hands-on learning. The importance of developing these skills is paramount but defy the need for a separate category as they are already largely present in these activities (ibid).

7.2.2 **Perceptions of Educators**

The educators focus group conducted in action cycle 2 presented a mixed view on the value of the Talent Bank model and the need for change. Several FE lecturers shared their fears through protectionist comments relating to their subject disciplines raising concerns about the potential negative impact the introduction of the Talent Bank programme would have on their students and their main programme grades, insinuating that the intervention would be burdensome and detract attention from their existing studies. The reality was quite different, in that many students improved their grades whilst participating in the programme. There is no causal relationship that can be attributed to the Talent Bank programme itself, although research does suggest that students who undertake extra curricula activities are more likely to succeed with higher grades (citation).

The effects of the Talent Bank model present a range of benefits for the FE institution including:

- improved curricula development praxis as input from employers and other stakeholders can provide valuable insight regarding the design and quality of teaching and realistic learning experiences.
- continuous quality improvement resulting from ongoing feedback and reflection being utilised to make incremental and continuous improvements.
- improved learner outcomes in STEM disciplines.
- adding value to the institution's educational portfolio as a recruitment tool to attract students.
- aiding the enhancement of reputation and visibility with regional organisations.
- providing access to expertise, facilities, and resources adding authentic dimensions to the programmes that ordinarily are not available to FE students and which would require high levels of investments to simulate.

- enhancing relationships with employers which can also provide benefit to other regional skills projects.

7.2.3 Perceptions of Participants

Participants in the pre-programme focus group overwhelming identified the main reason for participating in the programme as gaining meaningful experience in the NHS and other workplaces which is difficult to secure. Other reasons included working alongside employers and visits to organisations as well as to gain experience and develop skills for university applications.

Tested with two small cohorts of participants, the study aimed to determine if through participation in the Talent Bank programme supported students to become more aware of the life science sector and the range of careers it has to offer. The curated programme of experiential learning activities enabled participants to connect and learn from role models from a range of careers. Participants indicated overall enjoyment from the programme and described a range of personal developments including skills development such as problem solving, research methods, presentation skills and teamwork.

The study emphasised the importance of reflecting on learning experiences as a process to support deeper learning and understanding. The important learning takeaways are that participants constantly need to be reminded why certain sessions are designed and the how they relate to the real world and the benefits they should provide in relation to industry and meeting employer's needs.

Attendance levels throughout the voluntary programme was over 90% which is considered high by the sector for extra curriculum activities. This suggests the cohort of students had high levels of motivation, a sense of curiosity and satisfaction with the programme, which is evidenced by their perspectives alongside observation notes, reflective accounts of activities and photographic images.

The participants revealed in the post programme focus group a detailed understanding of what the life science sector was about and were able to describe a range of career roles and facts relayed to them in masterclass sessions with employers. The recall from the practice of the reflection following their learning experiences demonstrate a depth of understanding of industry. In addition, the majority of participants indicated that they would continue studying STEM at university and had decided upon various careers associated with the life science sector in health and medicine. Participants' feedback commented on the value of these experiences and their contribution to personal development and their positive influence on future career choices related to STEM following college education. The researcher and teachers facilitating the programme observed an increase in confidence, skills and capabilities amongst all participants as well as interest in activities across the course of the programme.

7.2.4 Similarities and Differences in Perspectives

The qualitative data collected from the three stakeholder groups provided a deeper understanding of perceptions particularly in the areas of consensus and key differences between the groups. The findings whilst not startling showed some significant differences in perspectives between employers and participants and between educators and employers which are useful to understand from an FEI perspective when planning learning provision which aims to meet all stakeholder needs.

Firstly, there are several studies that highlight differences between students and employers in perceived expectations of credentials for employment. This study supported similar outcomes, in that Talent Bank participants were aware that qualifications and grades were important to employers but not aware that skills and meaningful experiences were also viewed as important credentials alongside a professional attitude and interest to learn. Even at the reflection focus group at the end of the programme, the participants seemed to not fully realise the tools and opportunities their Talent Bank participation had afforded them. In contrast, the employers' views spoke most favourably about the learning journey and what the participants were able to articulate about their own learning experiences and skills. This suggests an opportunity for participants to be coached in how to articulate their learning experiences to sell their capabilities in interviews. Conversely, STEM studies conducted in higher education suggest the main expectation from students is to develop job skills and gain experience (Daugherty, 2011, Swanson and Tomkovick, 2011). This may suggest that the University places more emphasis on developing individual profiles for future careers than the case within further education.

Secondly, the educators provided a mix of perceptions and views on the Talent Bank model and its vision to resolve the regional talent problem for the life science sector. At the outset of presenting the Talent Bank model, there appeared to be a range of perspectives from educators ranging from the most positive to the most negative. This was in direct contrast to the views of the employer stakeholders who overwhelmingly identified an urgent need for such an intervention and welcomed the proposed model. The implications from these differences can help to inform of any potential conflict and should be considered against the proposed changes, as issues in communication could negatively affect and derail the implementation of a new programme. The FEI should plan time and communication to gain the trust of their educators to view the new programme as a pilot with the intention of improving learner experiences. It should highlight how it will fill gaps in the institution's education portfolio and the enhancements it aims to gain. Advocates or champions should be used to continually provide ongoing two-way communication to ensure any issues are addressed instead of being left to fester and build.

Secondly, the qualitative data evidenced that participants held the opinion that their A level qualifications and future degrees were the most important credentials when employers select future talent. Whilst they acknowledged that work experience was also important, many did not realise the range of experiences that could help distinguish themselves from the competition and the importance of skill development and professionalism that added value to their personal profiles.

The educationalists involved and some working with the participants on other programmes commented favourably about the learners' progress in gaining knowledge that could often underpin their A levels, whilst seeing the development of skills and growth in confidence over time. The educationalists who worked at both the college and supporting the Talent Bank students also fielded interest from other potential students to join the programme. Whilst it was not possible to accept later applications to join the programme due to the set criteria by the institution, the researcher believes that the collaborative approach between the three-stakeholder group provided unintentional benefits in marketing the programme primarily through word of mouth. This revealed the importance of using those involved in the programme as champions to further advocate interest and support.

7.2.5 Support of the region's life science ecosystem

Employers from the region's life science ecosystem were instrumental in supporting a range of activities that linked classroom learning with reality in the workplace. The life science ecosystem has a rich resource of expertise and facilities that has the unique potential to add value to the dynamic FE delivery model as ordinarily these resources were not accessible to FE students e.g., access to the training surgical suite or to the MRI scanner and other similar facilities. The value of this contribution cannot be easily quantified but participants positively refer to the benefit of the interactions and experiences with employers and their organisations. There are clearly implications to the FE sector to continue to develop relationships with the sector in order to continue to collaborate in the future. The key benefit from such collaboration also has an impact on the curricula design process in ensuring closer alignment of education provision with industry needs. The reality is that the further education sector needs to do more work creating a typology of college and industry partnerships to effect these changes and to gain the benefits for all students and sectors (Soares, 2010).

7.2.6 The Talent Bank Model and its experiential design

Since the commencement of this study many newer studies have been published examining the features and effects of experiential learning relating to integrated STEM education. Some notable studies of interest are discussed in the next section.

Kolb (1984) Experiential Learning Theory underpins the design features selected within the Talent Bank integrated STEM intervention model. Experiential learning usually refers to more hands-on, practical activities which places an emphasis on the process of reflective practice rather than more traditionally delivered STEM learning strategies. As the life science sector is dynamic and constantly changing as it pushes the boundaries of knowledge, it is difficult for practitioners to truly keep abreast of the changes in sectors, in order to reflect them in the planned learning experiences for their students. Curriculum development practices in FE seldom draws on ongoing expertise from employers unlike the higher education sector. Therefore, there is an obvious divergence between the curriculum, its delivery and the expected talent outcomes needed by industry. As a result, criticism levied at the FE sector suggests more can be done to bridge the gap between the supply and demand for STEM talent within the region through interventions and collaboration with industry (Holman and Finegold, 2010; Keep, 2012; Dymoch and Tyler, 2018).

Kelley and Knowles (2016) in their study of integrated STEM interventions, identified a criticism of researchers suggesting that they need to document their interventions and curriculum and detail more overtly how programmes were implemented. They suggested more evidence needs to be collected on the nature of the integration, methods used and the instructional delivery designs. The researcher has responded to this call to action and provided the key documentation used in the action research study either within the defined chapters or within the Appendices. The intention is that these documents can serve as scaffolding or frameworks for other practitioners or researchers to further assess or test the strategies in alternative contexts and add to the body of knowledge.

In a study by Kennedy and Odell (2014), reference was made to the importance of high quality STEM education programmes where the following elements were identified: a) the integration of STEM disciplines b) the promotion of scientific enquiry c) the offer of collaborative approaches to learning by connecting students and educators with STEM fields and professionals (Dymock and Tyler, 2018; Carbone et al., 2020), d) the development and provision of global and multi-perspective viewpoints e) the incorporation of strategies such as project based learning and formal and informal learning experiences and f) the incorporation of appropriate technologies to enhance learning. The researcher reflected on these elements and their emphasis was placed at the heart of the Talent Bank design. The model delivered on the many high-quality elements highlighted by Kennedy and Odell (2014) with the exception of using ‘appropriate technologies to enhance learning’. Whilst this element was identified and planned within the digital skills strand and several sessions were scheduled including presentations on the Internet of Things, Drone Technology and Apple Spiro demonstration, the researcher’s reflection considers this a key area for expanding and further improvement.

Since the commencement of the action research study a large-scale review of integrated STEM education and the instructional practices in secondary education was conducted by Thibaut et al., (2018). Integration of STEM content is outlined in many studies with experiential learning and instructional practices that advocate making connections between the STEM disciplines although the terminology used often differs. Bryan et al., 2015 refers to a spectrum of approaches that considers the delivery of the subject specific concepts and skills learned separately in each discipline and where students are expected to connect the content taught in different lessons on their own. Contrasted to the transdisciplinary approach where all the STEM disciplines are integrated into authentic and real contexts (examples of this transdisciplinary approach from the existing study includes a broad range of activities from across the STEM spectrum including: company visits, mentoring and work placements – NHS departments, volunteering in care homes, visits to research centres, accessing e-mentoring platform with role models; development of skills training workshops: – robotics, resuscitation techniques, signs of and dealing with death, simulated dissections or laboratories experiments – DNA of a strawberry experiment and lab book recording; dealing with live issues and problems through the Industry Challenge. Roehrig et al., (2012) makes the distinction that merging the disciplines and their content into a singular or themed curricula activity can highlight 'big ideas' from multiple content areas, suggesting that making strong connections between different STEM subjects is necessary for integrated STEM to work. Accordingly, these hands-on activities offer a bridge from the classroom to the world of work (Coco, 2000), enabling students to apply theoretical understanding to the world of work, and to experience professional practice and activities related to the application of knowledge (Beggs, Ross and Goodwin, 2008).

Pearson (2017) identifies the importance of making the integration explicit and to support students in building knowledge and skills across disciplines although this relies on students requiring sufficient knowledge of the relevant concepts in the individual subjects to connect ideas across disciplines (ibid). The Talent Bank study did not find evidence to support this notion as the students came from a diverse range of subjects and background but were still able to explore the industry challenge topic of ‘Diabetes in Wales’ through a range of experiential activities in addition, to the application of their research skills from the research methods unit and group work. The reflective practice enabled students to demonstrate their learning and understanding through peer discussions and identify links to current and future understanding.

Some key implementation points are raised regarding the delivery of integrated STEM across a range of different articles. According to Ashgar et al., (2012); and Bybee, (2010), instruction should be initiated with students by introducing a problematic situation that serves as the main vehicle and context for learning. By introducing the context at the commencement of the programme, students are better able to draw on existing knowledge from their STEM disciplines, utilise existing skills sets and prior experiences in a more meaningful way. Guzey et al., (2016), further suggest that instructions that take place in motivating and engaging contexts involving current events and contemporary issues, enable students to link the knowledge and skills to be learned to their personal experiences and meaningful learning is better encouraged.

Finally, the challenges presented should resemble authentic, open-ended, real-world issues where there is an abundance of information (Burrows et al., 2014; Shahali et al., 2017). This resembles the real work challenges of scientists and engineers in the workplace and allow for a multiple of solution paths and answers as identified in Ashgar et al., (2012). In many studies, experiential learning activities are used to promote knowledge construction (Wells, 2016) and students are stimulated to question their existing understanding about a topic and to identify the additional knowledge they require to move forward (Strump et al., 2016; Wells, 2016). Students through the development of their reflective practice, learn to use their prior knowledge to generate innovative ideas, design and construct research and investigations that lead to the discovery of new concepts (Wells,2016).

Predictors of success are identified as a number of variables associated with the effectiveness of a STEM intervention programmes (Nugent, et al.,2010). The quality of mentoring is a key area identified for improvement from within the Talent Bank study. The e-learning mentoring provision delivered by the Mullany Trust provided unique opportunities to connect participants with industry role models from across the United Kingdom. However, teacher observations and participant feedback indicated that this feature of the model surprisingly provided the lowest satisfaction score and needs adjustment and further support. The results may be attributed to further education participant inhibitions to online learning and engaging with ‘strangers”. Since the Covid 19 pandemic and greater access to online education, this may be less of an issue in the future. Other studies reference the quality of mentoring as a key predictor of success for example in internships (Coco, 2000). Evidence also suggests that challenging and realistic projects (Coco, 2000, Stump et al., 2016; Shahali et al., 2017, Keep) and greater autonomy (Mathis et al., 2017; Guzey et al., 2016) play a role in predicting effectiveness. Beneficial effects reported in other studies suggest that experiential learning promotes positive student attitudes (Swanson and Tomkovick, 2012).

The action research has contributed a singular case study of the design and implementation of an integrated STEM model called the Talent Bank. The model is underpinned by a curated set of experiential learning activities over the course of the programme and tests the support in delivery by employers and academics from the region’s life science sector. The study uniquely contributes to the literature on experiential learning (Kolb, 1084) as the theory underpins the design of the model that aims to address the regional need for talent with a bespoke curricula solution. The study was designed to use an action research approach to bring about change to curriculum development praxis in further education, by using three lenses of perception and views from different stakeholders (Brookes, 2005).

7.3 Interpretation of Results of the Study

Qualitative data was the main data collected in this study. However, several quantitative data sets were also collected unintentionally that may also play significance to the findings. Attendance records for both cohort of learner participants show remarkably high levels of attendance despite the programme being a voluntary extra provision on an otherwise 'free day' and the logistics of getting to and from the university campus location previously highlighted as an issue for some participants. That said, motivation levels of the students were also deemed high and largely focused, suggesting a pre-interest in the sector helped to maintain commitment across the entire schedule. The attendance records also reflect higher than normal attendance patterns than at the FE college. When asked about these levels of attendance in comparison to their other courses, participants indicated that they did not want to miss out on any opportunities as each week was designed differently to the previous. This created an advantage as well as a disadvantage. Organizing the programme and schedule of activities, the researcher and teaching team needed to arrange each scheduled day at least two weeks in advance. For some participants, the spark of interest of not really knowing what was scheduled created interest, whereas for others the feedback suggested a pre-planned schedule would be beneficial. The researcher also questions that those that felt the need for a structured and defined programme may select the sessions to attend and then the high levels of attendance would suffer and affect its viability. The researcher shared the reasoning for the lack of pre-issued and planned programme due to the varying nature of employer availability and last-minute changes and contingency plans that needed to be accommodated.

An important aspect of the support for the Talent Bank model from partner organisations, is to remember that it is offered in good faith on the understanding that flexibility must be paramount and that business needs must take priority over the programme. Several back-up plans needed to be put into place on several occasions when circumstances like this arose. With a small group of students i.e., less than 12, it can be questionable whether the session is feasible and of value or worth the time and effort made by employers and their representatives. Conversely, if decisions were made on mainstreaming the programme considerations would need to be given to larger cohort sizes. A maximum cohort size of seventeen on a minibus would impact arrangements, for instance on company visits as this would need to include the driver and at least one accompanying teacher. Alternatively, company visits prefer smaller cohorts of 6-8 when visiting workplaces to minimise any business disruption. These considerations were not necessarily considered at the outset but formed part of the learning takeaways from dealing with various programme activities and their implementation.

In hindsight, a mixed method approach to include a form of quantitative data could have been of value as part of learner participant reflective diary. The intention was to collect data on learner participant perceptions of learning experiences and the benefits gained. Despite the small cohort sizes, it would have been an interesting dimension to inform on the perceived value and rating of a particular feature and each week's programme. Analysing the qualitative feedback suggests correlation between the experiences of the two cohort groups. Both cohorts provided positive feedback on the Talent Bank approach, delivery and the engagement with employers. In the focus group all students were able to identify a person from the masterclass sessions that influenced them most on the programme and explain why. A key learning takeaway was to identify the personal motivations of each participant through a one-to-one interview to gain a deep understanding of their interests to offer a tailored and bespoke career plan. A few students identified several career interests, and the programme was able to match up role models to work with them to find out if the careers were potential areas they could consider for future employment.

7.4 Conclusion to Chapter

This chapter discusses the findings from three action research cycles. The Talent Bank study provides evidence that a collaborative approach to the praxis of curricula development in further education can lead to a more aligned and responsive provision that meets the needs of the life sciences sector with a combination of academic, employer, and participant involvement. The study evidences an approach and model that could be used by the FE institution to better address regional workforce needs with more relevant and focused experiential learning opportunities that utilise the wealth of existing expertise, facilities and resources from within the region's ecosystem. The impact of the experiential learning design within the model, as articulated amongst participants, suggests more effective learning and stronger awareness and understanding of STEM related concepts, careers and skills. Using a process of reflective practice following each learning experience, helped participants build on existing knowledge, assimilate new understanding from their experience, making connections with real life contexts whilst identifying its relevance and application to the future. However, the researcher suggests more research is needed on embedding reflective practice into further education. Learning derived from taking part in the experience, participants are better able to connect theories and deepen knowledge learnt in the classroom when applied to real world situations. As a hybrid model that accompanies existing STEM disciplines taught in a more traditional way, the holistic benefits from the

Talent Bank approach could have implications for other curricula areas, particularly in response to emerging sectors within the region's economy. This action research approach could introduce the changes required to respond to the workforce needs of the regional economy, ensuring any new curricula in the future is more aligned to meet these needs without disrupting existing provision.

The next chapter will draw together the findings from the action research study in order to present its conclusions and contributions to knowledge. The chapter will outline the key limitations together with recommendations for future research.

Chapter 8

CONCLUSIONS & RECOMMENDATIONS

8 CONCLUSIONS & RECOMMENDATIONS

8.1 Introduction

This chapter presents a synthesis of the research findings and its contribution to new knowledge and practice. In the following section, the researcher explores the originality of this research in relation to the multiple dimensions incorporated and draws conclusions to the major contributions to the wider body of literature. The chapter identifies the limitations within the study and concludes with recommendations for further research.

8.2 Revisiting the Problem

The impetus for the research study originated from a set of recommendations from a regional study, Life Science, Skills for Life (2014), which identified a lack of a sustainable talent pool to support the workforce needs of an evolving life science sector in the southwest region of Wales. The recommendations were levied at the FE sector with the aim of bringing about change in order to address the challenges identified. The research aims to develop a sustainable solution to the regional talent problem by developing an industry-facing STEM intervention, which could run alongside existing FE STEM education provision. This would be achieved by enhancing the existing curricula development praxis within the FE college.

The current state of knowledge in the field identifies gaps in the literature relating to workforce education and talent development, specifically in relation to regional solutions involving further education and the life science sector. The Talent Bank model draws on other STEM models identified in the literature with a focus on the design of experiential learning experiences aimed at raising awareness of the sector's talent needs and its range of STEM careers. The delivery model utilises a collection of key features and skills strands which aim to complement the pedagogical approach of experiential learning. The support of employers from the regional life science ecosystem is tested in the implementation of the pilot study, to see if their involvement can be relied upon to deliver the dynamic workforce education programme. The hypothesis is that further education curricula can be better aligned to the requirements of the sector and thereby address the sectoral talent needs through a collaborative approach drawing on the perspectives of industry, education and participant stakeholders.

The study shows the process adopted in designing, planning, implementing and evaluating the Talent Bank STEM intervention. The intervention aimed to raise awareness of the life science sector and the career opportunities in the southwest region with a view to inspire and increase consideration of future STEM careers amongst young people. The study aimed to widen aspirations by:

- Increasing awareness and knowledge of the life science sector and its importance to the regional economy
- Increasing awareness of the careers offered within the sector.
- Increasing knowledge of the needs of talent sought by employers in recruitment.
- Developing a range of skills, experiences and practical applications amongst participants through a range of learning experiences and additional qualifications within a STEM context whilst enhancing individual profiles.

8.3 Approach

The originality of the thesis is also evidenced in its methodology. The study adopts an action research approach over three action cycles over the course of the timeline. Two small cohorts of participants tested the Talent Bank model over two consecutive academic years as part of a day release from college. The programme was set within the university location to pilot its design and implementation with its bespoke skills strands and key delivery features over 26 and 24-week programme timelines.

8.4 Summary of research findings

The key findings from the action research study are:

- An action research approach to localised problem solving can be evidenced as a positive and practical approach to bring about change.

- The study was able to leverage expertise and resources from the life sciences ecosystem which demonstrated the sector's willingness to collaborate with FE to support the development and delivery of a solution - the bespoke and dynamic Talent Bank programme. This is a significant finding as the involvement of industry in curricula design can ensure provision is more relevant and aligned to the needs of industry.

- The findings from the stakeholder groups show differences in perspectives and areas of common view. The employer stakeholders illustrated a common need for a talent solution and a willingness to collaborate with further education stakeholders in its design. The educator's stakeholder group shows a mix of perceptions from across the education sectors including school, college and university contexts. Some FE lecturers were protectionist and adverse to the proposed intervention programme based on the likely changes it may have to their existing practices.

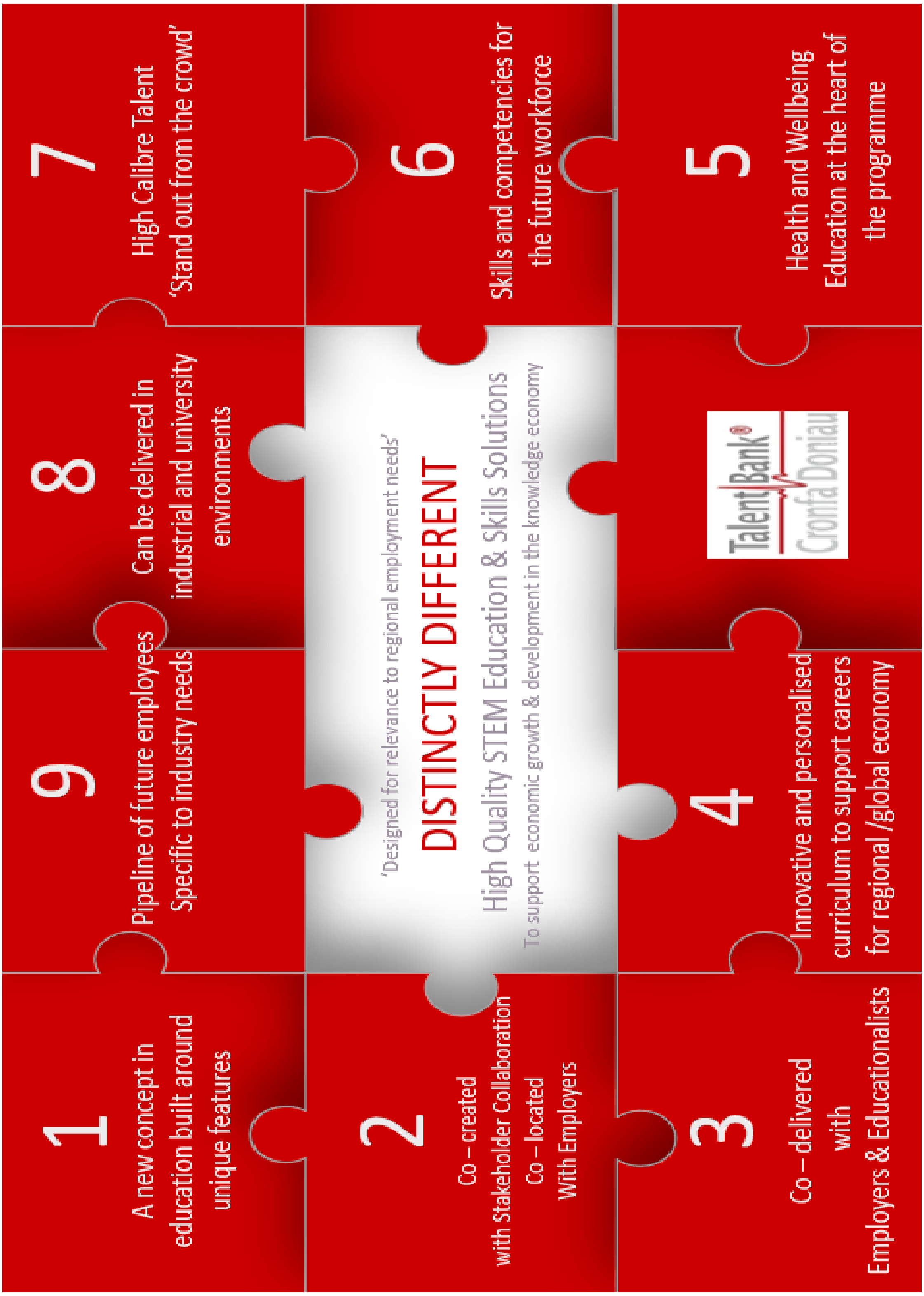

Figure 37: Talent Bank Regional Solution. The region's life science ecosystem is well developed with both large and medium sized multinationals as well as public sector healthcare organisations and various incubation facilities with micro and SME organisations. The Welsh Government's policy and regional strategies support the anticipated exponential growth in future employment opportunities. The researcher approached many organisations to seek their views on the intervention and its design and received encouragement and offers of various means of support in its implementation and delivery.

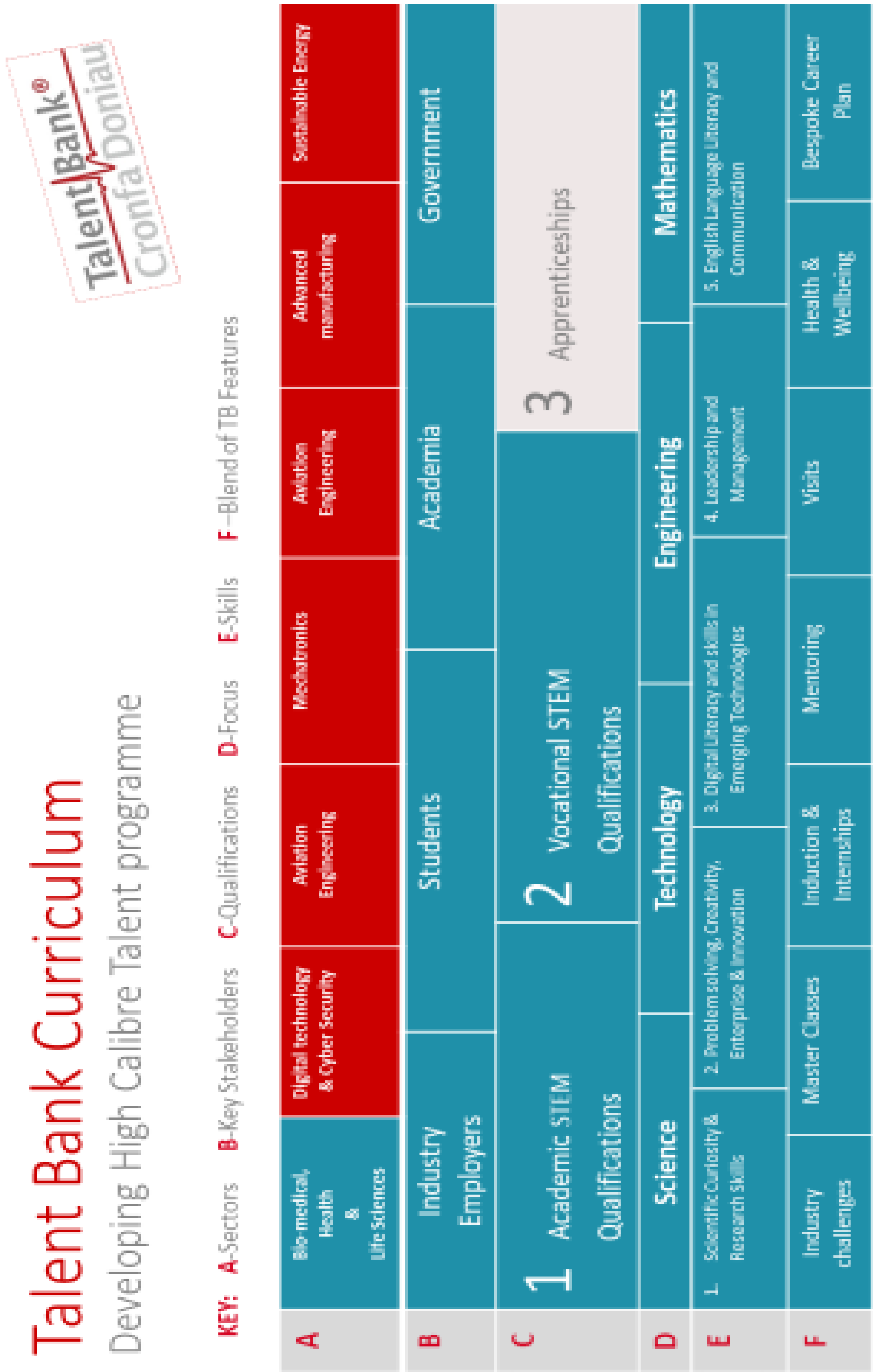

Figure 38: Created and designed by the Researcher Practitioner: (2016 -2018).

Participant's perceptions were most notably different to those of employers and educators, believing that qualifications were the most important requisite by employers when recruiting. These findings indicate the importance of considering the viewpoints of all stakeholders when developing new curricula plans. By valuing different viewpoints and understanding any differences in opinion that can be shared, it will help stakeholders appreciate each other's viewpoints and mitigate any problems such as sabotage or negativity from arising.

- Work experience and working with employers were the most popular reasons of participant stakeholders for joining the TB programme.

- The Operating Theatre live demonstration and hands-on workshop at which students assumed the role of an A and E doctor and a pathologist to identify the causes of death in a patient, were identified as the most memorable and enjoyable learning experiences of the programme. The experiences were designed to provide kinaesthetic learning. Observations of the workshop highlight the positive engagement and curiosity of students to enact in role play in areas they would ordinarily not be exposed to in a college setting. An endorsement letter from Operating Theatre Live commending the Talent Bank workshops is presented in Appendix R.

- The participation in the Talent Bank programme was voluntary and took place on a day release basis. Weekly attendance records were over 90 percent - a high rate for extracurricular activities suggesting high interest and motivation levels for the programme content. The extra-curricular activities provide opportunities for reinforcing classroom learning, offering the students the opportunity to apply academic skills in a real-world context. Research suggests participation in extra-curricular activities may increase a student's sense of engagement and lead to a decrease in the likelihood of failure or dropping out of education (Lamborn et al., 1992; Finn, 1993). If participation in extracurricular activities such as the Talent Bank can lead to student success, then access to the programme should be opened and available to students of all backgrounds. This raises an important implication about equality of opportunity.

- While findings did not show an increase towards promoted careers in life sciences, participants did indicate greater awareness and understanding of the sector. All participants indicated a likelihood to continue in a STEM related field at universities. Another indicator of successful participation includes aspirations to continue education beyond college (Freedman, 1995). If the Talent Bank became a sustained action research study, future research may be able to identify if there is any correlation of impact on industry recruitment from the Talent Bank as this could be used to open-up the existing talent pipeline from the existing outflow post university to a new outflow post college education. This is an area for potential development and consideration to ensure the true impact from the Talent Bank benefits the life science sector within the southwest region. An example of a press release referring to the launch of the Talent Bank facility and its opportunities is included in Appendix S.

- The research also presents evidence of an unintended benefit from participation in the Talent Bank intervention. Two participants who were interested in medicine had achieved average GCSE scores and disappointing results at AS level. However, the strength of their application to medical school from their experiences on the Talent Bank programme enabled them to secure places at University Medical schools at Imperial and Plymouth. These participants were able to improve their grades overall and re-balance any lower grades with a range of context relevant experiences and an enhanced skills profile that enabled them to compete with talented and gifted students. There may be implications from this finding that relate to the FEI offering the Talent Bank as a ‘second chance’ programme that helps to restore or rebalance the impact of previously average or less competitive results.

- Understanding perspectives through the lenses of different stakeholders enables curricula designers to create intervention programmes that are dynamic, responsive and aligned with stakeholder and sectoral needs.

Adopting a collaborative model of curricula development, design and delivery can also have long lasting implications on the value and impact of workforce education and strengthen the relationships between industry and further education.

8.5 Contribution to Knowledge

The key original contributions claimed from this research and which contribute to a wider body of knowledge are summarised in the introduction in Table 2, page 21. These are further discussed:

- Action research as an approach to conducting research whilst implementing change to resolve local problems by its very nature generates new knowledge. Whilst the context to the study was set in the southwest region of Wales and focused on the life science and FE sectors, the talent and skills problem investigated represents a real issue and concludes with a case study likely to be of value to many other regions and sectors.
- The study set out to design and implement an effective integrated STEM intervention model that could run alongside existing individual STEM disciplines in the FE college setting, to raise awareness of the careers and opportunities in life science and associated STEM sectors. The delivery of the Talent Bank programme factored employer support and access to facilities and resources from across the region's life science ecosystem to provide a set of unique and valuable learning experiences over the 26/24 weeks. The model provides a framework, but its implementation relies on being dynamic and responsive to industry inputs and developments. The success of this model is therefore predicated on strong relationships between educators and employer networks. The piloting of the Talent Bank with two cohorts of participants over two academic cycles show similar outputs. Participants on the TB programme respond well to the learning experiences designed and their personal development of these experiences and skills is evidenced in

their curricula vitae, Universities and Colleges Admissions Service (UCAS) applications and assessed presentations and work.

- This research provides a foundation for understanding how and why an integrated STEM intervention (Talent Bank) can support improvement in STEM learning outcomes and how it can be designed using experiential learning to be more effective in raising awareness and understanding of the life science sector and the careers it has to offer, amongst participants by presenting them in a way more closely representative of the reality of the sector. This extends the impact of academic research beyond academia and provides evidence of a regional community benefit.
- The requirements of REF 2014 (Given et al., 2015) have placed a requirement on research to provide evidence of societal impact. The action research study illustrates how its application can support the co-design, co-location and co-delivery of a STEM intervention solution to address a region's talent needs. The translation of academic research into practice is built into the study's design and is a key motivation for choosing the action research approach. The Talent Bank will contribute to the case studies on integrated STEM interventions which are mainly focused on secondary schools or higher education, as only a few studies are scoped for the further education sector or targets young people aged 16-19 years. Additionally, the Talent Bank has represented one of the projects within the ARCH portfolio. Further research on the success of the skills strategy and alignment with the evolving sectoral talent needs of the southwest region may include the Talent Bank as part of a broader regional case study. The ARCH overview of the Talent Bank skills facility project for Life Sciences and Health is presented in Appendix T.
- This study contributes to research on the integration and application of experiential learning theory in an industry facing education programme. Experiential learning theory states that reflection is as important to learning as action. It provides practical application of designing experiential learning opportunities combined with direct instruction within an integrated framework. Other studies such as (Roy & Novotny, 2001;

Bell, 2011; Charles, 2014) advocate blending learning theories since no one singular theory can accommodate all learning context that occur in real life or suit individuals preferred methods of learning. The practice of designing experiential learning helps participants understand what they already know, why they are learning the content and how it can be applied and developed in a constructed way to a real-life situation. The reflection of learning helps participants understand the change in understanding and the learning that has taken place. The findings illustrate the importance of reflection on a learning experience either written through the reflective diary accounts or verbally, guided by a set of questions to probe understanding of the experiential learning opportunity. The significance of experiential learning is not only that it involves the learner in an alternative way of learning but that it combines education and organisational contexts and thereby enables a better learning process which can lead to improvement in student learning outcomes.

- The findings from the study contribute to research conversations on young people’s aspirations and choices to study STEM post compulsory education. It provides supplementary evidence of how young people can be inspired to consider STEM as a future career choice, if given access to realistic work environments that demonstrate what working in the sector looks like. The PhD also provides evidence that an intervention programme can be used to support those who are not likely to be considered for medicine to consider other career options that they may have not been exposed to previously.
- The integration of careers into STEM intervention programmes through masterclass series, access to role models, company facilities and resources broaden and enrich the range of experiences. The study contributes to STEM career research by providing practical examples of how careers can be incorporated into age appropriate, hands-on activities that can be incorporated into existing or as standalone provision. By using employer role models the participants can relate and interact with visiting speakers and access information and wisdom on

career choices and personal journeys. This contributes to STEM learning on careers that engage student interests (Cotabish et al.,2013); Wooten et al., 2013).

- Action research contributes to wider conversation on its effectiveness to resolve local problems and bring about change to praxis. The iterative nature of the action cycle and the 4-step approach of planning, actioning, observing and reflecting provided the opportunity to test identified gaps with assumptions, ideas, or suggestions to see what works, what does not work well and to make adaptions and improvements based on stakeholder perceptions and feedback. The action research also provides evidence of unintentional outcomes that can occur providing hidden benefits of impact. By evaluating experiences via observations and reflective diaries any unintended or negative impacts can be mitigated at that moment in time rather than waiting until the results are known at the end of the study.
- Another contribution from this study arises from the multi-disciplinary approach adopted. The data gathering of three different stakeholder perspectives helps to show differences and similarities which support a better design and alignment with each stakeholder group needs. An understanding of differing and competing interests can be utilised in other disciplines regarding bringing about change. This would provide further evidence to demonstrate the need for adaptability and flexibility of the model and its implementation processes.
- The researcher's own career development and learning experiences on the PhD journey have contributed to her own personal knowledge development which has led to change in her own curricula development practice. Further explanation of this contribution will be outlined in Chapter 9.

8.6 Limitations and Future Work

This study is not without its limitations. The research uses a small sample and so generalizations of findings cannot be interpreted for replication to a population at large. In addition, small sample sizes limit the ability to understand any mechanisms that lead to productive patterns. However, this limitation does not undermine the contributions of the model or the approach - further studies can adapt and apply the study to larger cohort sizes. For the financial viability and sustainability of the Talent Bank programme, it is likely the FEI would need to consider scaling up the number of participants on the programme. This could lead to the need to examine the effectiveness of a larger cohort in a scaled-up research study. In turn, a larger cohort size would likely generate quantitative data where statistical inferences may be drawn, therefore a mixed method approach has the potential of being more suited to a larger more complex study. Secondly, the study is constrained to the geographical southwest region of Wales. Future studies could be compared to similar studies in other life sciences hotspots in the UK to explore the differences in cultural contexts and to see if similar findings can be established increasing STEM awareness and career aspirations amongst participants.

The researcher comes from a non-STEM background. Research suggests the critical importance of being STEM qualified and experienced in a discipline for success in a STEM intervention. The suggestion is that a non-STEM practitioner may limit the impact on the success of an intervention. This assertion needs further study and exploration as this was not a consideration of the current research.

A further limitation was the lack of a control group to measure impact against. The researcher reflected on the benefit of using a control group to enable the identification of programme effects and student selection. Whilst selection bias of participants i.e. only selecting those that already do well in STEM was ruled out at the outset, as it was predetermined that only students who selected three A levels would be considered for participation. A reflective thought for further study could explore differences in outputs if a control group delivered the context of the intervention in the traditional classroom alongside a Talent Bank cohort with a non-stem practitioner and employers. The question to ask is: would the participants gain the same enjoyment, value and benefits of awareness or would different findings be revealed?

A final limitation is that the study cannot reveal its impact on influencing the career destination of the participants and if they in fact pursue a STEM related career, as the timeline of the study only accounted for one academic year. A future study could explore the longitudinal progress of the participants involved in the Talent Bank to follow up on their career journeys to identify the careers they ultimately pursue, for example, in 5 years' time.

An additional recommendation for future research is in broadening the use and application of action research in all aspects of education including schools and colleges to bring about positive change. Championing the benefits of action research in education and promoting opportunities for practitioners to get involved in their own research to investigate solutions to problems in their own classes or departments could do much to develop the profession and the education sector’s research agenda. Lastly, a recommendation for the further education institution is to cultivate leaders as change agents to encourage action research as a tool to bring about innovation and change. This could provide encouragement and an opportunity for teachers to work with outside agencies on new learning programmes and services that could ultimately benefit all stakeholders and their organisations.

8.7 **Conclusion to Chapter**

This study provides a model framework through which an integrated STEM intervention design, based on the recommendations from regional research and other academic STEM studies, can effectively be implemented with a series of learning experiences to raise awareness of careers and the work of the life science sector. It contributes to the conversations on STEM learning, experiential learning theories, stakeholder collaboration and using an ecosystem to design and support a unique industry facing workplace and careers education programme. The research provides an approach and insight that other academics could utilise in their own intervention design. The study provides evidence of a real and practical application to stakeholder collaboration in the curricula development praxis of a STEM intervention in further education that aims to resolve and address a lack of suitable talent within a geographical region.

The next chapter is an epilogue to the study and focuses on the researcher's own reflections of the action research journey. The reflective epilogue will draw on the key aspects of the PhD study and its implications for the professional development and experience of the researcher-practitioner in learning the craft as an action researcher. She narrates her own story of personal change, from commencing as a novice to an action researcher, combining her role as a Regional Skills Advocate for the Life Science sector and her focus on curricula development practice as a means of seeking a solution to industry talent needs.

Chapter 9

REFLECTIVE EPILOGUE

'Who in the world am I? Ah, that's the great puzzle!

Lewis Carroll (1920)

9 REFLECTIVE EPILOGUE

9.1 Introduction

The purpose of this concluding chapter is an attempt to draw together and conclude the whole research journey and reflect on the personal impact it has had on the researcher. The individualised nature of a doctoral research degree makes it a highly bespoke undertaking, which will provide distinctly different characteristics and experiences for each individual. The chapter focuses on a few salient themes including the engaging of personal reflective practice, the development and growth of the researcher over the journey and the bridge to new opportunities the research provides beyond its submission. The purpose of this approach is not for self-indulgence but to hopefully share with the reader, an insight into some of the personal impact and challenges faced through the research endeavour and its effects on praxis, as the person setting out on this journey is vastly different to the one finishing it. This chapter therefore aims to encapsulate one's own individual growth and development through the entire learning journey. From this point forward, the reflective epilogue will take the mode of the first-person narrative to present one's experience of learning the craft of an applied action researcher.

It would be impossible to share all the highs and lows of this intrepid journey in a single chapter, so I will recount a few of the most symbolic moments and themes I feel represent the range of my experiences on the journey from the outset to the 'finishing line.' I will also discuss the role of reflective practice and the value of engaging in a self-narrative, that can lead to recognising personal growth, learning and development. I highlight some of the most important skills and personal attributes developed as a direct consequence of conducting this research. Finally, I outline the impact of the research on my own practice, and on the host organisation and how it ultimately shapes who I am as an educator today and where it may potentially lead me in the future.

9.2 **Reflective Practice**

When individuals decide to carry out action research, they generally want to find ways of understanding their circumstances and contexts better and find out what changes can be made to improve and enrich both their own situations and that of others. McNiff (2002, p.26) points out that 'action researchers are real people in real situations' who ask the question how can I improve or change what I am doing, necessary to work towards a better or improved result? Self-reflection is a key component of the learning process as the researcher simultaneously inquiries into others' lives whilst addressing their own role needs that combine as a researcher and practitioner.

'We do not learn from experience…

we learn from reflecting on experience'

John Dewey (1938)

Reflective practice is the ability to look back and review one's actions in order to develop a greater insight and understanding of oneself through a process of continuous learning when involved in a process with social interaction (Thompson & Thompson (2008). The practice of reflection is widespread in education, where practitioners learn at the outset of their training to self-reflect after lessons and to identify learning takeaways that can inform changes to improve future practice (Finlay, 2008). John Dewey (1933) emphasised the importance and use of experimentation as an approach to new knowledge. He considered reflective thought and its value as careful consideration of any form of knowledge which is built on successive portions of reflective thought. In relation to my research, reflective practice has been instrumental in developing a deeper insight and understanding of the context of inquiry from an internal perspective. This personal and subjective approach has offered a rich and detailed understanding which supports two main purposes. Firstly, it has helped me to understand the influence I have as a researcher-practitioner on what and who I am researching, but also as McNiff (2002) contends, it also places a focus on the individual researcher and why they do the things they do.

These reflections are referred throughout the three action cycles that promote certain actions that lead to improved educational practices and pinpoint the changes implemented by the researcher from the learning and understanding of a particular situation at a moment in time (Usher & Bryant, 2014). Secondly, the thought-provoking experience from the ongoing process of critical reflection as an analysis, identifies how things happened and why they happened that uncovers and explores the ‘fact’ or ‘truth’ of applied research. This secondary theme is focused on the researcher’s own personal development, judgement and behaviour and forms much of the basis of this reflective epilogue.

I was first introduced to the application of ‘deep reflective practice when I attended an Aspiring Senior Leadership programme with Lancaster University. The strategic programme was residential in part, with the discussion and application of many theories. One of the most memorable challenges was in relation to reflective practice and how the use of strategies by educationalists can create reform and bring about change. Schon (1991) describes the importance of reflective practice to create models from a body of previous knowledge, suggesting skilled practitioners utilise their experiences as a basis for assessing and revising existing theories of action. During the practical application of the theory, I was paired with a peer who was a complete stranger and invited to build a tepee on a hillside. Once the tepee was built using the equipment tools and kit, a challenge was set to sit inside the tepee and answer each other’s constructed and probing questions about ourselves and our experiences, as honestly as possible. The two of us in turn, asked initial questions about family, education, our beliefs and values. As time passed by, we exhausted the broad questions, and our cross-examining became more probing and searching. I found myself responding to ’deep’ questions that ordinarily would be off limits. In debriefing, I learned that part of completing a reflection can present an inner sense of discomfort as also noted by Boyd and Fales (1983), so it is understandable that this experience of this approach to deeper reflective practice in talking to a stranger about my life, was both a surprising and unnerving one. However, this ‘deeper’ approach of building on more effective action strategies in terms of questioning techniques began to delve deeper and deeper into areas of our lives we had not spoken so freely about previously. This practical activity has subsequently helped me to consciously question and critically reflect on my actions and decisions and to consider what I would, should or could do differently to make change and bring about improvements in practice. The decision to work in collaboration with the three stakeholder groups evolved over a period of time. I pondered over what it would be like to walk in ‘someone else’s shoes, what perspectives would I have, or would I view things differently by looking through a separate set of lenses? This idea progressed to account for the perspectives of the employers, educators and participants and comparing their views against my own, acknowledging that there is always a multitude of ways of approaching situations. The techniques and practices have routinely become embedded into practice to critically evaluate my actions and thoughts and be more mindful of their implications on others in day-to-day life.

Each action cycle identifies a reflection step to consider the actions taken and alternative choices that could have been made before setting the next set of action cycle steps. The cyclical nature of action research always provides a prompt to reflect which is unlike more traditional research where reflection is considered towards the end. There are many models of reflection geared towards different situations and practices in challenging our own personal beliefs and assumptions, each with varying degrees of success. A particular model of reflective practice that has been of interest to me and that I have utilised throughout my career as an educator, is that of Kolb (1975) and his Experiential Learning circle model. Kolb and Fry (1975), suggest that the process of learning can begin by a specific action being conducted and then determining the effect the action has had in a particular situation. This suggests that experiencing the actions and the ability to review and see connections between the actions and effects over a range of circumstances, is where learning can occur. As a pragmatic educator, who is committed to lifelong learning and who has often learnt in this way, it is possible to anticipate the effects of an action in a new situation or environment. Alternatively, there may be real surprises or confusion about why a set of actions work or do not work.

9.3 The Journey from the Outset

At the start of this journey, I never envisaged the challenges, the high, lows and even the U-turns that would form the messy map towards this doctoral thesis. Had I been fully aware, and as dramatic as it may sound, it is very unlikely that I would have signed up to what can only be described as one of the most challenging experiences of my entire life.

My broad career experience across a range of roles in education including senior education leader; curriculum planner; teaching practitioner; senior mentor for new PGCE (Postgraduate Certificate in Education) teachers and Regional Skills Advocate coupled together with my Master's qualification, should have prepared me well for the challenge. However, I found the reality to be quite different. My skillset in the first two years particularly, identified gaps in knowledge, skills and experience. A large part of my time was spent undertaking a range of useful and accessible University courses to develop my understanding and application of a range of research-related knowledge and technical skills which became an essential platform as I started to engage in the craft of applied research.

My confidence was buoyant and positive at the outset but began to take on a meandering path through ups and downs as I encountered roadblocks and challenges with the early actions I wanted to take. I started to doubt myself and anxiety and stress grew from thinking about the enormity of what I had taken on whilst working a fulltime job and managing a young family. A recurring issue I have had to deal with throughout my research journey was struggling with self-belief and a lack of confidence, often referred to as Imposter Syndrome (Clance and Imes, 1978). I constantly self-check whether I have the capability and whether I am worthy of the academic challenge that a doctorate presents. I have become more aware of why I do this and can recognise the associated feelings of pressure and frustration it can build. Not once, had I previously considered the emotional turmoil the entire process would inflict on me and the learning of coping mechanisms required to get me through. It is important to note that a good supervisor or team will always be able to help you see that these are normal and common feelings, understandable anxieties and parr for the course. Talking through these, often destructive and debilitating thoughts and voicing my anxieties became an effective coping mechanism and the process of self-reflection helped me unscramble my messy map, time after time, enabling me to get back on a path where I could navigate through the insecurities and focus on the end goal.

Once I started my first action cycle, I began to keep a regular diary of my activities and reflective notes on my actions and feelings across the timeline of the thesis. On reviewing these entries, I am more conscious of the changes in my emotions and moods and how these sentiments have ebbed and flowed from the highs to the lows throughout the study. These records show some of my innermost thoughts and feelings particularly at times of uncertainty and low confidence, where I would find seemingly dead ends, roadblocks or be unsure as to how to determine the next course of action. Across the research timeline, the most positive sentiments were recorded when implementing the Talent Bank programme with participants. It seemed I was most positive, comfortable and at ease when working in my practitioner role with students. This third action cycle was the most rewarding and conversely, most negative sentiments were recorded in the writing up phase which took me out of my comfort zone.

Reviewing my reflective accounts has shown the sources and patterns of learning and discovery. They illustrate some of the unexpected feelings, the surprises and reactions that have helped shape and define who I am today. I have learnt to become more aware of my emotions and cognisant of my behaviour or reactions and how to manage them. Many of the reflection records refer to the contemplation of quitting most notably at the writing up stage, however the very act of writing to oneself as if from an out-of-body experience, illustrates the power of ones' resilience, perseverance and strength. Consequently, I am more conscious of the role my state of mind has played in the process and its effect on my endurance and wellbeing. In particular, I better understand how I approach the process of writing and whilst it may appear chaotic to any outsider, it is a process I have come to recognise is filled with procrastination and elements of eloquence that eventually lead to meaningful text. For me, writing up my action research was an arduous process from start to end and I can now claim to be an excellent procrastinator! I have learnt to practice the Pomodoro technique (Giesbrecht, 2015) where small, timed starter activities can help me re-engage with the writing process. If I have fallen off the path and lost momentum in my writing, I found that by dividing up tasks into much smaller, incremental actions, timed for completion within 20 minutes, I can rekindle my application and resolve to move forward.

In October 2018, I became what is termed by Wisker and Robinson (2012), a doctoral orphan with the loss of my supervision team. This was at a crucial time in the writing up phase where I felt isolated, disorientated and made little progress. I pursued various approaches, constantly changing formats with a scattergun approach. With hindsight I recognise that I wasted so much time with limited focus and strategy. My diary shows I craved support from someone who would understand me and my situation, someone to talk through my ideas and share what I was feeling or thinking. However, without a supervision team to call upon for support and re-assurance for much of this period, my writing progress was slow and lacked clarity as I dipped into different sections and formats with no real plan. I had to figure this out for myself and with hindsight, I recognise that this crucial period could have been a make-or-break situation. I sought out this support from alternative sources and it was not until I sat and talked through my position with a colleague who agreed to help me work through the turmoil that was causing a mental blockage, that I began to make real progress. Talking about the Talent Bank story and how it unfolded and retelling it through the writing process helped me to piece the jigsaw puzzle together. It was a welcome relief to realise and reflect on the contribution I have made through my research and that this wasting of time was a key aspect of my personal learning and development and I now recognise that this is a hallmark of how I work. My reflective diary logs were routinely captured manually and digitally, together with hundreds of photographs (Appendix P) and screenshots to recorded milestones, memories of key points of thought, further questions, potential actions or ideas. Looking back there were plenty of times of deep despair where I wanted to 'give up' but an inner voice grew from within to keep the end goal in mind, perseverance in the knowledge that the entire process would be worth it in the end. The following diary excerpt illustrates one of many instances when I was feeling low and illustrate how my mind was working and how I was able to move myself forward to act by identifying a simple step that could propel me into writing even a few sentences which would push me towards the end goal.

Diary extract of reflections to self – May 2018:

> *"I just want to cry!!! Not sure this is possible. Why am I putting myself through this? This is taking over my life! Just give –up you have nothing to prove!*

Note to Self:

> *All the research has been done – the hardest part is over. Just write up what happened. I wish I had heeded the advice of Brian to write just 500 words a day! You can do this – discipline yourself – just keep going!*
>
> *Action next step: Write a paragraph from your notes on the visit to UTC*
>
> *Liverpool's Open Day – when, where, how and why – then so what –* ***just write!***

Early progress, successes and key milestones were easily identifiable within each action cycle along the timeline – some of these notable highlights include:

- gaining ethical approval for the study
- winning a 50k bid with Fujitsu for the creation of a technology lab at Swansea University which would become a home for the Talent Bank programme
- presenting the TB intervention programme to the Chief Medical Officer, Wales as part of the ARCH (A Regional Collaboration for Health) development plan

- agreement from the Board of Governors to proceed with a pilot study from the FE (Further Education) institution,
- recruiting the first cohort of learner participants to pilot the Talent Bank model
- presenting my research at a symposium in Wuhan, China with peers from the University's Medical School
- winning the Annual Enterprise and Innovation Award from the Medical School at Swansea University for the Talent Bank programme
- gaining publicity with the BBC for the work the Talent Bank programme was providing young people in the region.
- the Talent Bank programme being considered as part of the skills strategy within the ARCH programme

These early milestones created momentum and were welcome 'highs' to the initial commitment and reason for creating positive change through the process of action research. These milestones also provided early validation of the need for the research. However, once the data had been gathered and the programme completed, these highlights soon became historical components and the levels of motivation frequently weakened. As a researcher, I had received tips and advice from fellow researchers who were further ahead in their research journey urging me to write up as much as possible early into my doctorate. The difficulties of juggling work, a family and my research were already competing for the limited time I had available. In hindsight, whilst I did not fully adhere to this advice and acknowledge my excuses, I recognise the value of this wisdom and on reflection I would advise writing drafts in tandem to the actual data collection to maximise any gains from the momentum.

This PhD has provided much personal growth and development of skill sets as a part of my evolving researcher role. Besides learning the craft as an action researcher in information management, analysis, problem solving, written and oral communication, reflective practice, and the research topic under investigation, I have honed and enhanced several valuable and transferable core skill sets. Note-worthy skills that are personally valuable in my roles both in and out of academia include practices relating to self and project management, habits that help me to organise myself and set goals. My project management skills have been tested from the initial design of the thesis through to implementation and write up within the designated timeline. Managing myself over this length of time required strong organisational skills, use of systems that help with structuring and formatting, discipline with time management strategies in order to meet targets within the timelines.

A further area of personal development relates to presenting in public. I have never enjoyed public speaking but my research has afforded and warranted several opportunities to present my research work: at a medical symposium in Wuhan, China, at a feminist youth conference in Brussel, at a health conference in Swansea and to the Chief Medical Officer for Wales as part of the ARCH pitch. On all these occasions, I have had to prepare myself to feel more comfortable in presenting my ideas and to engage with larger audiences.

Networking, collaboration and facilitating teamwork have also been instrumental skills honed through the duration of this study. Whilst the research is a solo project, it has not happened in a vacuum and necessitated working with a wide range of stakeholder groups, drawing on expertise from companies and individuals within the life science ecosystem and learning how to negotiate with contacts to generate support and value in the design of experiences for young people. Any initial inhibitions have been lost and I can confidently say that I now enjoy meeting new people and talking about my work and about how we can support our regional community. Several employers have complemented my passion for young people and written endorsement letters of support. (see Appendix R). In addition, my entrepreneurial skills in creating the design of the Talent Bank, its branding and building its profile within the community, led to winning the Enterprise and Innovation Award from the School of Medicine at Swansea University Annual Awards; another proud but very unexpected moment.

The level of criticism of oneself within reflective practice and in relation to research rigour can be likened to few professions. I strongly believe that student impact is one of the most critical indicators to the success of my research making the investment in time and effort, all worthwhile. As an applied researcher, the risk of spending time on a programme that did not have an impact on the lives of those it was designed for, presents an underlying pressure which can weigh heavily on your conscience. Fortunately, this research and the Talent Bank intervention programme had a positive impact on those who participated. The real recognition for my work lies in the impact and testimony of those participants who gave their time to volunteer for the programme. At the time of writing, three of the participants have secured places and progressed to Medical Schools, whilst other participants have progressed to study dentistry, midwifery, nursing, phlebotomy, medical engineering, forensic science and psychology with autism. It is gratifying to have designed such a programme and together with the support of other stakeholders, to have played an impactful part in the early career successes of those that took part.

Action research as a methodology has lent itself well to my own philosophical position, as well as being an appropriate context for the study to test a resolution to the community problem set within the region. The craft of a researcher is a complex and challenging one, but the breadth of this learning process has also provided a clearer reflection of the decisions taken as a researcher and as an individual as one evolves through change. As Nottingham (2007) suggests in his creation of the Learning Pit, “learning is a struggle; a process where you should step out of your comfort zone into a culture of challenge, curiosity, reflection, and resilience. Taking risks, trying out novel approaches, making mistakes and revealing your weaknesses can help you develop abilities and deepen your understanding of who you are.” Seeing light at the end of the journey is a welcome one. I can take comfort from knowing that my full spectrum of emotions and experiences are a normal part of the elongated doctorate learning journey. The enhanced knowledge and understanding afforded by this study are more than evident. I gladly share my perspective in this epilogue in the hope that it may be of value to other potential researchers on their own research journeys.

9.4 The Importance of My Practice on the Organisation

The value of my practice and the outputs of my thesis should be of significant importance to my host organisation. Certainly, the Talent Bank intervention and the case study it presents, demonstrates the FEI's commitment to responding to the recommendations levied against it in the Life Science, Skills for Life (2014) report. However, a great deal of change has occurred in the internal and external operating environment during the study's timeline. At the outset, I was seconded from the further education institution as a Senior Manager to work for the Welsh Government's Sector Priorities Pilot programme as a Regional Skills Advocate for the Life Science sector. The role meant that I supported new innovative pilot projects across the southwest region of Wales and facilitated collaborations between education providers and sector employers. In truth, I was in the right place, at the right time to be afforded the opportunity to utilise the research conducted as part of my job role and to build on it further, to meet the requirements of a doctoral degree in an area of pertinent interest. Whilst the doctoral degree itself was not important to my employer, the subject of my research was of great value and interest. The institution invested in resourcing the Talent Bank pilot programme to utilise the research for creating new education provision that would support the region and life sciences sector.

Other aspects of usefulness to the FE institution will be the value of extending collaboration and planning with external stakeholders in curriculum design, particularly in utilising 'employer voices' to ensure vocational curriculum is relevant to the needs of the future STEM workforce. These types of practices need to become an active part of the curriculum design process which can support a dynamic and relevant learning experience for students whilst ensuring the capabilities of future talent reflect the needs of employers. Finally, another important conclusion from the research is that the FE institution can be more responsive to needs for talent in the regional economy by working more collaboratively and in partnership with the HE (Higher Education) sector. The universities are more experienced, agile, and representative in this landscape and the FE sector can learn a great deal from their lead.

When reflecting on how much my research has contributed to the institution, I can evidence that many of the key features of the Talent Bank model have been main-streamed and adopted at the college. These features include the qualifications piloted such as the Extended Project Qualification that students achieve when they conduct research and report on it. This is viewed as a valuable skill by universities and is credited with additional Universities and Colleges Admissions Service (UCAS) points. In addition, a series of masterclasses has become part of a regular schedule for A level students drawing upon the network of contacts made by the Talent Bank. Work experience and volunteering are also opportunities more regularly available to students, but which have now been disrupted due to the Covid-19 pandemic.

Whilst the Talent Bank model cannot claim a sustained and transformative solution to the talent problem identified in the south-west region or for the life science sector, the model will live on in adaptions the researcher aims to progress elsewhere. The stakeholder model approach has been demonstrated to work particularly well drawing together different interested parties committed to resolving the region's talent issues. The creation of a responsive and dynamic learning experience for participants that complements existing FE curriculum, provides real benefit of insight into the typical sector and the careers it has to offer with added value for the learner participants involved. The life science sector has demonstrated its' commitment to support such innovative initiatives in partnership with education providers. The FE sector should respond positively to embrace and embed the change in practice to ensure future curriculum is as aligned with industry needs as possible. There are many learning takeaways the institution should find valuable but for gains to be made across the further education landscape more action research opportunities like these are needed. The institution needs to remove any barriers to collaboration in its truest form and embrace all that innovation and change can bring to the sector. Working collaboratively instead of in silos and worrying less about losing power will yield a focus on greater potential from synergetic gains where everyone including students and employers gain from the collaboration, its outputs, and successes.

At the submission stage of the thesis, I no longer work for the host organisation having resigned my employment in September 2018. The benefits of this action research thesis live on in my current role as an Academic Support Practitioner with the Ministry of Education in the United Arab Emirates. My role mentoring and coaching teachers, supporting them in applied practice and online teaching, engages action research on a daily basis. An element of the role of an applied practitioner is concerned with supporting other teachers to engage in small action research projects to enhance skills and experience whilst resolving 'small' problems and creating incremental change. As an action researcher, I achieved what I set out to achieve and on reflection I achieved so much more. I remain passionate about my story; I am well versed and accomplished to advise and support others in similar settings and this experience directly adds value and benefit to my new employer and colleagues. My career opportunities have been truly impacted and enhanced as a direct result of my action research capabilities and this elongated PhD journey.

9.5 Conclusion to Chapter

This concluding chapter has shared a narrative of some of the highlights of the research journey and may provide a useful resource for future PhD scholars in the evolving world of applied doctoral research.

I will confess that I did not really comprehend the enormity of the task at the outset and with this in hindsight I would probably not take on this challenge; that said, I would not want to deter anyone from taking up this enduring but rewarding experience. Reflecting on the journey, now that I am at the finish line, I look back with immense pride on what I have accomplished and how far I have come, as a professional educator and as an individual; proud that I was determined and resilient enough to the ever-growing doubts in my ability to succeed, particularly in the latter stages and did not succumb to throwing in the proverbial towel.

9.6 **Final Words**

The role of the research practitioner has always been to act as a facilitator in this study and to galvanise the ideas and thoughts spurred from interactions with stakeholders into co-creating a viable solution to the identified talent problem. Action research has offered the appropriate vehicle for the study, empowering the researcher-practitioner to conduct practical and applied research, which has led to a viable talent solution and improvements to curricula development praxis in support of the regional skills agenda. The creation of the Talent Bank intervention itself has required a degree of flair and creativity curating the rich facets of expertise, facilities, and resources to design an entertaining and fulfilling programme of learning experiences that can transform young people's lives and inspire them into future STEM careers of tomorrow.

For now, I am grateful to my family, colleagues, the stakeholders involved particularly the student participants for their support in this endeavour. The knowledge that this thesis has had a direct impact in shaping young lives, however small that shaping may be, has also been one of the main incentives for persevering to its conclusion. I hope that this thesis may inspire others to consider action research to resolve a community situation and bring about change for the better. I can acknowledge that action research has had a profound impact on my professional practice as an educator through the process of inquiry, dialogue, and reflection.

Tomorrow, I will start to view this life changing experience differently, and start to lose sight of the numerous challenges, demands and obstacles and begin to value and enjoy the rewards that it reaps in getting to this new position, ready for the next challenge – wherever and whatever that may be!

"It's no use going back to yesterday because I was a different person then"

Alice in Wonderland - Lewis Carroll (1920)

My final words refer to the prose 'Making Waves' and its' sentimental poetry which stimulates many of the emotions and experiences felt through my personal doctoral journey.

Making Waves

The road to progress is built by those who want to make a difference.

Foundations are formed upon industrious minds with a willingness to test the mettle and a flair for the dramatic

Together, expanding what we think, what we know

And though there will be adversity along the way

We will always rebuild, grow and evolve

Creating a legacy that helps us better understand the world around us

With the power to innovate

The will to make a home and the strength to succeed

It's about forging connections and exploring what drives us

Knowing our purpose, our rights, our power, our abilities and how to apply them

And for those ready to be the best they can

There will always be a place

To make waves

At Swansea University

Making Waves since 1920 – Swansea University Centenary accessed 1/7/20

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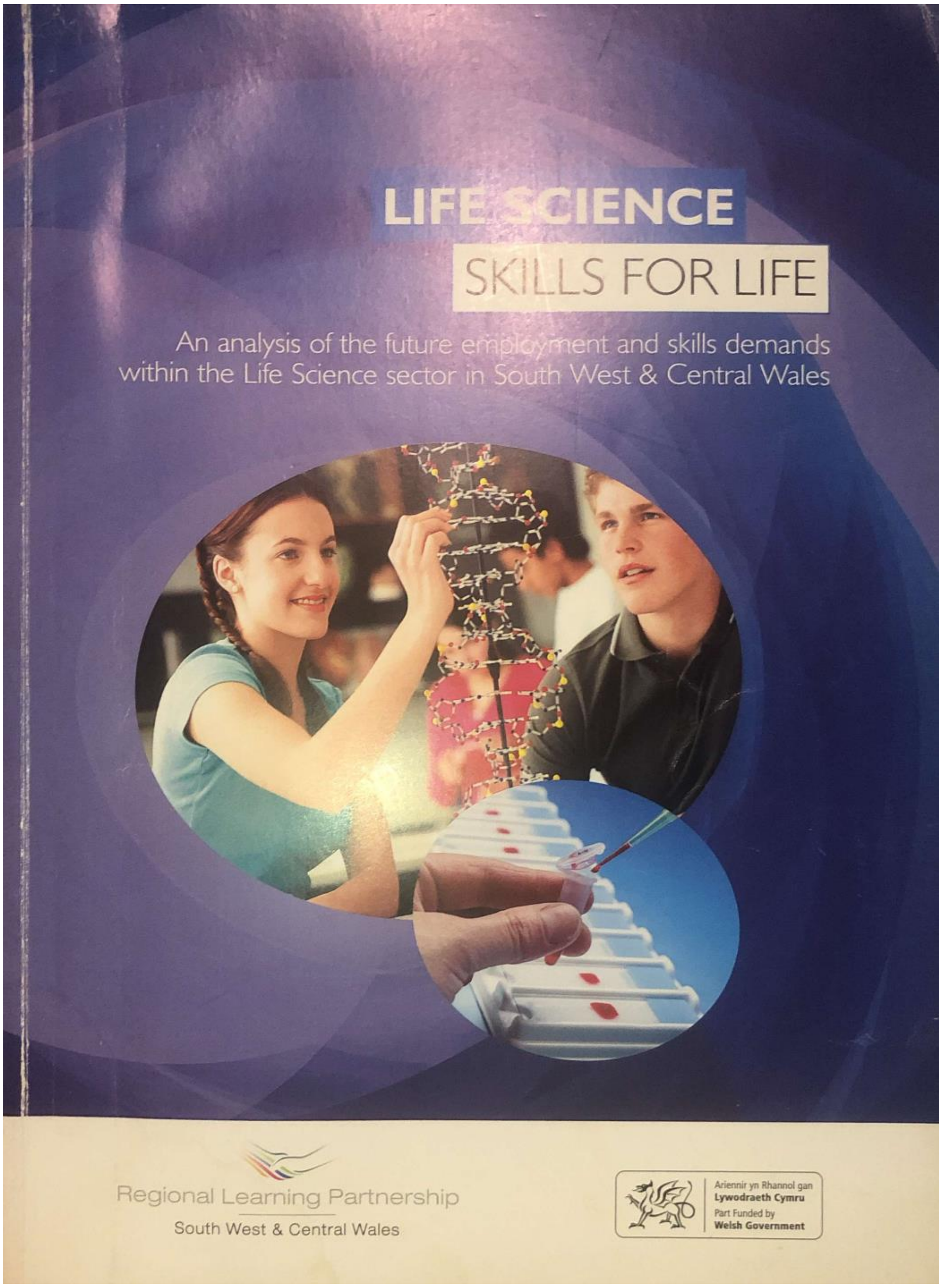
APPENDICES

Appendix A | Life Science, Skills for Life Report (2014)



http://www.rlp.org.uk/wp-content/uploads/RLP_Life_Science_report_Eng.pdf

Appendix B | Life Sciences at a Glance Factsheet (RLSP, 2014)

Regional Learning Partnership
Partneriaeth Ddysgu Ranbarthol
South West & Central Wales
De Orllewin a Chanolbarth Cymru

Life Sciences at a Glance

Ariennir yn Rhannol gan Llywodraeth Cymru
Part Funded by Welsh Government

What is the Life Sciences Sector?

The sector includes:

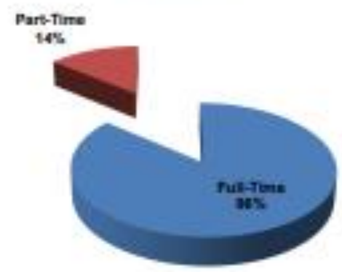
- pharmaceutical
- biotechnology
- medical technology businesses, with wide ranging activities including research, testing, manufacture and the provision of specialist services.[1]

The sector is diverse, research-driven and global with its characteristics constantly changing as new sub-sectors emerge and develop.[1]

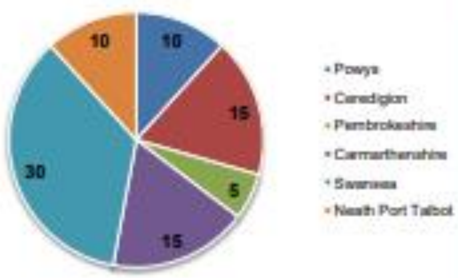
The sector serves large global markets which are growing quickly, driven especially by population growth, changing demographics and increasing expectations from medicine and therapy.[2]

The operational strengths in Wales cover a range of value added medical and scientific processes and technologies, products and development activities. These include pharmaceutical and biotechnology, diagnostic and medical devices, agricultural and industrial technology, from blue chip to small to medium sized enterprises (SMEs).[1]

Employment by Full-time/Part-time 16+, Wales, 2013[3]



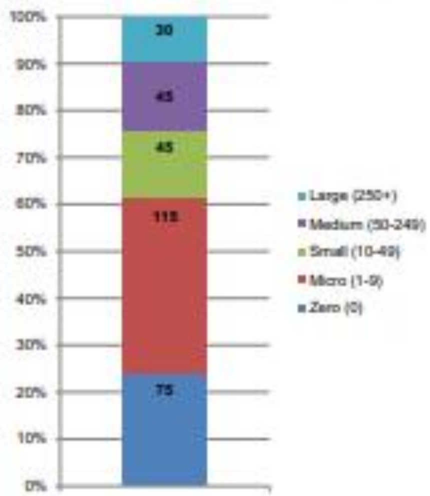
Local Units, 2013[3]



Key Sector Headlines

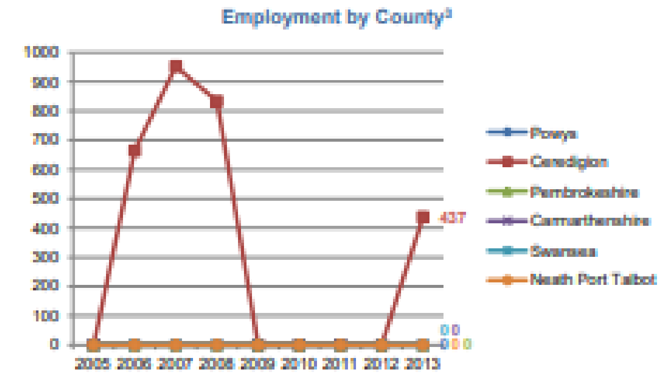
- There were 85 local Life Sciences business units in the region in 2013.
- Employment in the sector was predominately full-time in Wales in 2013 (86%).
- The majority of Life Sciences businesses at the Wales level in 2013 were micro enterprises (37.1%).
- Sector GVA at a Wales level increased by 24.2% from 2005 to 2012.
- Sector employment in the region in 2013 was highest in Ceredigion (437).
- In 2013, the majority of sector employment at a Wales level was attributed to the managers, professionals and associate professionals occupations (66%).
- Of the 1,300 Life Sciences employee jobs in the region in 2012, highest levels were seen in Ceredigion (400) and the lowest were seen in Pembrokeshire (less than 100).
- The sector's mean gross weekly earnings at a Wales level increased for full time employment by £137 from 2005 to 2013 and decreased for part time employment by £9.90 from 2005 to 2009.
- Employment in the sector at a Wales level was predominantly male in 2013 (61%).
- 53.6% of the sector's workforce at a Wales level in 2013 were qualified to NQF level 4 or above and 40.4% had other qualifications.
- The 25-49 age range accounted for the largest proportion of the sector's employment at a Wales level in 2013 (71%).

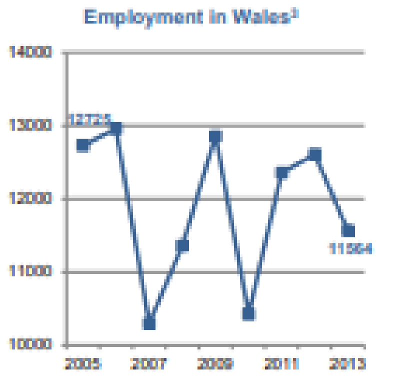
Local Units by Sizeband, Wales 2013[3]

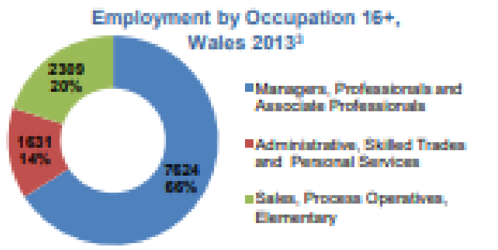


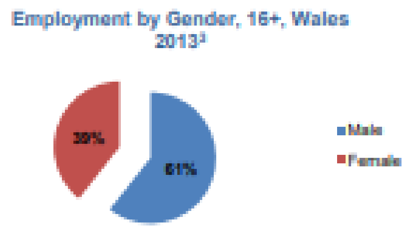
Gross Value Added (GVA)[3]

GVA	2005	2006	2007	2008	2009	2010	2011	2012	Change 2005-2012		Change 2010-2012	
									No.	%	No.	%
Wales GVA (£m)	455	488	471	548	744	544	561	565	110	24.2	3	0.6
UK GVA (£m)	16,019	16,526	16,685	15,828	17,022	18,619	14,215	14,815	-1,205	-7.5	599	4.2



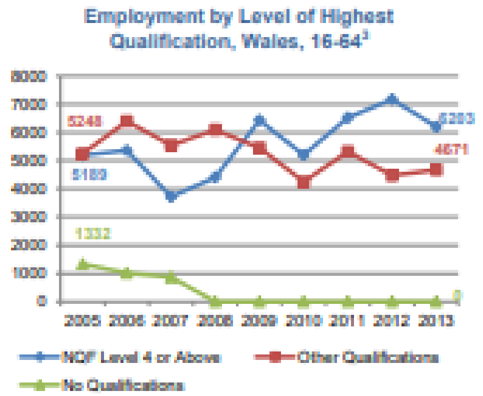


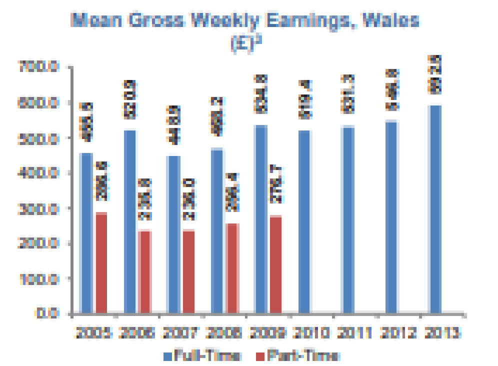


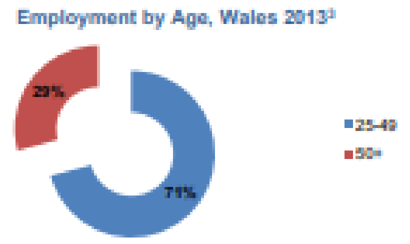


Employee Jobs[3]

Local Authority	Employee Jobs – 2012
Powys	100
Ceredigion	400
Pembrokeshire	Less than 100 (rounded)
Carmarthenshire	300
Swansea	200
Neath Port Talbot	300
Region	1,300







Sources:
1 Accessed electronically via http://wales.gov.uk/topics/businessandeconomy/sector/life-sciences-sector/ (July, 2013)
2 Accessed electronically via http://wales.gov.uk/docs/det/publications/130123deliveryplanen.pdf
3 Accessed electronically via http://wales.gov.uk/statistics-and-research/priority-sector-statistics/ (2014) 16/02/15

Appendix C | Talent Bank Information Sheet

Gower College Swansea

Tycoch Road,

Sketty,

Swansea

SA2 9EB

August 2016

Re: Talent Bank Pilot Programme **Information Sheet** – September 2016

Dear Parent/Guardian,

Following your interest in attending the Talent Bank Open events, we wrote to you in February regarding the decision to postpone the opening of the Talent Bank (TB) facilities until September 2017.

We have since been working on developing a pilot programme of some of the distinctive features which we wish to launch this September with a cohort of 20 students. This will also form part of a research study which will run in parallel examining the potential impact of the TB programme and its key elements as perceived and experienced by students in the pilot. As you have previously shown interest in the programme, we wanted to offer you and your child first choice before opening up this offer to other students progressing to Gower College Swansea following their GCSE results.

The proposed Talent Bank Pilot programme:

What: Regional and national evidence suggests a rising demand for STEM students entering growing industry sectors. The Talent Bank programme will work in partnership with the university, the region's health boards and industry professionals to offer learners a curriculum that blends extremely high levels of academic rigour with enviable hands-on real-life scenario opportunities and experiences; assets greatly valued by employers and educators alike. Students will graduate with exceptional advantages that will take them forward into rewarding careers and higher education. The Talent Bank team are passionate and committed to preparing students for ambitious careers in STEM related fields through a combination of qualifications, work-based projects and personal development experiences.

Additional Qualifications: – Extended Project Qualification – equivalent to an AS level – 70 UCAS Points; Good Lab Practice (GLP).

Why: The Talent Bank for 2017 forms part of a wider strategy to deliver against its ambition to serve the communities of the wider region of south west Wales with bespoke STEM education set within the context of the health science and life science sector; in order to provide a significant skilled talent pool and employment benefits to young people across our region.

The pilot will provide opportunity to trial key elements of the innovative model whilst developments relating to finance, real estate and academic integration are progressed with a view to informing future decision-making to the potential sustainability of the programme for future cohorts of learners.

Who: Aimed at young people aged 16 years progressing to Gower College Swansea to study STEM related subjects - academic and vocational, following success at GCSE level? The programme will create a supported environment bringing students into the company of our network of experts and 'leaders in their field' from our partner organisations such as Schools of Medicine and Human and Health Science at Swansea University, GE Healthcare, GSK, Life Science Hub, Fujitsu and many more.

Where: Programme will be delivered at various sites including Hospitals at Singleton and Morriston, Swansea University - Singleton and Bay Campuses and various visits to industry. The participants will be able to access unprecedented state of the art resources enabling one of the most advanced learning spaces in the region. Please note transport arrangements to these sites will rely on accessing public services with bus passes.

When: Day release – every Wednesday 9:00 – 4:00 during term time and 'experience of work' week during half term – either October or February

Entry Criteria: 6 GCSEs with grade A* - C including B grades in Science and Maths

It is important to note that due to the constraints of timetabling, the Talent Bank programme will only be open to students studying 3 A-levels from Biology, Chemistry, *Physics, Maths and Further Maths or vocational Science at level 3. The fourth AS-level option will be replaced by the Extended Project Qualification (EPQ). Whilst every effort will be taken to support the permutations of students' subject choices within this range, regretfully no guarantees can be made and final decision on allocation to the 20 available places will rest with the Admissions team.*

Participating in the Research Study:

The pilot programme will run in parallel to a research study being led by Beverley Wilson-Smith, a post graduate researcher at the School of Medicine, Swansea University and whose earlier research has informed the design of the Talent Bank programme. The study aims to collect data on the participants' views and experiences as they progress through the year. It is hoped that this information will help inform decision making on potential scope to broaden and shape the programme for the greatest of impact amongst future cohorts.

Research Process:

If you are agreeable, the research will involve interviewing your son/daughter at the start of the programme as part of a focus group with other students to find out their views on their STEM education experiences to date and their perceived views of how the Talent Bank pilot programme can add value to their future educational experiences. This will also involve keeping a reflective diary account about their learning journey as they progress each week.

A further focus group at the end of the programme will seek participants' views on the features of the Talent Bank and suggestions for improvement. Both focus groups will take place at Swansea University during the normal contact hours on Wednesdays and will take between 45 minutes and at the most 2 hours of your child's time.

Key questioning themes will include: Environment, facilities and resources, content of sessions and delivery, mentoring, skills development, recommended improvements and recommendation to others.

Data: The focus groups will be recorded, generate notes and visual records. These will be reviewed by Beverley Wilson-Smith alone. The data will be analysed for various aspects that have been highlighted during her previous research. All information gathered will be stored electronically in password –protected files. As part of a doctoral thesis, the results will be open to the public.

Risks: We do not think there are any known risks involved. If your child agrees to participating in this study, the focus groups will be conducted in a stress-free environment.

Benefits: Whilst your child will certainly benefit from participating in the programme it is possible that your child will not directly benefit from participating in this study.

However, this study should provide your child with a valuable opportunity to think and talk about emerging technologies and their experiences and their future aspirations. In addition, I hope that this information will prove vital to the efforts to continually improve the programme in order to meet students' needs and to help inform decision-making on broadening the potential scope of the programme amongst future cohorts.

Confidentiality: The confidentiality of study records will be maintained to the fullest extent possible. Responses by your child to interview questions will be coded in such a way that his/her identity will be concealed. Your child will never be identified with any particular response, comment or materials that he or she might share. Any views expressed would be given in confidence and any quotes used would be anonymised. It is hoped that the information gained will act as a starting point for further development of this innovative educational approach as well as material for academic publication.

Right to refuse or withdraw: Your child may refuse to participate in this study. If you allow your child to participate, your child has the right to not answer any questions I might ask. Even if you agree, you and your child may change your mind and withdraw at any point.

Costs: There are no costs associated to your child participating on the pilot outreach programme described on the attached information sheet or as part of the study.

Next Steps:

If you and your son/daughter are interested in participating in the Talent Bank pilot programme and research study, please register your interest as soon as possible by email before 19th August 2016 at darren.vincent@gowercollegeswansea.ac.uk. Places will be allocated according to the criteria and on a first come first served basis.

We hope this letter has inspired you to join us and we look forward to hearing from you very soon.

Yours faithfully,

Mark Jones

Principal and CEO

Enc. OCR Extended Project Qualification

Appendix D | Study Approval Letter to FE Institution

Talent Bank® Cronfa Doniau

Swansea University Prifysgol Abertawe

Gower College Swansea Coleg Gŵyr Abertawe

Beverley Wilson-Smith
Talent Bank Project
Researcher
c/o School of Medicine
Swansea University
Institute of Life Science 2
Singleton Park Campus
Swansea
SA2 8PP

10th August 2016

Dear Mr Jones,
You will be aware that I am conducting research as a part-time researcher to fulfil the requirements of my PhD within the School of Medicine focused around the reconfiguration and design of STEM education programmes for 16-18 year olds. Building on the recommendations of the report Life Science Skills for Life published in May 2014, the Talent Bank programme aims to bring greater alignment in the supply of the education, skills and competence needs demanded by employers within the health science and life science sector.

Prior to undertaking the third iteration of my work in piloting the Talent Bank design, I need your agreement/consent to approach students within the organisation to take part in a study to pilot the programme and evaluate its potential impact. I aim to recruit 20 young people aged 16 years who choose to study STEM at level 3 and meet the requirements of the agreed criteria.

I can assure you that I will make every effort to ensure the study does not disrupt the working environment or create pressure on students and any data collected will be stored securely and remain confidential. As the pilot programme involves participants under the age of 18 years, I am applying for ethical approval for the study from Swansea University, School of Medicine and Human and Health Science Ethics committee and therefore I seek your written approval to support this application.

My research is supervised by Professor R.M. Clement, Dean of School of Management, Swansea University, Bay Campus, Swansea.

Yours sincerely,

Beverley Wilson-Smith

Talent Bank Project Director
[redacted]
Tel: [redacted]

Appendix E | Ethical Approval Letter & Checklist

TalentBank®
Cronfa Doniau

Gower College Swansea
Coleg Gŵyr Abertawe

Gower College Swansea
Tycoch Road
Sketty
Swansea
SA2 9EB

To the School of Medicine and Human and Health Science Ethics Committee at Swansea University

As the Principal of the Gower College Swansea, I confirm that permission for the proposed research on the views, perceptions and experiences of the 20 Gower College students of the Talent Bank pilot programme to be conducted form September 2016 – April 2017 has been approved.

The research will take place during day release each Wednesday for a period of 30 weeks at Abertawe Bro Morgannwg University Health Board - Singleton and Morriston Hospital and sites at Swansea University.

I confirm that in accordance with normal college practice, written consent from parents and participants will be required before the programme commences. The data collected from the weekly reflective surveys will be analysed and reported at the end of May 2017 to the Board of Governors to aid decision making on the potential sustainability and scalability of the programme.

Mark Jones
Principal

Date

ETHICAL APPROVAL CHECKLIST

	Attached Yes / No / N/A	Comment
Overview of Action Research Methodology	YES	A
Recruitment advertisement –college poster/flyer	YES	B
Participant information sheet(s)	YES	C
Consent form(s) – parental and participant	YES	D
Debrief sheet	YES	E
Overview of Talent Bank pilot programme features	YES	F
End of weekly session Questionnaires and Reflective Diary Log	YES	G
Interview or Focus Group schedule /question themes	YES	H
Written consent letter sought from public institution	YES	I
Written approval letter from public institution i.e. College	YES	J
Supervisor signature	YES	√

Principal Investigator	Beverley Wilson-Smith
Date	14th July 2016
School	Medicine
E-mail address	[redacted]
Title of Proposed Research	• What are the essential elements of an effective STEM skills intervention to create an indigenous talent pool as perceived by the three key stakeholder groups – employers, educationalists, and learners? • In designing an effective skills intervention programme through collaborative action research with perceptions from students, educationalists, and employers: How effective is the Talent Bank programme in addressing the challenges and issues identified as perceived by the three stakeholder groups. • Lessons from the Talent Bank case study.

Appendix F | Participant Consent Form

Talent Bank® Cronfa Doniau

Swansea University
Prifysgol Abertawe

Gower College Swansea
Coleg Gŵyr Abertawe

Participant Consent Form

To participate on the programme and the study I need to know that you are willing and that your choice to do so is entirely voluntary.

Your signature below will indicate that you have agreed to a) participate on the Talent Bank pilot programme and b) volunteer as a research subject and that you have read and understood the information provided above:

Please review your rights below and sign if you agree to participate.

These rights are the rights of every person who is asked to be in a research study. Please initial each line to confirm that as a research subject:

1. I confirm that I have read and understand the information sheet for the above study. I have had the opportunity to consider the information, ask questions and have had these answered satisfactorily

2. I understand that my participation is voluntary and that I am free to withdraw at any time, without giving any reason, without my relationship with the College or University, or my legal rights, being affected

3. I understand that relevant sections of any research notes and data collected during the study may be looked at by responsible individuals from the University for monitoring purposes, where it is relevant to my taking part in this study. I give permission for these individuals to have access to my records

4. I agree to take part in the pilot programme and action research study

CONSENT: Participant Name:

Signature: Date:

Beverley Wilson-Smith

PhD Researcher

School of Medicine

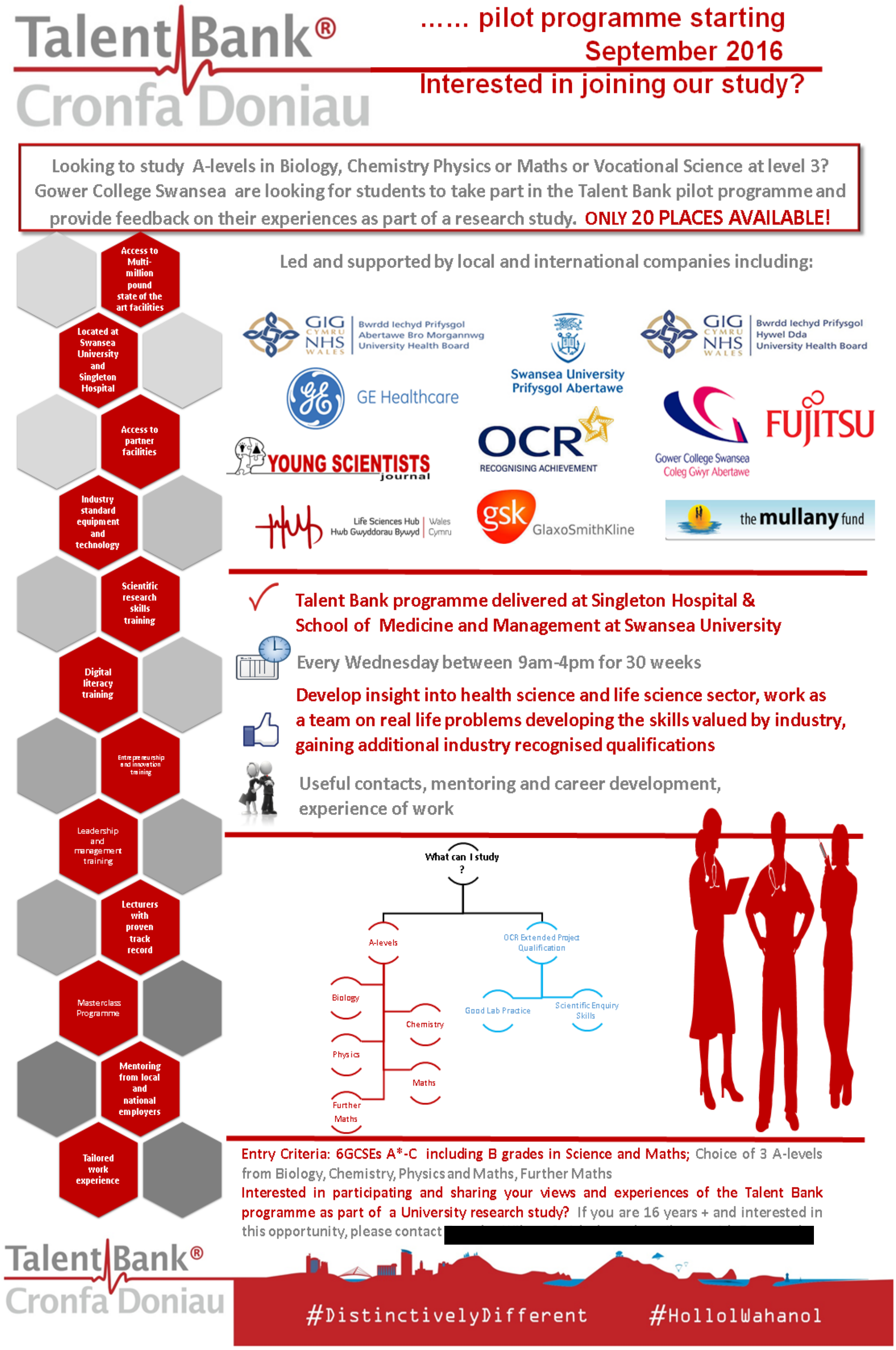
Swansea University

Questions: If you have any questions, please feel free to contact me by email at:

Beverley Wilson-Smith – [redacted] This study is supervised by Professor R.M. Clement of Swansea University and if you have any comments or complaints about this research you may contact Professor Clement at [redacted]

Please keep a copy of this document and consent form and submit a copy to your course tutor before commencing the programme.

Appendix G | Marketing for Participants



Appendix H | Parental Consent Form

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Parental Consent Form

Thank you for your interest in the Talent Bank pilot programme and action research study. Just to remind you, the data your child provides in the course of this project will be treated in the strictest confidence and will be used to improve the programme and for research purposes only.

PARENTAL CONSENT – Research study on the perceptions, views and experiences of students on the Talent Bank pilot programme: Please initial each box to confirm:

1. I confirm that I have read and understand the information sheet for the programme and study
2. I have received enough information about the research
3. I understand that I am free to ask any questions at any time. I am free to discuss any questions or comments I would like to make with the researcher or supervisor
4. I understand that participation is voluntary and that my child is free to withdraw at any time from the programme or study, without giving a reason
5. I understand that copies of my child's work, entries in logbooks and reflective diaries from each session may be used as evidence for the research
6. I agree to my child taking part in focus group sessions with a researcher in which questions will be asked regarding their views, perceptions and experiences of STEM education and the Talent Bank programme
7. I understand that his/her participation will be treated confidentially, and all information will be stored anonymously and securely. All information appearing in the final report will be anonymous. My child will have the option of withdrawing their data from the study, up until the transcript has been anonymised
8. I understand that I am free to contact the Ethics committee at Swansea University to discuss any complaints I might have
9. I also understand that at the end of the study I will be provided with additional information and feedback about the findings of the study
10. I agree for my child to take part in the programme and the action research study

I, (NAME) consent to my child participating on the Talent Bank pilot programme and with the action research study led by Beverley Wilson-Smith under the supervision of Professor R.M. Clement.

Signature of Parent or Guardian:

Date:

Name of Child:

Questions: If you have any questions, please feel free to contact me by email at:

Beverley Wilson-Smith – [redacted] This study is supervised by Professor R.M. Clement of Swansea University and if you have any comments or complaints about this research you may contact Professor Clement at [redacted]

Appendix I | FAQ sheet on Talent Bank

FAQs

What is the Talent Bank Pilot Programme?

- A new, innovative and bespoke education and skill programme to support the evolving life and health science sector
- A collaboration between ARCH partners - Swansea University, Abertawe Bro Morgannwg and Hywel Dda University Health Boards and leading organisations such as Fujitsu, Intel, Microsoft, Pfizer, GSK, GE Healthcare, etc.
- Ensures young people graduate with the necessary capabilities to progress to university, go on to work-based learning or directly into employment
- Features a broad, inclusive life and health science curriculum
- Supported by a group of leading organisations that have played a role in developing the curriculum, ethos and organisational plans so all aspects of the Talent Bank are grounded in real life situations and knowledge
- Combines teaching with industry challenges, work experience and master classes

Who is it for?

- Education programme of experiences for young people aged 16+ to accompany STEM A Levels or Level 3 vocational and technical qualifications with a day release/week with Swansea University and life science organisations.

Where is it?

- The facility will be located on Swansea's Singleton Hospital adjacent to Swansea university campus, and at the School of Management at the Bay Campus
- Latest industry standard equipment and technology to develop technical skills in a realistic work environment, as well as access to our partners' facilities

What are the entry requirements?

- You will need seven GCSEs at grades A*-C with B grades in science and maths subjects
- This is, however, guidance only as we would prefer to discuss your own personal entry profile across a wider range of skills

What subjects can I study?

- Academic: a choice of three A Levels selected from biology, chemistry, physics, maths or further maths
- Vocational: BTEC Extended Diploma in Applied Science/Forensic Science
- Technical: OCR Extended Project Qualification – equivalent to AS level

How is the programme delivered?

- Delivered in the context of the life and health science sector at Singleton Hospital or Swansea University's Bay Campus
- Enhanced with industry and academic expertise from our collaborative partners
- Wednesday 9am to 4pm for 26 weeks

How to find out if the Talent Bank is suitable for you?

- The Talent Bank will not be suitable for all students because of the way it is delivered – combining traditional teaching with practical experience and challenges - and is limited to certain subjects in the initial phases.

What are the advantages of the Talent Bank over sixth form/college?

- Allows students to study a subject they are really enthused by in facilities that reflect the real workplace with teachers/lecturers who have practical industry experience
- Offers opportunities above and beyond those in a traditional learning setting through practical experiences
- Students benefit from regular input and mentoring from professionals within local/national employers and universities
- In addition to their academic teaching, students will also learn skills to help them get ready for future employment; there are four key ‘skill’ strands, which are being supported by leading companies in the sector – scientific research and enquiry, entrepreneurship and innovation, leadership & management and digital literacy

How do I get more information?

- Contact admissions for advice and guidance (01792 890750/284179) or email [redacted]

Appendix J | Implementation checklist

Talent Bank Pilot Programme Checklist

Focus	Resources	Agreed
Preliminary		
Pilot Programme	Overview of pilot design – project canvas	
Funding	Cover additional resource requirements	
Additionality	OCR Extended Project Qualification	
Duration and Day	24 weeks – Sept –April - Friday	
Locations	Singleton, Bay Campus	
Sample size	6 Academic 6 Vocational Total of 12 students	
Letters/email to parents	Outline of pilot programme	
Application process	Flow Chart	
Selection Criteria Letter Personal Statement C.V. Interview	Raised interest in Talent Bank – GCS Online Templates Assessed by: Researcher	
Consent forms – Research and data mgt – work experience – Trips/visits, photos	Required for Ethics Committee at SU	
Uniform	Scrubs, lab coats, lanyard ID	
Resources	Lab Log Book, Reflective Diary	
Transport	Acceptance of bus pass between sites	
Safeguarding Policy	GCS – amendments /additions needed	
Staffing	1 lecturer full-time + part-time - CRB check,	
Evaluation Design – Impact/Student Experience		

DM/BMA/16/MAC

Focus	Resources	Agree
Delivery		
Delivery Plan	Scheme of Work	
Room bookings	Timetable – ILS2 Hub, LABS, SOM, Digilab, LWC – Singleton, Library	
Pre-programme survey	Online Baseline Survey/Focus Group	
Induction programme	Tour, Dean of Medical School, ASMU,	
Library tour and registration	ID cards	
Technology - Fujitsu	Link up with Mendip, Media Team at SU – Masterclass videos	
Masterclasses and guest speaker programme	2 days a week	
Visits	Minibus hire – 3 days	
Work Experience (half terms)	Co-ordination hours – 5 days – Singleton and Morriston	
Staffing	GCS 1 lecturer full-time + part-time SOM – 1 lecturer + 3 occasional Academic support,	
Evaluation –Impact/Student Experience		

Focus	Resources	Agree
Post Delivery		
Evaluation Post Programme -Survey, Personal Statement, C.V., Interview -Reflective Journal Lab Lab book,	Focus group on student experience/ Interviews/Event	
Recommendations	GCS Governing Body, Employer & Youth Board, ARCH – Regional Skills	

Appendix K | Attracting Employers

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Interested In Supporting the Talent Bank?

A new, innovative STEM education and learning choice for young people aged 16 years and over from across the Swansea region.

Name: ....

Company: ....

Position: ....

Email Address: ....

Contact No: ....

What Talent Bank features would you consider important for developing young people interested in health and life science related careers? *Rank in order of importance 1-6*

- Specialised sector focus ☐
- Technically-oriented skills programme designed by industry ☐
- High standards of professional delivery ☐
- Latest modern technology for the field ☐
- Support from University and industry ☐
- Real life practical experiences ☐

Other: ....

www.talentbank.wales • info@talentbank.wales • 07500 668381

What Talent Bank benefits would be most important to your company? *Rank in order of importance 1-5*

- Opportunity to talent spot future employees ☐
- Meeting corporate social responsibilities within the community ☐
- Build the profile of your company ☐
- Strengthen connections with academia and other companies ☐
- Ensuring future talent is "job ready" ☐

What support would your company be able to offer the Talent Bank?

- Delivery of master classes ☐
- Provide consultancy on skill needs ☐
- Support delivery of Industry Challenges ☐
- Provide workplace visits ☐
- Provide access to resources and facilities ☐
- Provide mentors and coaches ☐
- Provide company sponsorship, e.g. awards, bursaries, uniform ☐

Other: ....

Organisation: Contact: Email: Date:

Checklist: Types of Industry Contribution .... can offer the Talent Bank

Support Needs	*The Talent Bank is an innovative, new concept in educating and developing the future talent for your workforce of tomorrow. Aimed at 16 year olds + and led by Gower College in partnership, the facilities will open in September 2016 and be located with the Institute of Life Science at Swansea University and Abertawe Bro Morgannwg University Health Board.*	Resources	Time Phase	Please Tick	Comments
MARKETING	Permission to use company logo in marketing materials to publicise your support for the Talent Bank	Nil	Now		
	Company sponsorship of modules e.g. Sony – Innovation in Practice Module	Nil	Now		
	Advocating for the Talent Bank at your networks; introducing contacts	Nil	Now		
	Supporting events in order to raise awareness	3 hours a year	March 2016		
SKILLS DESIGN	Member of Employer Curriculum Board	2 hrs month	Now		
	Advising on course design and curriculum development		Now		
	Company sponsorship of modules e.g. business improvement techniques, laboratory skills,		Now		
	Creating case studies and other industry learning materials	Up to 20 hours	Now		
DELIVERY	Delivery of specialist one off sessions – presentation/workshop as part of an annual Masterclass programme	Half day a year	From Sept 2016 onwards		
	Providing materials or access to specialist facilities	As	From Sep 2016 onwards		
	Offering visit to premises for groups of learners	Half day per group	From Sep 2016 onwards		
WORK PLACES	Offering work experience opportunities	1 day – 4 weeks	From Oct 2016 onwards		
	Offering apprenticeship or employment opportunities	As required	June 2018		
	Mentoring of students	1 hour a week	Starts Sep 2016		
FINANCIAL	Sponsorship of prizes/awards	£100	April 2016		
	Bursaries for Learners	£500	April 2016		

Talent Bank
Employer Led Curriculum Design

Steering Committee

- Advise and create online platform
- Design learning experiences to develop academic, technical and 'craft' skills against backdrop of sector
- In line with awarding body and qualification criteria
- Access to industry resources

Stakeholders

- Fujitsu, Cisco, Microsoft, HP,
- Pfizer, GSK, Siemens, GE Healthcare
- OCR
- Swansea University/College Academics
- PGCE students
- Talent Bank Students
- Community

Appendix L | Industry Diabetes Challenge

Industry Challenge 1

Diabetes

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#DistinctivelyDifferent #HollolWahanol

OVERVIEW

There are over 3.9 million diabetics in the UK (diabetes.co.uk, 2016). Diabetes is usually a manageable condition but can result in a variety of complications. With population statistics predicting an increase in the prevalence of contributing factors, the prevalence and impact of diabetes is likely to increase in Wales over the coming years.

There is much world-leading research being undertaken in Wales and during this challenge you will meet and listen to a variety of industry experts. The project requires scholars to identify information associated to diabetes, understand current innovative diabetes research, design and optimise methodologies and utilize best practice laboratory techniques to test a cohort of volunteers for diabetes using invasive and non-invasive technologies.

Scholars will then need to analyse the collected data using statistical analyses and present the data in the form of an **academic poster presentation** for review by a panel of industry experts for National Diabetes Week.

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Week 1	INDENTIFY	Identify the types, causes, impact, risk factors, biology, diagnostic techniques and treatments
Week 2	RESEARCH	Research the current trends in scientific literature
Week 3	DESIGN	Design experiments using appropriate scientific experimental design
Week 4	OPTIMISE	Present your initial design and modify accordingly
Week 5	TEST	Conduct the scientific experiments using industry standard techniques and protocols
Week 6	EVALUATE	Evaluate the results of the experiment and present

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You should review text books and resources available to you to expand your knowledge of diabetes in terms of biology, diagnosis, testing, types, impact, risk factors and therapeutics. You should aim to collect as much information as possible as some of this information will be used in your poster presentation

Diabetes UK	NHS	WWIC	Patient
A Diabetes UK representative will deliver a presentation to inform you on the subjects of prevalence, impact and risk factors	A Diabetic specialist nurse in Diabetes will talk about diagnosis and testing and therapeutics	A Clinician/ Podiatrist will discuss the complications of diabetes	A diabetic individual will discuss the impact of diabetes on quality of life, giving a personal account of their story

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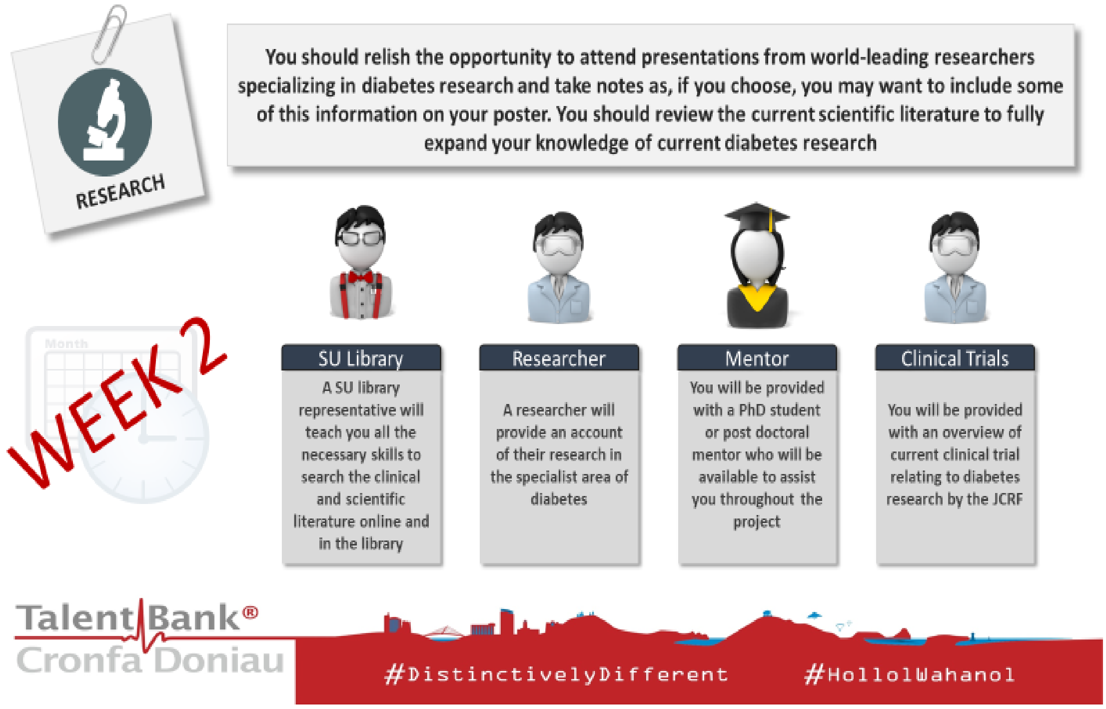
RESEARCH
You should relish the opportunity to attend presentations from world-leading researchers specializing in diabetes research and take notes as, if you choose, you may want to include some of this information on your poster. You should review the current scientific literature to fully expand your knowledge of current diabetes research
WEEK 2
SU Library
A SU library representative will teach you all the necessary skills to search the clinical and scientific literature online and in the library
Researcher
A researcher will provide an account of their research in the specialist area of diabetes
Mentor
You will be provided with a PhD student or post doctoral mentor who will be available to assist you throughout the project
Clinical Trials
You will be provided with an overview of current clinical trial relating to diabetes research by the JCRF
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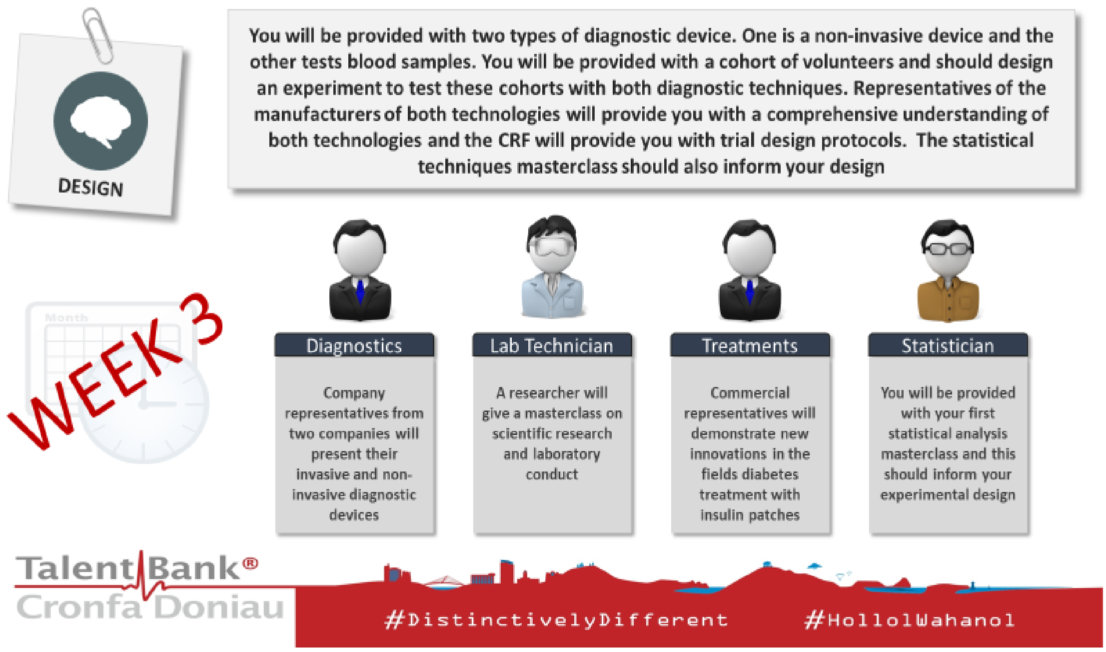
DESIGN
You will be provided with two types of diagnostic device. One is a non-invasive device and the other tests blood samples. You will be provided with a cohort of volunteers and should design an experiment to test these cohorts with both diagnostic techniques. Representatives of the manufacturers of both technologies will provide you with a comprehensive understanding of both technologies and the CRF will provide you with trial design protocols. The statistical techniques masterclass should also inform your design
WEEK 3
Diagnostics
Company representatives from two companies will present their invasive and non-invasive diagnostic devices
Lab Technician
A researcher will give a masterclass on scientific research and laboratory conduct
Treatments
Commercial representatives will demonstrate new innovations in the fields diabetes treatment with insulin patches
Statistician
You will be provided with your first statistical analysis masterclass and this should inform your experimental design
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#HollolWahanol

OPTIMISE

WEEK 4

You will discuss your experimental designs and protocols with your mentors before presenting these to an expert panel. The panel will provide you with constructive criticism and you should modify designs where necessary based on this feedback

Mentor

Your mentor will be available to give you feedback on your initial experimental design

Panel

You will verbalise your initial experimental design to a panel of experts who will provide you with feedback and suggestions

Pitching Coach

A pitching coach will guide you in how to deliver the perfect pitch

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TEST

WEEK 5

Prior to conducting your testing you will be given masterclasses on good clinical and laboratory practice, how to keep a lab book and lab protocol. You will be provided with all materials required as determined by your protocols and design. You will be expected to conduct your experiments as a team and record the data as individuals but all scholars will be expected to participate in lab work

GCP

You will receive a masterclass in good clinical practice (GCP)

GLP

You will be given a masterclass in good laboratory practice (GLP)

Lab Book

You will be issued your first lab book and will be given a masterclass in recording of scientific information

Lab Protocol

A current laboratory researcher will summarise a 'a typical day' and will cover appropriate conduct and lab protocol

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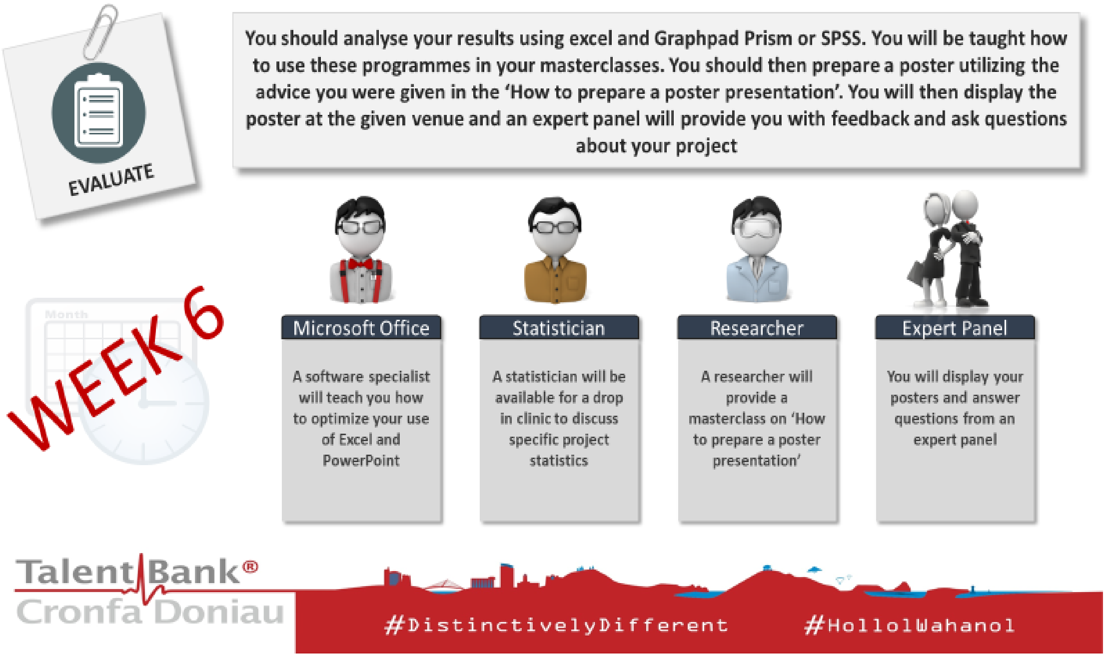
#DistinctivelyDifferent #HollolWahanol


EVALUATE
You should analyse your results using excel and Graphpad Prism or SPSS. You will be taught how to use these programmes in your masterclasses. You should then prepare a poster utilizing the advice you were given in the 'How to prepare a poster presentation'. You will then display the poster at the given venue and an expert panel will provide you with feedback and ask questions about your project
WEEK 6
Microsoft Office
A software specialist will teach you how to optimize your use of Excel and PowerPoint
Statistician
A statistician will be available for a drop in clinic to discuss specific project statistics
Researcher
A researcher will provide a masterclass on 'How to prepare a poster presentation'
Expert Panel
You will display your posters and answer questions from an expert panel
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Appendix M | Pre-Focus Narrative Sheet

Focus Group Narrative sheet

As a participant in the Talent Bank pilot programme you have signed up to participate in a research study which aims to identify three key things: your views and perception of your experiences of STEM education to date, your views on your experiences and learning journey during the programme of its distinctive features, and your views on the most effective features of the Talent Bank programme following completion and how it could be improved for the benefit of future learners.

To address these important areas, we would like to ask you questions during two focus group sessions – at the beginning and at the end of the programme. The time for this activity is estimated to be between 45minutes and 1 and half hours. The answers you provide will be used to draw general conclusions about your views as a student, your motivations for doing the programme and your aspirations for the future in relation to STEM industry led education and learning.

Your answers will be available only to the research team members and will be anonymised and statistics applied to show generalised trends relating to the programme. The data collected will be stored safely and abiding to the Data Protection Act 1998.

Your Expectations and Motivations

This section seeks to characterise the reasons why you have joined the Talent Bank pilot programme.

What attracted you to apply to participate in the Talent Bank pilot programme?

What would be a successful outcome of participating in the Talent Bank pilot programme for you?

Please rank in order of priority (1) highest of the 'distinctively different' features that attracted you to the Talent Bank programme:

- Professional learning environment
- Learning location at the University
- Access to employers and networks
- Mentoring support from practitioners
- Developing skills working on real life industry challenge projects
- Experience of work opportunities with the NHS
- Experience of work opportunities with industry
- Developing digital literacy skills
- Developing scientific enquiry skills
- Gaining a greater insight into the sector
- Masterclass programme
- Other – please specify

How did you find out about the Talent Bank programme:

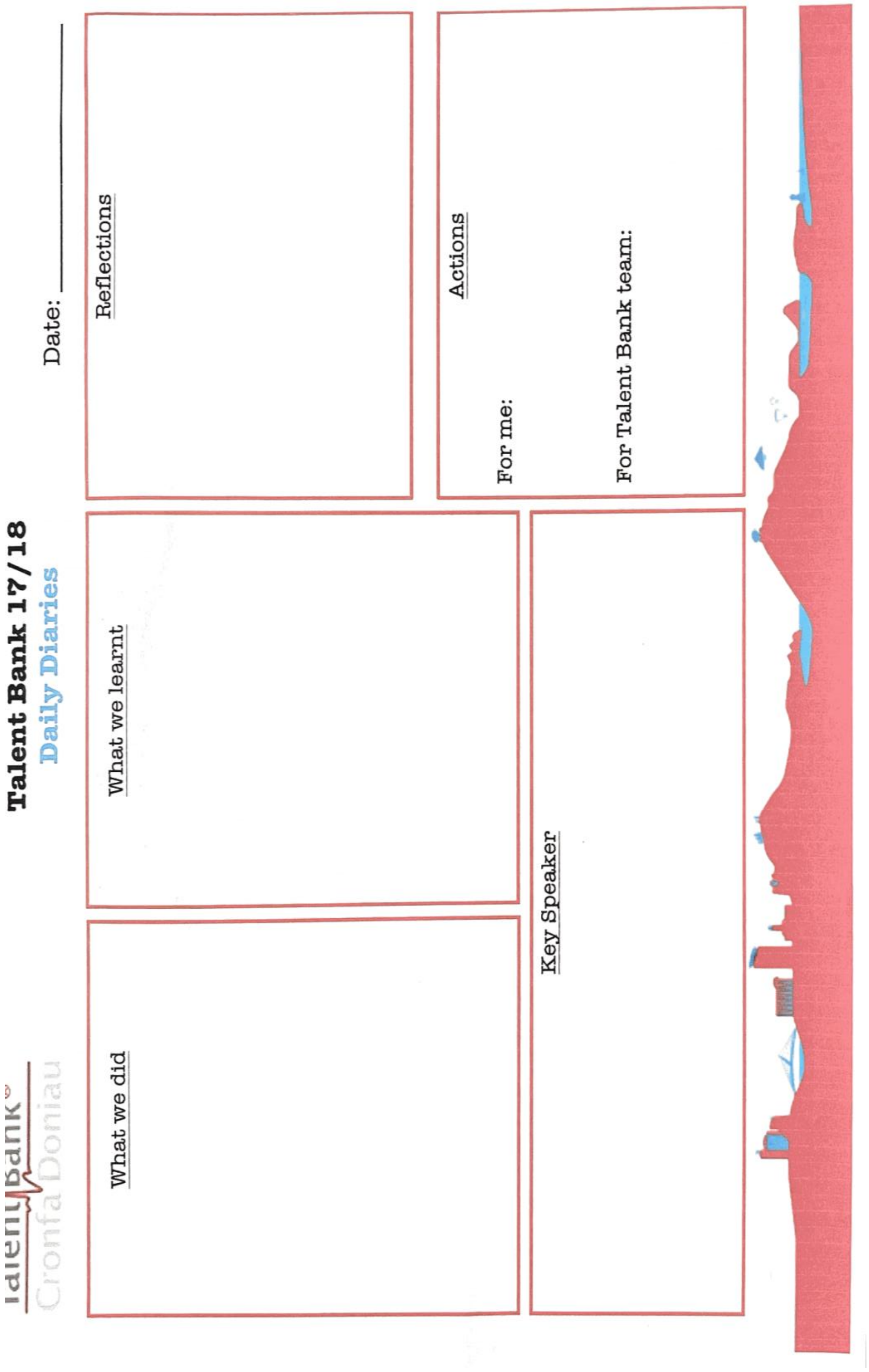
- School
- Careers advisor
- Gower College prospectus
- Gower College website
- Parents
- Talent Bank website
- Evening Post
- Other media press releases
- Other – please specify

What do you hope to gain from participating on the Talent Bank programme

- Additional qualifications
- Better understanding of the life and health science sector
- Careers advice
- Work experience
- Advantage over other students on traditional programme
- A unique personal statement for applying to university
- A better understanding of opportunities available
- A blend of academic and practical application
- Other – please specify

What are your intentions after year 13

Appendix N | Reflective Diary Template


Talent Bank
Cronfa Doniau

Talent Bank 17/18
Daily Diaries

Date: ____________

What we did

What we learnt

Reflections

Key Speaker

Actions

For me:

For Talent Bank team:

Appendix O | Debriefing Letter

Participation Debriefing letter

Thank you for giving permission for your child to take part in my study. I feel it is important to listen to the voice of young people about their experiences in education to make sure their experiences and views can lead to improvements and better educational experiences for others in the future.

The aims of the study were to gather information on learners' perceptions and experiences of the key features of the Talent Bank programme, namely:

- Learning in context of a potential future sector of employment
- Development of transferable skills – Scientific Research, Enterprise and problem solving, digital literacy and leadership
- Working with industry via real world challenges
- Gaining an insight into the life science sector via programme of masterclass experts
- Experience of work
- Mentoring support from industry
- Undertaking additional industry recognised qualifications

The information your child has provided will be held anonymously and will not identify them when written in the final report or any academic publications.

You will be invited to attend a presentation of the programme and the study at an Induction event with other participants and parents. There will be an opportunity to raise any questions either within the group or confidentially on a one to one basis.

A final debriefing information sheet will be emailed following completion of the programme and study. Participants will also receive a group presentation of the outcomes of their involvement to demonstrate how their 'voice' has shaped the Talent Bank programme for future cohorts of learners.

If you have any questions you would like to ask outside of these arrangements, please do not hesitate to contact me on the details provided.

Yours sincerely,

Beverley Wilson-Smith - Researcher

Appendix P | Photographic Image Gallery

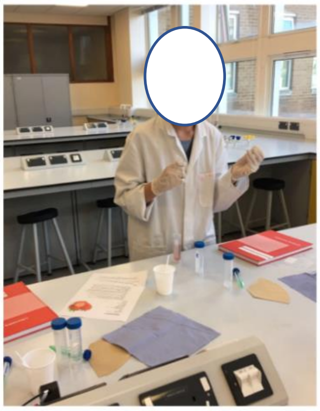
<table>
<tr><td colspan="2">Professor Marc Clement opening address on the expected value of Talent Bank to the south west region at official opening event of Talent Bank Hub at School of Management October 16th 2016 Talent Bank sponsored by Fujitsu, Inyel, Kyocera and Brocade and Swansea University</td></tr>
<tr><td>Fujitsu Director of Operations at official launch event</td><td>Masterclass presentation</td></tr>
<tr><td>Presentation on history of the NHS by Aneurin Bevan Commission team member.</td><td>Talent Bank students in Hub at School of Management. Robotic demonstration from Engineering department</td></tr>
</table>

Operating Theatre Live workshop with presenter Josh from the Dragon's Den programme and Mira – Maths Teacher and Talent Bank facilitator	Induction day activity with Nigel Richards – volunteer from HMS Coastguard service – the art of survival!	Young Person's conference at Swansea University with panel of partnering organisations
Collaborate conference – Talent Bank students were part of the conference as delegates and supported the Colon Cancer presentation	Operating Theatre live Worksop demonstration	A range of Experiential Learning Activities
Practical work shop set up ready for students to join	Talent Bank presentation for Open Evening	Employer Q and A session with students

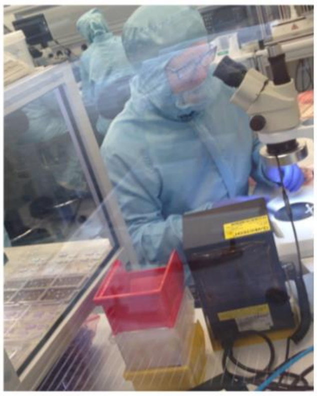
Visit to Renshaw's brain surgical suite with precision equipment used to train doctors	Welsh Ambulance Trust Resuscitation Workshop - Skills	Young Medical Conference held at Swansea University – employer speaker panel
Swansea University Management students talking about uni life and academic expectations!	Cadaver at Operating Theatre Live workshop – day long programme on 'signs of death'.	Students kitted in their lab coats and ready for Operating Theatre Live workshop
Pupils from schools invited to Talent Bank Young Person's Medical Conference at Swansea University	Academic presentation on nanomedicine delivered by Swansea University Engineering department	Cohort 2 students in their scrubs for NHS Induction Day at Morriston Hospital
Academic presentation on prosthetics and knee	Engineering Department visit for robotics	Various images of activities September 2017 – 2018

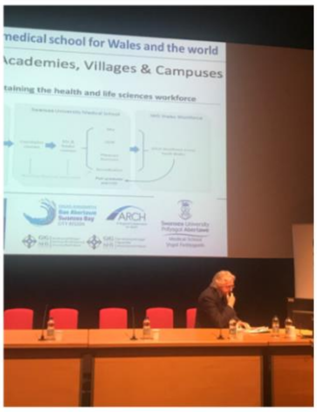




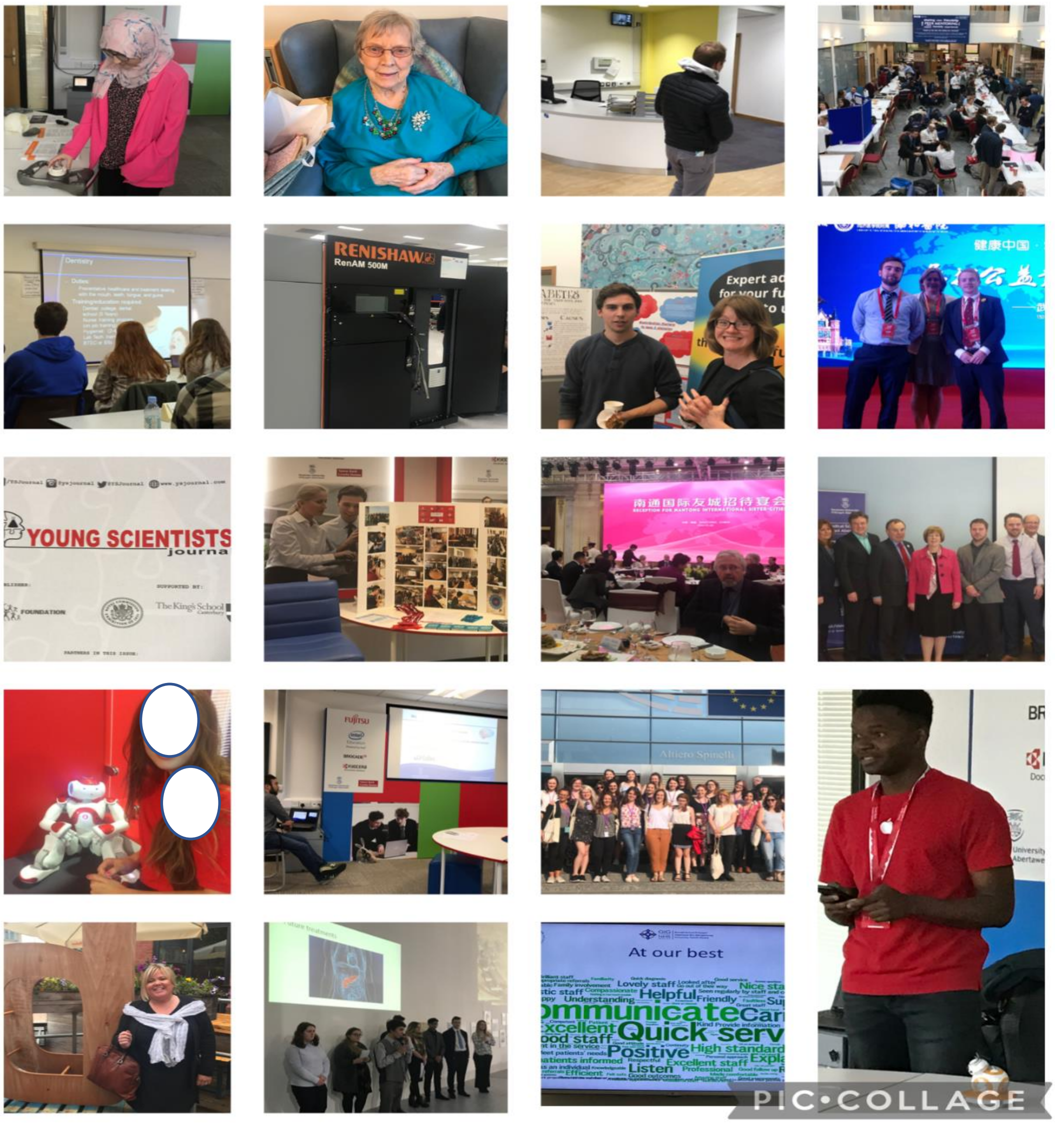


Celebration event and giving of certificates at Morriston Hospital Education Unit	Dissection skills at the Operating Theatre Live workshop	Testing communication skill speaking to BBC Wales reporter on the Talent Bank
Learning in the clinical skills unit at Morriston Hospital for Graduate Medicine	Launch presentation	Robotics engineering at School of Engineering
Experimenting on extracting DNA from a strawberry	Precision engineering – training suite for brain surgeons	Assessing signs of death at Operating Theatre Live workshop





Interview skills with Graduate Entry Medicine students from Swansea Medical School	NHS Induction visit to surgical unit at Morriston Hospital	Company visit to Cellnovo at Sony plant to view smart manufacturing of external diabetes pumps linked to Industry Challenge
Practicing phlebotomy skills from a simulation arm guided by GEM student	Clinical Skills suite – A and E – checking signs of life – directed by GEM student	Collaborate conference – Life Science regional conference hosted by Swansea University Medical School
Visit to Pathology Lab at Singleton Hospital	CEO of Cellnovo – visit following masterclass session	Practicing dissection skills at the Young People's conference



Dentistry presentation and artefacts	Volunteering at Nursing Home – chatting to residents	Visit to Swansea University Health Centre – talks and demos	Practicing research skills with Enterprise Fair attendees at School of Management
Mentoring presentation from Mullany Fund	Company visit to Renishaw precision instruments for dentistry and surgery	Research methods lecturer at Swansea University and PhD scholar	Researcher presenting study progress as symposium in Wuhan China
Young Scientific Journal to share online research papers by 12-19 year olds	Presentation of Talent Bank event	Symposium in Wuhan China – presentation of Talent Bank model	Meeting Dr Ruth Hussey-Chief Medical Officer for Wales following presentation of Talent Bank model
Attendee at Talent Bank Hub launch	Accommodation at Hub	Presentation of TB to Feminism Conference in Brussels	Apple Spiro demonstration
Nichola – TB employer relationship and event organiser	TB students presenting to Oriel Science exhibition	NHS Induction event at Morriston Hospital on values	

Appendix Q | Personal Statement for Fujitsu Case Study (Artefact)

<u>XXXXXXXXXX– Student in pilot Talent Bank programme – September 2016</u>

My background:

Having completed my GCSEs at xxxx School, I went to Gower College Swansea where I studied A-levels in Biology, Chemistry and Maths. I am now looking forward to starting my university Medicine course at Imperial College London in October. Outside of school, I enjoy swimming, playing table tennis and of course, binge watching Netflix!

Why did I apply for the Talent Bank programme?

I attended an open day where I was able to speak to Talent Bank staff and gain an insight into what the Talent Bank programme was about. I found it to be a great opportunity to be with like-minded people in a professional, yet relaxed environment with many resources at our fingertips. I think what attracted me to Talent Bank the most, was being able to develop a more in depth knowledge of what a medical career would be like; by speaking to various medical professionals and visiting a wide range of medical departments and companies. I knew it would give me to opportunity to see and do things that I wouldn't be able to do in school/college. In addition to this, it seemed like a very good way of boosting my university application as the programme provides you with a broad range of experiences, work experience placements, personal statement and interview help, and so much more!

Highlights and main experiences of the programme:

One of my favourite parts of the programme was visiting the medical education department at Morriston Hospital, part of the Abertawe Bro Morgannwg University Health Board, and speaking to graduate entry medical students from Swansea University and trying out clinical procedures such as taking blood from a synthetic arm with their guidance. As an aspiring doctor, it was a great way of finding out what medical school would be like, in addition to learning through experiences and having a lot of fun.

We also had the opportunity to undertake our own research projects about diabetes where we had the freedom to look into whatever aspect of diabetes interested us. As part of this, following a master class session, we went to visit a diabetes medical company called CellNovo, which specialise in providing treatments for people with Type 1 Diabetes. I found it very interesting as it showed me a part of medicine which I haven't seen before. What I liked in particular is being able to talk to the company executive about their medical devices and gain a deeper insight into the innovation and process involved in producing a medical device safe for patients to use. The project experience taught me a great deal and I was also able to apply my knowledge from the Research Methods module I took with staff from the School of Management at Swansea University and talk about my own research work when I went for interviews at prospective Universities.

Learning at the university in the Fujitsu Innovation Hub:

I found being in a university location every week to be very useful as it allows you to become familiar about what studying in university would actually be like. Also, it provides you with more responsibility and independence, helping bridge the gap between school/college life and life in higher education. I very much enjoyed working in the Fujitsu Innovation Hub, as it was a spacious, relaxing environment right in the heart of the university. We also had access to state-of-the-art laptops and a large screen online whiteboard providing a modern and enjoyable learning experience.

How did the programme help with my university application?

The Talent Bank programme provided me with a lot of support such as:

- UCAS personal statement advice and review
- DBS application support for long term volunteering in a local Care Home
- Work experience in Morriston Hospital, neurology department
- Chance to speak to many medical students and visit explore many different aspects of the medical profession
- Interview tips and mock interviews from trainee and practicing doctors

In addition to all of this, the Talent Bank programme has made me more responsible and more confident when speaking to other people which are not only vital to be a doctor but will help me in university in general.

My advice on students who are interested in a career in medicine:

- I think it's very important to try and get as much understanding of what a medical career will be like beforehand by taking every opportunity you can to volunteer, go on work experience and speaking to doctors and medical student. This will hold you in good stead when it is time to apply for medical school.

- The application process is long and can be tough at times so I would advise you to set yourself mini targets to achieve throughout your AS/A level years to help you maintain focus and progress through the many stages of the application process.
- Don’t forget to work hard but also find time to relax and do things that you enjoy because a good work-life balance is extremely important.

Would I recommend the Talent Bank programme to others?

Yes, most certainly, if you make the most of the many opportunities the programme provides and work hard, the programme will do a lot in helping you boost your university application, in addition to making you a well-rounded individual helping you stand out from the competition and prepare you well for higher education.

Appendix R | Employer Letters – Operating Theatre Live

ITAE GROUP

Dear Beverley

Thank you for the opportunity for working with the ITAE Group and featuring us as, and forming some of the highlights of, your programme for young people. The ITAE Group are proud to support and endorse the work of Talent Bank, especially as we share your passion to encourage more young people to consider careers in medicine, Health and Life Sciences.

We are delighted to have now worked with Talent Bank on two occasions, offering The VIVIT Experience, October 2017 and Operating Theatre Live, October 2018. Feedback from the students have commended the workshops, with students valuing the practical and innovative experience. I know that this an area that Talent Bank are keen to focus on, bringing science and medicine to a wider audience in an interactive and engaging manner. We hope to be able to work with Talent Bank to strengthen this relationship year on year for the benefit of young people and the future prosperity in Wales.

On behalf of the ITAE group, I wholeheartedly support the Talent Bank's commitment and efforts in creating an online platform to provide a mechanism for the content of their programmes and events to be accessible and reach a wider audience and we do hope to work with them closely in the future.

Kind regards,

[redacted]

Dean Thomas-Lowde MA PGCE Bmus(Hons)

Director of the ITAE Group

SAMUEL PIRI | DIRECTOR
SAM.PIRI@ITAEGROUP.CO.UK - [illegible]
WWW.ITAEGROUP.CO.UK

THE ITAE GROUP, DISCOVERY HOUSE, JUBILEE ESTATE, GORSEY LANE, COLESHILL, WEST MIDLANDS, B46 1JU

COMPANY NUMBER [illegible] VAT REGISTERED VAT NUMBER [illegible]

Appendix S | Media Release – Swansea University

Media – Press Releases, Web Links

Global technology leader Fujitsu opened its new Education Innovation Hub at Swansea University's £450 million Bay Campus this week.

The technology-focused hub is the latest notable development to be announced at the University's School of Management, following last month's news that The Bevan Commission has relocated its headquarters from Cardiff to the Bay Campus.
A host of guests from across academia, industry, health, education and government gathered at the School of Management on Tuesday October 18th (2016) to see the ribbon cut to officially launch the education hub, which is supported by the Talent Bank Further Education programme, and to welcome the University's prestigious new partner.

Talent Bank, which is led by Gower College in a partnership with Institute of Life Science at Swansea University's Medical School, is a new bespoke education and skills programme specifically designed to support the evolving life and health science sector in South West Wales.

Professor Sir Mansel Aylward, Chair of the Bevan Commission, who formally opened the hub, said: "The School of Management is delighted to welcome such as prestigious and multi-national partner as Fujitsu to the University's Bay Campus, which strengthens the University's position in digital innovation and will ensure a strong collaboration with the University.

"Relationships such as this between the University and Fujitsu and Intel will ensure local students can be immersed in an innovation-rich environment working with leading industry, health and life science partners."

Ash Merchant, Director of Education at Fujitsu, who helped open the hub, said: "The Talent Bank is vital to transforming the way students learn

"A recent survey by Fujitsu revealed that around a fifth of consumers believe digital education should be part of the modern education curriculum, which points towards a real need to see educational establishments focus on an embedded digital journey. Contemporary models such as the Talent Bank will play a crucial role in making this happen – and Fujitsu supported by our partners, is committed to supporting them in bringing their vision to life.

https://www-2018.swansea.ac.uk/press-office/news-archive/2016/globaltechleaderfujitsuopensneweducationinnovationhubatuniversitysbaycampus.php

Media – Press Releases, Web Links

Appendix T | Talent Bank as part of ARCH Regional Skills

ARCH Research, Enterprise & Innovation: Summary

Project Title (brief descriptive one-liner title)
Talent Bank – skills facility for Life Sciences and Health

Project Outline (two or three paragraphs describing proposed activity)
The Talent Bank (led by Gower College) is a new and innovative education and skill programme for the regional development of skills to support the evolving life and health science sector. Our young people will experience a broad, inclusive life and health science curriculum delivered in the context of the sector to the highest of standards: led, shaped and determined by employers and our partners. This ensures our learners receive personalised, practical experiences offering opportunities that enrich their experiences above and beyond that normally expected in a traditional learning setting and thereby enhancing each individual's employability and prospects for success in their chosen career pathway. The Talent Bank is a full-time education programme aimed at young people aged 16 years+ wishing to pursue STEM A-levels or level 3 vocational and technical qualifications. Young people aged 18 years who become employed in the sector can pursue a higher apprenticeship programme either in the Life Science or Human and Health Science pathway, or continue in HE. The multimillion-pound Gower College facility will be resourced with the latest industry standard equipment and technology in conjunction with access to our partners' facilities, learners will be able to develop their technical skills in a realistic work environment.

Alignment with ARCH Vision (i.e. targeted high-level benefits)
Integral part of the ARCH promoting training and business engagement to: • Create a multi professional learning and training environment to support a talented workforce designed to deliver and sustain ARCH • To recruit, develop, inspire and retain the best talent and promote increased opportunities for the population of South West Wales • Internationalisation of FE agenda, providing overseas recruitment opportunity for GC with progression through to SU programmes. • Design and deliver an integrated skills development framework to develop and channel the skills needed to sustain the ARCH ecosystem of service provision, science, translation/commercialisation

Foundations (existing activity/prior projects relating to this initiative)
As an evidenced-based skills solution the Talent bank has been developed in response to research published by the Regional Learning Partnership conducted with employers across the life science sector in Wales[1]. The findings of this research highlighted the importance of the life science sector to the south west region and this research coupled with the Welsh Government's policies and interventions to accelerate growth has led to the design of this new transformative delivery model of STEM education. The key features have been shaped and led by employers across the sector to address the spectrum of skill challenges highlighted whilst also aiming to enhance the skills levels in the region.

Potential Location(s) (outlining where in ARCH region activities would be undertaken)
The Talent Bank will be located on the footfall of Singleton Hospital and Swansea University Singleton Park Campus

[1] Life Science: Skills for Life, Regional Learning Partnership: South West and Central Wales, http://rlp.infobasecymru.net

Partners (formally involved in development/delivery)	
Organisation/Group	Role

Gower College	Lead
Swansea University	Collaborator
ABM University Health board	Collaborator and location of Talent Bank
Hywel Dda University Health Board	Collaborator
Private Sector	Partners e.g. Fujitsu, GE Healthcare, GSK

Stakeholders and Beneficiaries (groups interested/benefiting from)	
Group	Interest/Role
Swansea University	Undergraduate recruitment and industrial engagement
Private Sector	Development of talent and integrated FE/HE approach to supporting business needs
ABM and Hywel Dda UHB	Supply of talent through recruitment, development and retention of local skills base

Planned Deliverables/Outputs/Impacts by Timescale (bullet points - quantified where possible)	
Deliverable	Timescale
• Talent Bank Plans – Curricula and Infrastructure • Industrial Partnerships and Market Testing • Funding Secured	Q4 - 2015 Q4 – 2015 Q4 - 2015
Output	Timescale
• Student Recruitment – 20p.a. stepping to 50p.a. • Initial Facilities (Phase 1) School of Mgt, ILS2 for 14 students • Expanded Facilities (Phase 2) 50 Sept 17	2016 and 2018 Q3 - 2016 Q3 - 2017
Impact	Timescale
• Increased student numbers into home/EU SU STEM provision (40+p.a.) • Increased student numbers into overseas SU STEM provision (10+p.a.) • Improved recruitment and retention into private sector LS&H • Improved recruitment and retention into private sector LS&H • REF Case Study	Q3 - 2017 2018 2018 2020

Resources by Type (number e.g. #FTE admin, and nature e.g. #m2 lab)		
People	Space	Other
Project Team 2xFTE through secondment Teaching staff in place	Phase 1 – 100s.m. Phase 2 - 400s.m. mixed teaching and labs	Collaboration with researchers and business engagement functions

Resources by Value (number e.g. #FTE @ £#p.a. for #months, and nature e.g. #m2 @ £.m2)		
People	Space	Other
Teaching Resource (GC)	£1-2m dependent upon location, phasing and scope (based on £1k/s.m. refurb, £2k new)	N/A

Resources Identified (Targeted)/Secured/Shared (e.g. £#m bid to #, £# offered by #, Existing lab shared with #)		
Identified	Secured	Shared
Potential co-investment from unused infrastructure	Investment of £1-2m from GC	ILS E&I supporting project development

Timescales

Activities (Q4 2015 - Q2 2016) (high-level by bullet point)
• Engagement: Open Evenings, Press Releases, Events • Confirmation of plans and resources: space, equipment, curricula, funding • Identification and development of team members (staff induction and training) • Facility development (Phase 1) Evaluation by SU – May 2017

Activities (Q3 2016-Q4 2017) (high-level by bullet point)
• Launch of Talent Bank 14 students in year 1 Sep 16 (Phase 1) • Development of Phase 2 facilities/ scope (50 students) • Operationalisation of Phase 3, scope of 100 students including expanded international recruitment

Activities (Q1 2018-Q4 2019) (high-level by bullet point)
• Sustainability of activities and steady-state operation • Development of potential further sites/online/international delivery

Integration and Dependencies

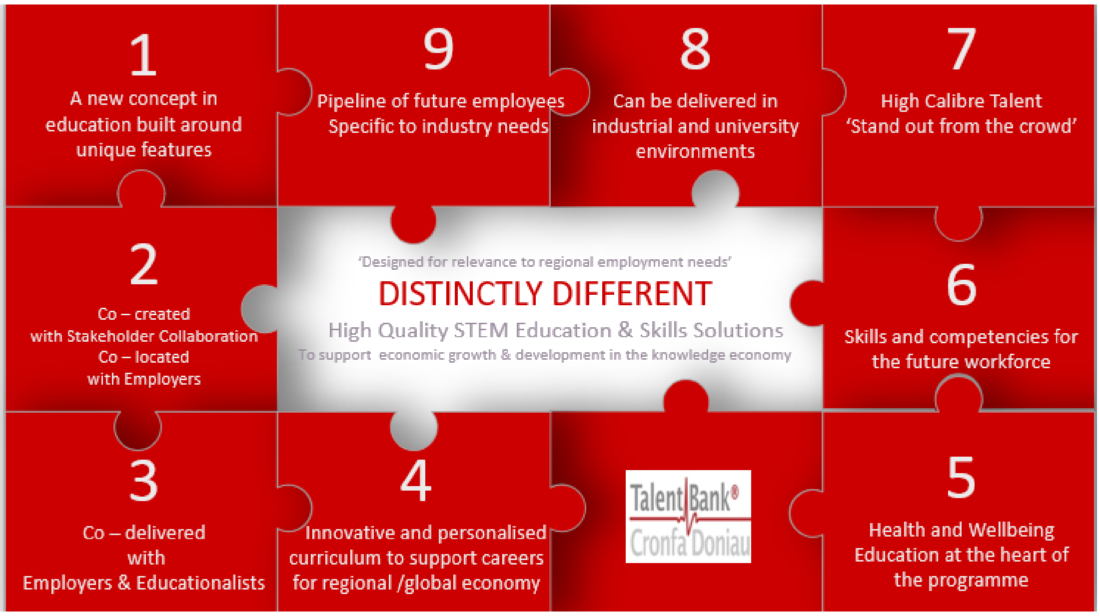
Alignment/Integration/Requirements with other ARCH activities (high-level by bullet point)
Workforce Development • Integration with SU, UHB and other stakeholders • Education & Skills, Recruitment & Retention, CPD **Research, Enterprise & Innovation** • Preparation for development of higher level skills and greater productivity in RE&I activities • Enterprise engagement strengthened through broader skills provision **Service Delivery** • More sustainable recruitment, development and retention of local talent to provide healthcare • Community Engagement and Healthcare Excellence

Alignment/Integration/Requirements with non-ARCH activities (high-level by bullet point)
• Supports Reaching Wider ambitions for SU • Develops Athena Swan agenda by supporting female participation in STEM careers • Strengthens recruitment into STEM for both Home/EU and overseas SU programmes • Supports wider WG development of key sectors with STEM skills requirements

Risk

Key Risks and Mitigations		
Risk	Mitigation	Owner
Delay in confirming/realising space impacting on start-date / impact on recruitment	Engagement with senior stakeholders and pragmatic (phased) facility plans	Project Team
Low student numbers from recruitment	Large number of local potential students entering FE	Gower College
Cost over-runs	Effective cost-control, fixed-sum contract and project management	Project Team

Appendix U | Talent Bank Presentation Slides

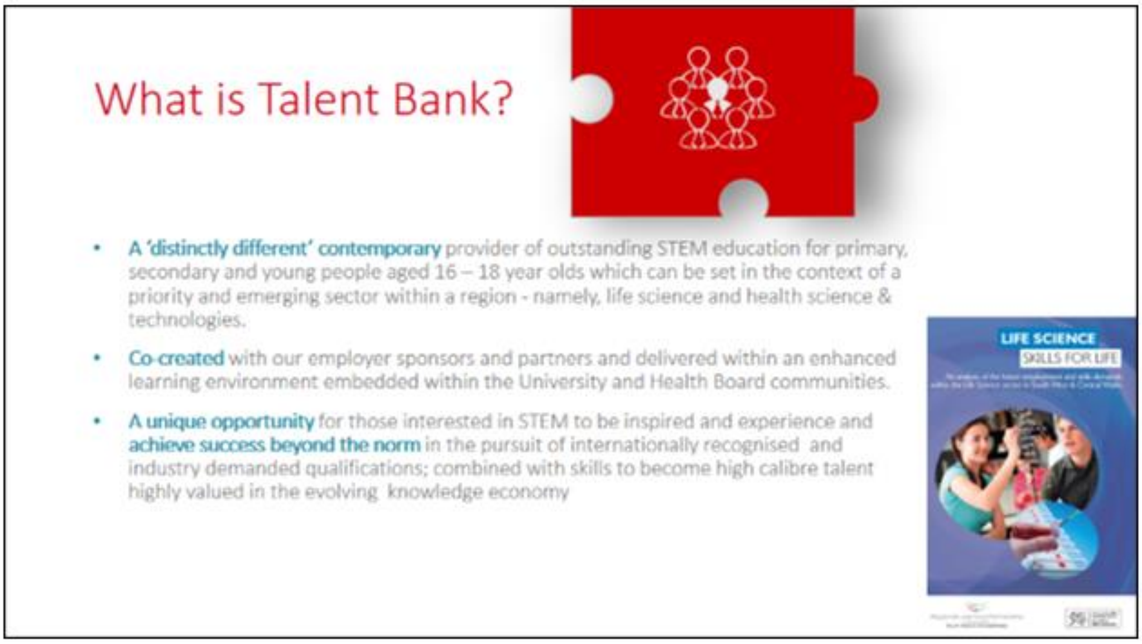


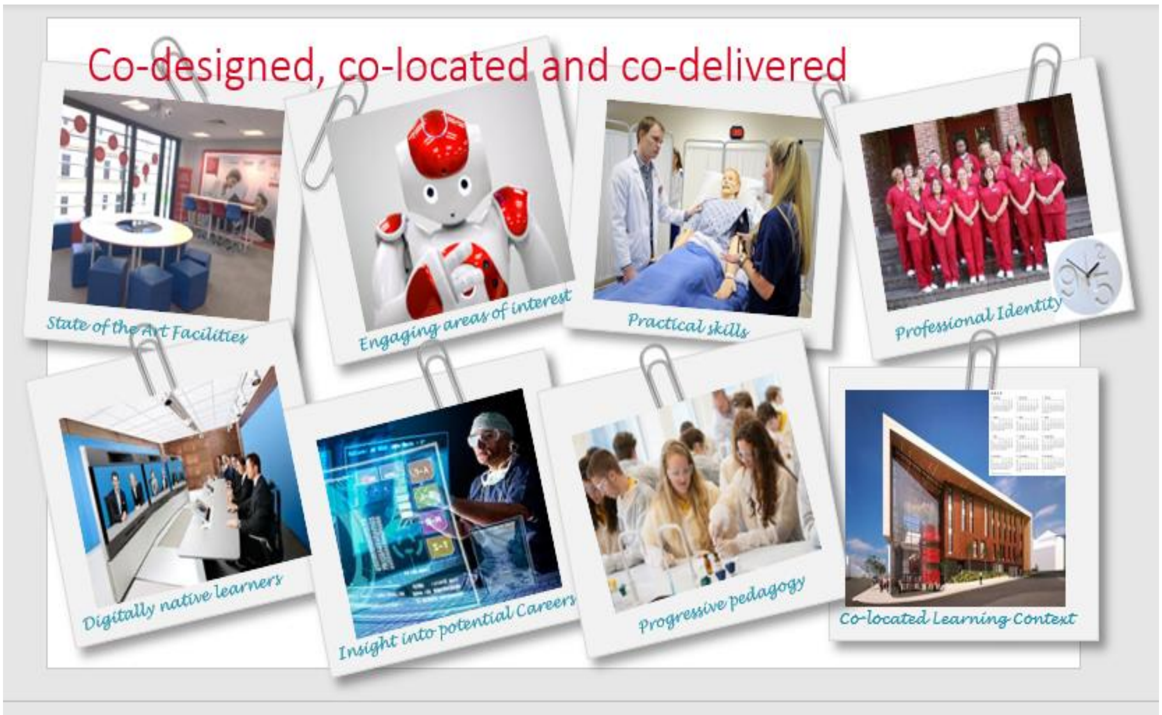
Our Mission is to transform education through collaborative partnerships between industry, educationalists and learners themselves. The education we deliver, is underpinned by action research and is therefore distinctly different to mainstream education. It is not for the elite, however, it isn't for everyone! But it is for those with an open mind who want to develop the skills for university and with an interest in a future career in STEM related occupations.

Our vision is to create high calibre talent amongst our young people – helping shape their learning experiences which in turn shape who they become, development for a better future. This vision aims to enhance the further education learning provision with industry led workforce learning which helps to support and further stimulate economic development in our region across Wales and beyond.

Our values: are derived from our learner and industry centric mission. The Talent Bank vision can be articulated and advanced through the promotion of the following design and delivery themes:

- Collaboration and partnership – strategic relationships, local, national, and international. Such networks have the potential to inspire our learners, partners and staff to create exciting learning experiences, enhanced knowledge, skills and professional competencies.
- Developing enhanced employability – harnessing 4 key skills strands to allow our students to develop and practice their transferable skills in order to secure the best STEM employment.


What is Talent Bank?
A 'distinctly different' contemporary provider of outstanding STEM education for primary, secondary and young people aged 16 – 18 year olds which can be set in the context of a priority and emerging sector within a region - namely, life science and health science & technologies.
Co-created with our employer sponsors and partners and delivered within an enhanced learning environment embedded within the University and Health Board communities.
A unique opportunity for those interested in STEM to be inspired and experience and achieve success beyond the norm in the pursuit of internationally recognised and industry demanded qualifications; combined with skills to become high calibre talent highly valued in the evolving knowledge economy
LIFE SCIENCE
SKILLS FOR LIFE


Co-designed, co-located and co-delivered
State of the Art Facilities
Engaging areas of interest
Practical skills
Professional Identity
Digitally native learners
Insight into potential Careers
Progressive pedagogy
Co-located Learning Context

Talent Bank Curriculum

Developing High Calibre Talent programme

KEY: **A**-Sectors **B**-Key Stakeholders **C**-Qualifications **D**-Focus **E**-Skills **F** –Blend of TB Features

A	Bio-medical, Health & Life Sciences	Digital technology & Cyber Security	Aviation Engineering	Mechatronics	Aviation Engineering	Advanced manufacturing	Sustainable Energy
B	Industry Employers	Students	Academia	Government			
C	1 Academic STEM Qualifications	2 Vocational STEM Qualifications	3 Apprenticeships				
D	Science	Technology	Engineering	Mathematics			
E	1. Scientific Curiosity & Research Skills	2. Problem solving, Creativity, Enterprise & Innovation	3. Digital Literacy and skills in Emerging Technologies	4. Leadership and Management	5. English Language Literacy and Communication		
F	Industry challenges	Master Classes	Induction & Internships	Mentoring	Visits	Health & Wellbeing	Bespoke Career Plan

Experiential Credentials

Our defining characteristics include:

- an innovative and agile experiential learning model, whereby we add value to the learning experience with our distinctively different approach, delivered with academic rigour
- Offers and integrated curriculum which delivers distinctive high calibre talent attributes in the areas of STEM, employability and professionalism, enterprise and global citizenship
- Dedicated to the personalization of learning on an individual basis supporting the learner through their own career development journey
- Pioneering new approaches with the support of the life science ecosystem within the region that will enhance workforce and enterprise capabilities
- Committed to continuous improvement and evolving our model and all aspects of sustainable development