CAMAU

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Learning about Progression –

Informing thinking about a Curriculum for Wales

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Explanatory Foreword

Learning about Progression – A Research Resource Tailored to Meet your Needs

'Learning about Progression' is a suite of research-based resources designed to provide evidence to support the building of learning progression frameworks in Wales. 'Learning about Progression' seeks to deepen our understanding of current thinking about progression and to explore different purposes that progression frameworks can serve to improve children and young people's learning. These resources include consideration of how this evidence relates to current developments in Wales and derives a series of principles to serve as touchstones to make sure that, as practices begin to develop, they stay true to the original aspirations of *A Curriculum for Wales – A Curriculum for Life.* It also derives, from the review of evidence, a number of fundamental questions for all those involved in the development of progression frameworks to engage.

Within this suite of resources you will find

- **Reviews of research into progression in children and young people's learning**
  - research related to progression in learning generally and research on progression in learning specifically related to each of the six AoLEs
- **Reviews of policies on progression from other countries**
  - who have similar educational aspiration to Wales in each of the six AoLEs
- **A review and analysis of progression as it is emerging in Wales in *Successful Futures* and in *A Curriculum for Wales – A Curriculum for Life*.**

We hope that you will find 'Learning about Progression' a useful resource. We recognise that a range of audiences will want to make use of its contents for a range of purposes and thus present information from 'Learning about Progression' in different ways, leaving you to choose which form is most useful for your purpose.

1. **Learning about Progression: a comprehensive review of research and policy to support the development of Learning Progression Frameworks in Wales**

   The whole report, 'Learning about Progression' offers a **comprehensive overview of research and policy related to progression in learning in general and to progression in learning in all six AoLEs**.

2. **Diving into Research and Policy in an Area of Learning and Experience**

   For individuals or groups who are interested in finding our more about the **evidence as it relates to an individual Area of Learning and Experience (AoLE)**, a detailed report is provided for each AoLE derived from Section 2 of 'Learning about Progression'. These six reports offer an overview of research on progression, an in-depth analysis of evidence exploring how different countries have tackled progression in an individual AoLE and evidence from research on progression within the discipline. These reports are entitled *Learning about Progression: Expressive Arts, Learning about Progression: Science and Technology* etc. You are currently using this mode.

3. Learning about Progression: From Ideas to Action

If you want to identify key messages from 'Learning about Progression' and your major concern is how to **use** the ideas as you develop progression in your AoLE, then read '**Learning about Progression: From Ideas to Action'** as your first point of engagement. This provides

- **key messages** on progression relevant to all of the AoLEs
- **an analysis of how the evidence from international policy and research relates to policy advice on progression in Successful Futures and A Curriculum for Wales**
- principles that might act as a touchstone to promote a close alignment between ideas and action and
- information on the strategy used to **inform decision making** about the framework to be used to develop statements of progression.

'Learning about Progression: From Ideas to Action' is supported by

- **a series of PowerPoint slides to introduce key ideas to others**
- **Decision Tree Workshops**

The evidence emerging from 'Learning about Progression' indicated strongly that there were a number of decisions that AoLE groups had to take before embarking on the development of statements of progression. These related to the major questions derived from the research. Decision tree workshops were designed to support AoLE groups and others in that process.

Decision trees were used as the basis of workshop activities at AoLE meetings to support AoLE discussions. Each decision tree

- identified the decision to be taken
- offered evidence from the 'Learning about Progression' report (from research, policy and practice) to help inform discussions within each AoLE
- was consistent with the principle of subsidiarity and encouraged AoLE members to add to the evidence available
- provided a framework where each individual AoLE, having reflected on the evidence, agreed a decision proposal to be shared with the Coherence Group.

All proposals were reviewed to ensure that they were consistent with the vision *A Curriculum for Wales – A Curriculum for Life* and reflected what AoLE members believed would best serve young people in Wales.

Proposals from the six AoLEs were then submitted to the Coherence Group whose task was to reach agreement about which decisions had to be consistent across AoLEs to promote coherence across the system and where there could be flexibility for individual AoLEs. This would then inform the next stage of work of the AoLE groups.

Terminology within both the Welsh and English versions of this report reflects the range of current thinking about concepts of progression; this may lead to one term being employed with different but related senses and/or to one concept being referred to by different terms.

Introduction

The education system in Wales is in the process of transformation. Since the publication of *Successful Futures* (Donaldson, 2015) and the subsequent adoption of its recommendations in *A curriculum for Wales – a curriculum for life* (Welsh Government, 2015), a national strategy has been underway to build new curriculum, pedagogy and assessment arrangements to offer young people in Wales educational experiences that are fit for the 21st century. The creation of these new arrangements is the responsibility of all involved in education in Wales – communities, policy makers, practitioners and researchers – and is led by a network of Pioneer schools whose task it is to identify what matters in the curriculum and how progress might best be described and discerned. The Curriculum Pioneer schools are working in national groups related to each of the six Areas of Learning and Experience (AoLEs) – Expressive arts; Health and well-being; Humanities; Languages, literacy and communication; Mathematics and numeracy; and Science and technology. The CAMAU project, a collaboration between the University of Glasgow (UofG) and the University of Wales Trinity Saint David (UWTSD), funded by the Welsh Government and the UWTSD, seeks to support the Welsh education system in its task by providing evidence to address three main questions:

- How might curriculum, progression and assessment be described and developed in Wales to focus on learning and to promote better alignment between research, policy and practice?
- In what ways do models of curriculum progression relate to progression in learning emerging from evidence of learning and progression within schools and classrooms?
- To what extent is it possible to think of assessment as the use of evidence to enable future learning, as 'progression steps', rather than as a summary of past achievement? (And how might we avoid this focus leading to a narrowing of the curriculum?)

The focus of the CAMAU project is **progression**. It takes its starting point from *Successful Futures* (Donaldson, 2015) and *A Curriculum for Wales* (Welsh Government, 2015), builds on the work of the Progression and Assessment Group (Welsh Government, 2017) and on what the AoLE groups have identified as what matters. The project works with teachers, schools, researchers and policy makers (local, national and international) to bring different knowledge, skills and understandings together to explore how progression might best be described and developed in relation to the AoLEs and to investigate how progression steps might be most helpfully identified, described and used to support learning.

Progression matters. Since the seminal Black & Wiliam (1998) review highlighted the potential for formative assessment (or Assessment for Learning as it is sometimes called) to enhance learning, particularly amongst learners who found learning most challenging, countries internationally have sought to realise that potential in schools and classrooms. The way in which Assessment for Learning has spread has been compared to a 'research epidemic' that has 'feverishly spread into every discipline and professional field' (Steiner-Khamsi, 2004: 2). However, at best, the enactment of Assessment for Learning has been patchy (Hayward *et al*, 2006, Marshall & Drummond, 2006) and problems around the articulation of progression have been part of the problem. Wiliam & Thompson (2007) offer a framework to articulate the roles that key actors (teacher, peer and learner) play in the assessment process based on three key ideas: where the learning is going, where the learner is right now and how to get there. Implicit in this model is the centrality of progression. For example, for teachers to provide feedback that moves learners forward, they must have a conceptualisation of what matters next both for learning in the domain and for the learner. But self-evident as that might seem, progression and its relationship to assessment and learning has proven to be a complex business. Indeed, in a recent article Baird *et al* (2017) argue that learning and assessment have been 'fields apart'. Recognising the inexorable relationship between learning and progression, Heritage (2008) argues that

> *'By its very nature, learning involves progression. To assist in its emergence, teachers need to understand the pathways along which students are expected to progress. These pathways or progressions ground both instruction and assessment. Yet, despite a plethora of standards and curricula, many teachers are unclear about how learning progresses in specific domains. This is an undesirable situation for teaching and learning, and one that particularly affects teachers' ability to engage in formative assessment.'* (p.2)

Internationally, there are areas of the curriculum where work has been done to build understandings of progression. Pellegrino (2017) argues that research undertaken on cognition and learning has led to the emergence of highly developed descriptions of progression in particular curricular areas (science, reading and mathematics) and that these can form a sound basis for assessment design (e.g. Bransford, Brown, Cocking, Donovan, & Pellegrino, 2000; Duschl *et al*, 2007; Kilpatrick, Swafford, & Findell 2001; Snow, Burns & Griffin, 1998). There are, however, other areas where work related to progression is far less well developed.

Progression as a concept is built in to *Successful Futures* through the identification of reference points (Progression Steps). The term 'reference point' is important. It establishes learning as an expedition, with stops, detours and spurts, rather than as a linear process. The progression frameworks will be central to the work of teachers and learners as they seek to enhance the learning of every young person in Wales and thus it is crucial that these frameworks are dependable. To address this challenge, the CAMAU project seeks to work with policy makers and practitioners to build progression frameworks that are, as far as is possible, evidence informed and supportive of assessment practices that are consistent with the 'spirit' rather than the 'letter' of assessment for learning (Earl, Volante & Katz, 2011; Marshall & Drummond, 2006).

Theoretically, the design of the CAMAU project builds on the work of Senge & Scharmer (2001) and on the empirically derived Integrity model of change (Hayward & Spencer, 2010). This model argues that for change to be meaningful and sustainable, project design must pay attention to three main areas:

- Educational integrity (a clear focus on improving learning)
- Personal and professional integrity (participants have a significant role in the construction of the programme, rather than being passive recipients of policy directives)
- Systemic integrity (coherence in development at all levels of the education system)

The CAMAU Project is designed in three phases. This first phase is concerned with the co-construction of an evidence-based Progression Framework. The second phase is designed to develop, review and learn from feedback on the draft Progression Framework and the third phase will trial, evaluate and review the Progression Framework in action. In all phases of this project teachers, pupils, policy makers and researchers are co-investigators with the shared aspiration of developing high quality, well-informed curriculum, pedagogy and assessment arrangements for Wales.

This report provides evidence on three specific aspects of the first phase of the CAMAU project:

- the review of how progression is described and structured within frameworks in other countries
- the review of progression in learning (in policy and research) and of evidence related to progression contextualised in each area of learning experience and
- initial work undertaken to explore teacher perceptions of progression in learning. (Evidence on teachers' and pupils' perceptions of progress will be collected throughout the CAMAU project and will be published in the final research report.)

Following this introduction that includes a description of methodology, Section 1 of the report identifies ideas about progression as they emerge in *Successful Futures* and then analyses these ideas using evidence from research on progression.

Section 2 is divided into six sub-sections, each devoted to one of the six Areas of Learning and Experience (AoLEs) identified in *Successful Futures* (Donaldson, 2015): Expressive arts; Health and well-being; Humanities; Languages, literacy and communication; Mathematics and numeracy; Science and technology. The evidence offered to each AoLE is in two parts. The first part is a review of how different countries have conceptualised and interpreted progression in that area of learning. The second part provides insights into evidence available from research on progression relevant to the specific AoLE.

Section 3 provides evidence of teachers' understandings of progression.

Section 4 draws together themes emerging from the different sources of evidence analysed and identifies decisions which require to be taken to allow the development of statements of learning progression within the AoLE.

This research report is intended to provide a dependable evidence base to inform thinking in the AoLE groups as ideas of progression are developed. The CAMAU project team throughout the project will work with AoLEs to use evidence from international curriculum and assessment documentation of how progression has been conceptualised in the research literature and in policy contexts similar to Wales. When AoLEs have identified what matters in the curriculum and have built initial models of progression, the CAMAU team will obtain and analyse empirical evidence from wider teachers' and learners' experiences of progression in schools and classrooms: evidence from teachers' perceptions of what is central to enable effective progression in their pupils' learning; and pupils' reflections of their own progression in learning. This sense checking of existing and expert models of progression is intended to promote curriculum, pedagogy and assessment arrangements in Wales that are grounded in teachers' and young people's actual experiences in learning. This work will be reported in the final CAMAU project report.

Methodology

The central purpose of the reviews of international policy and of research on progression is to provide dependable information to AoLE groups to support their thinking. Thus both the policy review and the review of research are focused and purposeful. Discussion with AoLE groups made it clear that to be useful, the reviews must be clearly focused, succinct and directly related to the task which the groups are being asked to undertake. In addition, the CAMAU project sits within the demands of a development programme operating to tight policy deadlines: all activities must be undertaken within a limited time-frame and with limited resources. This is not a situation peculiar to this project.

Dependable Evidence Summaries

The methodology for the creation of dependable evidence summaries emerges from the recently developed EPPI (Evidence for Policy and Practice Information) protocol for a rapid review of existing evidence (O'Mara-Eves *et al.*, 2016). Rapid reviews have been commonly used in Health policy contexts to inform evidence-based practice. The Welsh Government has itself used the process in an educational context, e.g. in a review of the impact of poverty on attainment (Wilson, 2011). Rapid Reviews are contentious. They are seen by some as conforming to policy timelines at the cost of rigour in the literature or policy review. More recently, rapid evidence assessments have become more common in policy contexts and the method is referred to on a number of Government websites across the UK. The Department for International Development identifies three main uses for rapid evidence assessments:

> *'[They] provide a more structured and rigorous search and quality assessment of the evidence than a literature review but are not as exhaustive as a systematic review. They can be used to:*
>
> - *gain an overview of the density and quality of evidence on a particular issue*
> - *support programming decisions by providing evidence on key topics*
> - *support the commissioning of further research by identifying evidence gaps'*
>
> (https://www.gov.uk/government/collections/rapid-evidence-assessments -- accessed 10/07/17)

These aims are consistent with the aspirations of the CAMAU project. The challenge is to provide evidence that is dependable within the constraints identified.

Grant *et al.* (2009) suggest that if Rapid Research Reviews (RRR) are to be dependable, they need to be rigorous and explicit about their methodology and acknowledge the concessions that have had to be made to breadth and depth. The need to synthesise evidence within a limited time frame with the specific intention of informing decision making processes lies at the heart of the increased use of RRRs. Khangura *et al* (2012) argue that, despite the rise in the popularity of this approach, very little has been published on appropriate methodologies. They rename RRRs as evidence summaries and propose a methodology to increase the means by which the validity, appropriateness and utility of the review might be discerned. The authors identify eight steps developed from their Knowledge to Action programme. These steps have been adapted in the CAMAU project as the framework for the development of the Dependable Evidence Summaries, designed to inform the thinking of AoLE groups as they tackle the complex challenge of describing progression.

Table 1: Outline of eight steps informing Knowledge to Action evidence summary approach (Khangura et al, 2012)

Knowledge to Action step	Task
Step 1	Needs assessment
Step 2	Question development and refinement
Step 3	Proposal development and approval
Step 4	Systematic literature search
Step 5	Screening and selection of studies
Step 6	Narrative synthesis of included studies (including assignment of evidence level)
Step 7	Report production
Step 8	Ongoing follow-up and dialogue with knowledge users

The Evidence Summaries in the CAMAU project have been developed as part of a process of on-going discussion with the knowledge users – each of the AoLE groups.

Progression in International Policy and Practice

The countries involved in the international policy and practice review were identified in two ways. The first priority was to identify countries of particular interest to the individual AoLE group. Second, CAMAU team members sought to select countries with aspirations similar to those identified in *Successful Futures* where different approaches to descriptions of progression were illustrated. The analysis of policy in each country followed a three-stage process:

- eliciting information on curriculum design, 'what matters' in the curriculum and how progression is described
- making summary statements of the above
- analysing information from across countries

Table 2 on the next page provides the framework for responding to questions on progression. The complete protocol can be found as Appendix 1.

Recognising the difference between policy intention and policy enactment, the final stage of this policy review went beyond the analysis of policy documentation. As part of the work of the CAMAU project's National and International Advisory Group, leading researchers in selected review countries were invited to discuss the enactment of policy in their respective countries in order to provide insights into how ideas have played out in practice. These reflections on the implementation of policy and on lessons learned add depth and texture to the information available in policy documentation and enhance the knowledge of policy-in-action afforded to CAMAU researchers by research publications.

Table 2

Country Information
Name of Country: Year the curriculum was written/published/updated: Website(s) where materials were found:
How is the curriculum structured? e.g. Is there a curriculum document as well as achievement outcomes or are these combined? Are there supporting materials for teachers? Is there one curriculum across all ages or is it split into primary and secondary? How many stages/levels/benchmarks are included? Are they aligned with specific years?
What components/subjects/themes related to the AoLE are covered in this country's curriculum? What seems to be missing?
How does the documentation define 'what matters' in this AoLE? Does this include content knowledge, competencies, skills, etc? What is the balance between knowledge and understanding, skills, attributes, and capabilities?
How is progression defined? Is it defined explicitly or implicitly? You may need to look beyond the statements themselves at the supporting documentation and introductions to the curriculum. Give some specific quotes or examples.
Are key progression points identified as expected standards for specified ages? Or as descriptions of knowledge, skills, capabilities needed for further progression in learning? Or is it some combination?
What form do statements of progression take? Are they detailed or broad? Are they in pupil-first person language or written for the teacher? Provide some examples.
To what extent does the curriculum for this AoLE seem to align with what is written in Successful Futures? Does it seem to align with Donaldson's vision for progression? Give some examples.
Is there anything else worth noting? E.g., Is there anything particularly unique, innovative, or useful about this curriculum? Are there any aspects of the AoLE that are included in cross-curricular aims? Was there anything within this portion of the curriculum that seems to have connections with any other AoLE?

Progression in Research Literature in the Context of Policy in Wales

The review of research literature in the context of policy in Wales was undertaken in three strands

- a review of *Successful Futures* to identify what had been written about progression
- a review of seminal papers on the concept of learning progression
- six separate reviews, one undertaken for each of individual AoLE.

Whilst much has been written on curriculum progression, far less is available on learning progression. Papers for the review were identified using three approaches:

- expert knowledge (including recommendations from CAMAU Professorial Consultants - internationally recognised experts in individual Areas of Learning Experience)
- search strategies
- reference snowballing.

As reviews for individual AoLEs were undertaken by several members within each AoLE team, detailed guidance was provided. Reviewers conducted independent searches using keywords, employing Ebscohost or a similar academic database. Key terms were contextualised in each AoLE, e.g. 'progression in mathematics'; keywords specific to particular domains were identified, e.g. in Health and well-being keywords included 'child development' and 'developing'. Texts published before 2000 were excluded unless identified by Professorial Advisors as seminal texts. Wales is a bilingual country. Where possible, eg, in LLC, the review included evidence from bilingual countries. However, we recognise that most of the evidence used to inform this report has been drawn from material published only in English, that the research has to a large extent considered practice in English speaking countries and that, with few exceptions, progression frameworks examined have been drawn from countries and states in which English is the sole or a major language of schooling. This limitation has to be recognised.

When lists of possible texts had been generated, titles and abstracts were reviewed to identify potentially relevant sources. Expanded or snowball searches were also carried out where authors cited within the original sources were investigated, either by following up on articles cited or by undertaking author searches within Ebscohost. In addition to recommendations made by Professorial Advisors, CAMAU researchers sought advice from colleagues in the University of Glasgow and in the University of Wales Trinity Saint David with specific expertise in a particular area. From this range of sources, a list of all papers considered was generated by each group and the screening processes that led to the final selection of papers to be reviewed were documented.

The analysis of literature review is intended to address critical questions related to progression within a particular Area of Learning Experience. To illustrate this process *Table 3* on the next page offers an example from the review for the Health and well-being AoLE. The full protocol can be found in Appendix 2.

Table 3

Literature Review- Critical Questions
• What evidence exists that informs our understanding of progression in this domain?
• In what ways have researchers described how children develop their knowledge/ skills/ capacities in this area? In other words, how do they model progression? For example: – According to the literature, are the changes that children make qualitative jumps (with big steps at key moments) or more gradual sophistication (children seen to gradually add more of the same skills over time)? – Is progression linear or could children move backwards and forwards? – Do the researchers see children's progression as something that can be impacted on by the environment and open to change, or is it fixed? – Is there one path that children seem to take in this area, or are there multiple paths? Do the researchers acknowledge that children may have different paths based on the context in which they grow up/learn? – Are there different models of progression for the same topic and to what extent do they overlap, complement, or conflict?
• To what extent does the literature focus on how children develop in terms of their knowledge/understandings vs. behaviours/skills?
• To what extent is the progression that is described at a micro-level (for one lesson/unit) or at a macro-level (across multiple years)?
• What ages are covered when describing how pupils learn in this area? Which ages seem to be missing or receive less adequate attention?
• What is the theoretical background of the relevant literature (e.g., education, public health, psychology, etc.)? We may get some insight by looking at the journal it is published in.
• Importantly, what seems to be missing in this area? What do we still not know? Is there little research on this topic?

Building Dependable Evidence: Synthesising Sources

The evidence emerging from across the six AoLEs was then compared with the review of *Successful Futures* and the more general research evidence on progression. From this synthesis key themes were identified. These themes were then used as the evidence base to inform for the final section of this report, Learning about Progression: from ideas to action.

This central purpose of this research report, *Learning about Progression – Informing thinking about a Curriculum for Wales*, is to provide a dependable evidence base to inform the work of each AoLE. To maximise the use of the evidence to inform action in AoLEs, the research report is available in a number of forms.

The full research report is available to all interested parties. In addition, a domain specific report has been developed for each individual AoLE. Each individualised report contains key points from:

- the introduction
- the review of *Successful Futures* and research evidence on progression as a concept
- the policy review and research review specific to the area of learning experience
- 'Decision Trees' as an enabling artefact to stimulate use of an extensive evidence base in practice: 'Decision Trees' structure evidence from the research report succinctly around key questions for use within AoLE workshops. Their purpose to promote better informed decision making.

The decision trees identify crucial questions to be addressed by each AoLE as they design a progression framework for the Welsh curriculum. Using evidence from the research report, they offer insights into how issues have been tackled in different countries and suggest some initial possible advantages and disadvantages related to each decision. They also identify relevant insights from research. Examples of decision trees can be found in Appendix 3.

Using the decision tree approach as a stimulus for discussion and negotiation, each AoLE group was invited to respond to each question, to consider evidence available from research and policy and to add insights from their own professional experience. Once the group had considered the evidence, they were invited to develop proposal to be considered by the cross-AoLE Coherence Group. The role of the Coherence Group was to consider proposals from each AoLE and to take decisions to promote consistency and coherence across the six AoLEs.

Evidence from Teachers and Learners

A central feature of the CAMAU methodology is to promote approaches to progression that are empirically informed by evidence from practice.

In line with the principles of partnership, subsidiarity and collaboration which underpin the CAMAU research project, teachers are co-researchers. While teacher participation in the curriculum development process was an expectation arising from their employment in pioneer schools, participation in related research was voluntary. Consequently, all teachers in the AoLE groups were asked and agreed to participate in this research in accordance with the ethics procedures of the two universities.

Between April and July 2017, collaborative research focused on the articulation of teachers' conceptualisation of learning progression. Evidence was generated through approaches which acted as prompts to support this articulation. The aim was to draw on teachers' practical experience to contribute to developing learning progression frameworks.

Four research questions were developed by the CAMAU team. These were designed firstly to explore evidence of teachers' understanding of progression in learning emerging from the data and secondly to consider the efficacy of different approaches to the collection of evidence of teachers' understandings of progression:

- What evidence on progression emerges from teachers' articulations of progression in learning in their classrooms?
- What are the characteristics of learning identified?
- What types of activities led to teachers articulating their understanding of progression most effectively?
- What sorts of group structures and size supported such activities?

Evidence related to the first two questions would directly inform the drafting of progression statements; evidence related to the latter two would inform later research into teacher views to further develop these statements and to offer insights into processes of sustainable change.

The CAMAU team developed three principal approaches to gathering evidence relevant to the first two questions. It was agreed that the approach(es) used in each AoLE would recognise the views of teacher participants and would be reviewed in the light of evidence related to the latter two questions. The CAMAU team adapted tasks to take account of the broad direction of developing thinking within each AoLE about what matters.

Approach One – Time1-Time(n) (see Newby, 2010)

Teachers were supported to articulate typical learner progress across a period of time; the number of stages (i.e. T1-T2, T1-T3) used was determined by the perceived requirements of each AoLE. The fundamental questions posed took the form of:

- T1 - Can you describe what, in general terms, you expect a learner to know, understand and be able to do at a start time (e.g. the beginning of the year)?

- T2 - Can you describe what, in general terms, you expect a learner to know, understand, and be able to do at an end time (e.g. the end of the year)?

A variant of this approach explored progression made by three individual young people in a class as they moved through a phase: one who finds little challenge in relation to expectations; one who generally achieves expectations; one who finds expectations challenging.

Approach Two – Evaluation of progression in other countries' frameworks

Teachers were asked to examine critically aspects of frameworks from other countries. This afforded opportunities for teachers to review, from a relatively disinterested stand-point, policy and practice and to articulate views on models of progression, broad progression steps and appropriate language.

Approach Three – CoRe (Content Representation) (see Eames et al. 2011; Loughran et al. 2004)

This approach involves identifying areas of knowledge or skill that seem central to learning in an AoLE and for each of these areas responding to questions such as:

- What do you intend young people to learn about this idea or skill?
- Why is it important for them to know this?
- What prior or related knowledge do learners have of this idea or skill?

- What difficulties / limitations may be associated with progression in developing this idea or skill?
- How do you ascertain learners' progression or difficulties in developing this idea or skill?

Findings from this early stage of teacher research are reported in Section 3.

Section 1: Progression – Welsh Policy and Research Insights

Progression in learning is crucial to the realisation of the aspirations of *Successful Futures* and it is essential that progression as developed across the AoLEs is well informed. As indicated in the Introduction, the evidence to promote well informed ideas of progression in learning comes from different sources. This section of the report reflects on two sources of evidence: evidence from policy – what *Successful Futures* says about progression – and evidence from research – an analysis of research on progression.

Evidence from the Policy Context in Wales - Donaldson, Progression and Learning

The concept of progression is at the centre of the new curriculum in Wales. It structures, describes, and enables learning. Donaldson's use of the term represents a shift in discourse that aims to restructure the learning experience for pupils, from discrete and generalised stages of attainment, to a **learning continuum** of individual achievement. Within this new structure, each learner moves forward fluidly through statutory education from age 3 to age 16, guided as appropriate by reference points, supported and challenged according to his/her needs, and assessed in relation to the four purposes of the curriculum.

The four purposes describe what all children and young people should become and achieve through statutory education as well as how they are perceived and positioned as they experience the curriculum.

Recommendation 2 (p.23) states:

> *'The school curriculum should be designed to help all children and young people to develop in relation to clear and agreed purposes. The purposes should be constructed so that they can directly influence decisions about curriculum, pedagogy and assessment'.*

This follows the argument that:

> *'statements of curriculum purpose need to be formulated carefully so that they have integrity, are clear and direct and become central to subsequent engagement and development; in that way they can shape the curriculum and suffuse practice. Common understanding of* ***why*** *we are doing what we are doing is a powerful starting point from which to determine* ***what*** *it is we need to do and* ***how*** *we are going to do it.* (p.22, author's emphases)

The purposes tell us about how children should experience their curriculum day to day. Learners progress to become more ambitious, capable, enterprising, creative, ethical, informed, healthy, confident individuals. Progression is characterised in terms of depth, complexity, level of abstraction, accomplishment and skill, for disciplinary knowledge and wider competencies, and each child's learning continuum functions as a journey through the curriculum. This journey will include diversion, repetition, and reflection, as appropriate for each individual to make progress in learning. There is greater responsibility for teachers to ensure child-centred learning to ensure effective learning takes place, since the pace of each journey is set according to the requirements of the learner.

Discerning the progress being made by each child is fundamental to establishing learning. While the concept of progression shifts control of the curriculum into the hands of the schools, it also shifts assessment from generalised phases and stages, to a greater focus on the evaluation of learning from the perspective of the child: a shift from 's/he should' to 'I can'. This means all children and young people can travel on the same continuum, regardless of any Additional Learning Needs. In the new curriculum, assessment is purposeful and designed to support the progression of each child's learning: what does each child need in order to move forward, what difficulties might s/he have, what are the next steps and how might these next steps best be supported?

Assessment is the means by which teachers seek to discern progress and to identify what is most important for future learning. Progression, and therefore achievement, in Donaldson's terms is positive, beginning from the child or young person's point of departure. Progression describes a forward movement for each learner which is not necessarily linear and which does not end at a given age or stage. Throughout the Donaldson Review, learning is conceptualised as growth. Learners build on previous knowledge/skills/competencies/dispositions in a continuous journey across and within the Areas of Learning and Experience.

Learning is defined through the concept of progression, which is represented as a coherent continuum without separation or interruption. The continuity that the new curriculum places at the centre of learning describes a holistic approach to the development of the individual, including experiential learning that is valuable in and of itself. Learning is the end goal of the education system. The learner is at the heart of the process and a fundamental element of the curriculum is choice. Learners are encouraged to take responsibility for their own learning, to become pro-active, and teachers are encouraged to ensure learning is meaningful and 'authentic', so that it has real world relevance.

What Successful Futures says about Progression

The term progression occurs 116 times in Successful Futures. Additional Document 1 provides a list of each occasion when the word progression is used and an analysis of the different contexts for the idea of progression. In *Successful Futures* (2015) the four purposes provide 'coherence, progression and flow' to learning intentions (p.21). Significant emphasis is placed on manageability:

> *'Having common Areas of Learning and Experience from 3 to 16 should promote and underpin continuity and progression and help to make the structure easier to understand'* (p.39).

Successful Futures presents a clear vision for progression

1. Phases and key stages should be removed in order that progression can be continuous, increasing the potential for higher attainment by minimising transitions.
2. Progression in each Area of Learning and Experience should be based on a well-grounded, nationally described continuum of learning that flows from when a child enters education through to the end of statutory schooling at 16 and beyond.

3. Learning should be an expedition, with stops, detours and spurts rather than a straight line. Progression is a 'road map' for each and every child/young person's progress in learning though some children and young people will progress further than others.
4. Progression Steps will be described at five points in the learning continuum, relating broadly to expectations at ages 5, 8, 11, 14 and 16 (staging points for reference rather than universal expectations – but expectations should be high for all learners).
5. Progression Steps are made up of a number of achievement outcomes linked to what matters in the curriculum and linked to the four purposes ('I can' statements). Literacy, numeracy, digital competence and wider skills should be embedded as well as elements of the Cwricwlwm Cymreig.
6. Achievement Outcomes should not be a checklist of knowledge or skills and should incorporate effective pedagogy.
7. Achievement outcomes should inform next steps and be framed as broad expectations achievable over a period of time (approximately 3 years).
8. Achievement Outcomes should use 'I can', 'I have' (and 'I am ready to') statements to describe progression (not over specified or overly vague – this may vary across AoLEs).
9. Assessment (relevant and proportionate) should be focused on learning intentions and progression in relation to the four curriculum purposes and based upon the intentions set out in the Achievement Outcomes at each Progression Step within each Area of Learning and Experience. In each AoLE the Achievement Outcomes at each Progression Step will need to encapsulate the most important aspects of learning, take account of the ways in which children progress in different kinds of learning and recognise what they need to be able to know and do to move securely to the next stage.
10. Professional judgement is central to assessment (formative assessment with relevant summative information collected and used formatively within classrooms and schools).
11. Schools should use teacher assessment of progression systematically, together with other sources of evidence, to inform their self-evaluation for school improvement purposes.

The ideas presented in *Successful Futures* form the principles from which curriculum, progression and assessment in Wales should be developed and offer a touchstone against which emerging proposals can be evaluated.

Evidence from Research – an Analysis of Research on Progression

The inter-relationship of curriculum, assessment and pedagogy is recognised as being at the heart of learning. Yet, Wyse, Hayward & Pandya (2015), analysing the state of the field internationally, suggested that all too often research has focused on these as different fields leading to a lack of alignment in how curriculum, assessment and pedagogy are experienced in learning. This theme was developed by Wiliam (2017:1) who argued that theories of learning and theories of assessment lack connection because assessment and learning are trying to do different things and each field has been inward looking in identifying and addressing challenges. *Successful Futures* (2015) recognises the importance of promoting a strong relationship between curriculum, assessment and pedagogy. The policy states clearly that everything in education in Wales should be driven from the curriculum: the identification of what matters for a person to be considered educated. What matters in the curriculum in Wales is being identified by the Pioneer Schools in each AoLE. This research review begins from that premise and explores how progression and assessment might emerge in relation to what matters.

Curriculum, Progression, Pedagogy and Assessment – a Coherent Whole

Built into every curriculum internationally is a notion of learning development but there are different ways in which this can be done. Some countries seek to describe outcomes in different areas of the curriculum through the specification of standards commonly related to ages and stages on development in schools. The aspiration is that by specifying standards, these will become teachers' expectations and student performance will improve. Yet concerns have been raised that many of the statements of standards do not provide the information necessary to achieve that aspiration and are not helpful in developing an understanding of where students are in relation to what might be regarded as desired goals (Heritage, 2008). This lack of clarity can lead to problems emerging between curriculum and learning, for example, teachers may find these statements of standards difficult to use for formative assessment purposes – where the learning is going, where the learner is right now and how to get there (Wiliam & Thompson, 2007). Learning progressions offer the potential to support learning more effectively as they offer teachers the opportunity to relate learning in their class to learning undertaken in previous and learning to be undertaken in future classes. They can make connections between prior and future learning and use information from formative assessment to discern where students' learning lies, allowing them to relate teaching more specifically to what matters and, crucially, to what matters next. Heritage (2008) suggests that '*Explicit learning progressions can provide the clarity that teachers need'.*

Heritage (2008:2) also suggests that greater attention should be paid to the different levels of specificity used to articulate the curriculum. Some curricula specify detailed objectives to be mastered at each grade in sequence. When the curriculum is described in this level of detail, its 'grain size', it may be difficult to see how these discrete objectives connect to bigger, organising concepts and learning can become little more than a checklist of things to be learned. Curricula organised around core concepts or 'big ideas' and sub-concepts offer better opportunities for a stronger relationship between assessment and learning goals: assessment for formative purposes. However, Heritage (ibid) argues that care also needs to be taken with this approach for too often 'big ideas' are not brought together as a coherent vision for the progressive acquisition of concepts and skills. Without a coherent vision the potential for teachers to have a broad overview of learning in a specific domain is restricted. Broadly speaking, learning progressions differ in the span of the progressions and the degree of granularity in their description. Some models present a learning progression as almost a unit of work, whilst others, such as spelling, span several years. Often, the shorter the span, the greater the detail and specificity.

The work of Black *et al.* (2011:74) develops the idea that having a coherent model of progression that is closely linked to assessment and pedagogy will effectively support learning. They conclude that progressions are essential to high quality learning and teaching.

> *'One essential ingredient for a teacher is to have in mind an underlying scheme of progression in the topic; such a scheme will guide the ways in which students' contributions are summarized and highlighted in the teacher's interventions and the orientation the teacher may provide by further suggestions, summaries, questions, and other activities.'*

Pellegrino *et al.* (2012) offer further insights into what is important in the assessment process, a process he describes as reasoning from evidence, and how assessment might relate to curriculum and pedagogy. He identifies three interconnected elements that should underpin any assessment and conceptualises these as an assessment triangle whose three sides are:

- a model of student cognition and learning in the assessment domain
- a set of assumptions and principles about the kinds of observations that will provide evidence of competences
- an interpretation for making sense of the evidence

Whilst all three elements are essential, in a later article (2017:361), Pellegrino argues that often the critical cognition component is missing. The focus of learning should be determined as far as possible by models that describe *'how people represent knowledge and develop competence in the domain of interest'*. This, he suggests, is a distinguishing feature of an evidence-based approach to assessment design, where the most important aspects of student achievement are identified, aspects which then become the focus for '*inferences'* and which should '*provides clues about the types of assessment tasks or situations that will elicit evidence to support those inferences'.*

Although most work on learning progressions has been carried out within domains, deeper understanding of what is important to improve learning may require work to be undertaken across domains. Some more recent studies have begun to explore learning progression across domains. An example of this is to be found in Wylie *et al* (2017 in press) where the researchers sought to build companion learning progressions in mathematics and language. They argue that analysing mathematics and language learning progressions together offers a more detailed and nuanced picture of progression to inform teaching and formative assessment. By focusing on both mathematical knowledge and the discursive skills required to share that understanding, the researchers moved thinking from right versus wrong to a deeper understanding of the ways in which pupils were developing competences in mathematics and language. The application of content and language progressions, they suggested, provided teachers with a deeper understanding of the interaction of mathematical knowledge and language proficiency.

What are Key Characteristics of Learning Progressions?

Mosher & Heritage (2017:1) define Learning Progressions as

> *'inferences or hypotheses describing the order of definable steps, stages, or levels that students' understanding and skill in a subject or discipline are likely to go through over time in response to instruction and experience as they reach the levels of understanding and skill that are the goals of instruction.... The inferences should be based on empirical evidence from student work, assessment performance, responses to clinical interviews, or other observations by teachers or researchers. They may describe likely steps or growth paths in the context of typical instruction, or they could describe what becomes possible with more effective instruction.'*

Learning progressions are pathways along which students are expected to progress. These pathways or progressions are the basis of teaching and assessment. Learning progressions can be conceptualised in different ways but as part of a review of a range of different approaches to learning progressions, Heritage (2008) identified certain common features.

- All models conceptualise progression as a continuum of increasing sophistication of understanding and skills as young people move from 'novice to expert'. (p.4)
- No definition contains references to grade or age level expectations, in contrast to many standards and curriculum models. Instead, learning is conceived as a sequence or continuum of increasing expertise.
- Learning progressions adopt a developmental view, inviting teachers to conceptualise learning as a process of increasing sophistication rather than as a body of content to be covered within specific grade levels.
- Progression also implies a sequence along which students move incrementally from novice to more expert performance. Implicit in *progression* is the notion of continuity and coherence. Learning is not seen as a series of discrete events, but rather as a trajectory of development that connects knowledge, concepts and skills within a domain.
- Learning progressions are accommodating. They recognise that students do not move forward at the same rate or with the same degree of depth and progression and see this as an expected part of learning.
- Learning progressions enable teachers to focus on important learning goals paying attention to what a student would learn rather than what a student would do (the learning activity). The learning goal is identified first and teaching, pedagogy and assessment are directed towards that goal. 'Consequently, the all too common practice of learning being activity driven rather than driven by the learning goal is avoided.' (p.5)
- Learning progressions are an important part of assessment to support learning. Clear connections between what comes before and after a point in the progression offers teachers a better opportunity to calibrate their teaching, to address misunderstandings or to develop skills as revealed by assessment, and to determine what important next steps would be to move the student forward from that point.

Further key features of learning progressions are identified in the work of Duschl *et al* (2007) and Pellegrino (2017). Duschl *et al.* (2007) suggest that a distinctive feature of learning progressions is the evidence base from which they are developed. They define learning progressions as evidence based hypotheses about how students' understanding and ability to use core concepts and explanations become more sophisticated over time. These hypotheses represent the pathways that young people are likely to follow as they make progress. These pathways should be empirically tested to ensure that they relate closely to how most students experience progression and should be empirically evaluated to determine their efficacy to discern whether or not lead to better learning.

Pellegrino (2017) suggests that although learning progressions are not developmentally inevitable, they may be developmentally constrained. He suggests that numerous progression paths are possible and that progress rather than being linear may be more like 'ecological succession' (p.362). A learning progression offers one or more possible paths but 'does not represent a complete list of all possible paths'. In addition, at any point in the process, an individual may demonstrate thinking and/or practices that could be considered to be at different points on the path. Mosher & Heritage (2017) support this view, adding an optimistic view of learning progressions which suggests that there is a small number of likely paths, that the steps along the way are clearly distinguishable and that they represent understanding and related skills which are stable for reasonable periods of time. They also re-emphasise the complex nature of the progression concept, its non-linear pathways, its confusions and regressions as learner thinking develops over time to new levels of sophistication.

The inter-relationship between the learner and progression is further complicated by regressions that can occur in particular circumstances, e.g. stress or challenges that feel to them to be too great. This approach may align more closely with Bruner's spiral curriculum than any model of linear learning, building on the hypothesis that '*any subject can be taught effectively in some intellectually honest form to any child at any stage of development*' (Bruner, 1960*:* 33). Pellegrino (2017) argues that there is a clear connection between progress in learning and the quality of teaching to which the young person is exposed. High quality curriculum and pedagogy are essential for optimal progression as is the teacher's confidence in dealing with the complexities of differentiated instruction.

Learning Progressions and Audience

There is a further characteristic of Learning Progressions worthy of consideration: the audience. Many learning progressions are written primarily for teachers and tensions can arise if a single learning progression attempts to serve too many purposes. For example, Heritage (2008) draws attention to the problems that can arise if it is assumed that the same degree of granularity will serve both planning and assessment. The degree of granularity in a learning progression designed to ensure that teachers have an overview of progress from novice to expert is very different from the degree of granularity necessary to enable teachers to support learning formatively: the latter would require a far more detailed analysis of progress in learning. She proposes that a possible way to deal with this issue would be to have different learning progressions serving different purposes. An overview learning progression to offer a multi-year picture of the journey from novice to expert. These could then be linked to learning progressions related to each of the key building blocks of what matters in the curriculum. These more detailed learning progressions would support teachers in formative assessment whilst their relationship to the multi-year learning progression would allow them to locate their own work in the bigger learning picture. This could also be helpful in offering support to teachers who are working with young people whose learning is outside the range of normal expectations for the group or year with whom they are working.

Learning progressions can also be written in ways which provide a framework for learners to understand the learning journey they are on. Heritage (2008) argues for the importance of learners being aware of longer term goals and the relationship between those and their day to day progress. It is unquestionably desirable for students to know what the longer-term goal is or what the final product of the learning will be. Increased involvement in learning occurs when teachers share with the students what their longer-term goals are and enable them to participate in evaluating the degree to which they have met the goals. The changing role of the learner within social constructivist and sociocultural theories of learning is highlighted by Baird *et al.* (2014, 2017). Within these overlapping theories, there are common learner characteristics. Learners are active in the learning process, involved in self and peer assessment, in social processes and interactions where there is a changed 'contract' around learning. If the aspirations for this new relationship, this new contract between the learner and society, as articulated in Baird *et al.* (ibid) are to be fulfilled, there are implications for the level of transparency in curriculum, progression, pedagogy and assessment. Learners need deeper and more meaningful understandings of what matters in learning and a voice in what matters. They would have the right to understand the longer-term journey in the domain being studied and the responsibility to work with teachers and others to engage in learning processes and, crucially, in assessment as part of learning. Learning progressions are a crucial part of this process.

Progression and Assessment

There is strong research evidence that approaches to formative assessment can and do improve learners' attainments (Black & Wiliam, 1998; Wiliam *et al.*, 2004). Black *et al.* (2011) suggest that these approaches are based on principles of learning well informed by cognitive research. They define the principles as

- *'Start from a learner's existing understanding.*
- *Involve the learner actively in the learning process.*
- *Develop the learner's overview, i.e. metacognition – this requires that students have a view of purpose, have an understanding of the criteria of quality of achievement, and self-assess.*
- *Emphasise the social aspects of learning (i.e. learning through discussion) as these make a unique contribution.'*

There are strong areas of overlap between this definition and Heritage's (2008) conceptualisation of formative assessment:

- eliciting evidence about learning to close the gap between current and desired performance (Pellegrino (2001) would describe this as drawing inferences);
- providing feedback to students; and
- involving students in the assessment and learning process.

Both definitions privilege the role of the learner in learning and assessment.

Black *et al*. (2011) make a strong case for the centrality of teacher assessment. They suggest that teachers' in-classroom assessments offer opportunities to achieve far better standards of validity than national or state tests. The evidence they generate is richer and more meaningful. However, they caution that significant professional development (2001:106) is necessary, for teachers' professional judgements to be both valid and reliable. The authors present five steps essential to the design and implementation of any learning exercise. The exercise must have strategic aims that involve understanding concepts and methods of a subject or developing reasoning skills. Teaching has to be planned, involving what the authors describe as choosing the tactics for realising the strategy in order to '*help build a picture of learners' existing understanding, especially with respect to the learner's location on the learning progression, so that the next challenge can be framed to take that understanding further'* (2001:77). The plan then has to be implemented, reviewed and summed up. The researchers argue for the importance of a curriculum as an evidence-based model of the paths through which learning typically proceeds used to inform both pedagogy and assessment. These 'road maps' they describe as central for all five steps outlined above. And they offer an example of a road map for the scientific concept 'atomic-molecular theory of macro properties'. Through this example, the authors suggest that we can create roadmaps by synthesising several sources of evidence (2011: 85)

- research results about common pupil misconceptions
- internal logic of the concepts involved
- indications from learning theory about difficulty of the types of thinking involved

- results from assessment items that indicate problems/possibilities with the topic sequence

They argue that, although previous qualitative studies on this topic provide rich understandings of progression of learning, they are limited by the specific contexts in which they were developed. They propose larger scale and longitudinal studies to deepen understanding of trajectories of change of individuals.

Black *et al*. (2011) argue that progression is needed for formative assessment:

> *'(a) to formulate a task or test so that the responses can provide evidence of learning progression, (b) to formulate helpful comments, tailored to the individual needs of each student, and (c) to give clear guidance on how to improve, all require a clear road map, that is, a view of the learning aim and of the steps along the route, or routes, that the student needs to take to get closer to the aim in light of his or her position en route.*' (p. 75)

Pellegrino (2014, 2017) supports this view. He suggests that learning progressions are helpful ways to think about the assessment of student learning. Like Black *et al* (2011), he argues that learning progressions should contain multiple elements, including *Learning Performances.* These he describes as

> '*the kinds of tasks students at a particular level of achievement would be capable of performing. They provide specifications for the development of assessments by which students would demonstrate their knowledge and understanding. Such assessments allow one to observe and infer students' levels of competence for major constructs that are the target of instruction and assessment within and across grade levels. Thus, an adequately specified learning progression should include an approach to assessment, as assessments are integral to learning progression development, validation, and use'* (2017:362).

He also concludes (Pellegrino, 2017:363) that when detailed maps of learning progression exist at grain sizes to support teaching and assessment, these will form a conceptual base that can be used as evidence of longer term growth and change, evidence currently collected through large-scale assessments. This will improve the validity of the assessment because there is a clearer idea of the construct being measured and the level at which student learning and performance is understood.

In conclusion

There is recognition in both policy in Wales and research of the importance of learning being articulated progressively. Although in Successful Futures (2015) this is described as a *learning continuum* and in research as a learning progression, these terms share many common characteristics. For example,

- Curriculum, assessment and pedagogy should be seen as an integrated whole
- Progression should be continuous
- Progression is not linear
- The journey from the point a young person transitions into the curriculum until the point where the young person transitions into life beyond school education should be sufficiently clear to allow both teachers and learners to make sense of how day to day activities relate to the learning journey over time.

- Assessment for learning has the potential to enhance young people's learning but there are a number of areas to be considered as part of curriculum and assessment innovation if this potential is to be realised

The key messages emerging from the review of all the evidence sources examined in this research report and possible implications for how evidence from policy and research might influence emerging practice are considered in the next section of this report.

Science and technology: Review of Frameworks

Introduction

In reviewing examples of progression in the specification of curricula, countries or regions were selected as meeting one or more of the following criteria:

- High performance in international comparative measures (e.g. TIMMS & PISA),
- Some evidence from research of student learning development
- Two official languages of equal status
- Similar aims to the ambition of a Curriculum for Wales

Documentation from seven jurisdictions was analysed in one or more of Science, Design and Technology and Computing.

Finland
Science
7 to 16 years old

http://oph.fi/english/curricula_and_qualifications/basic_education [retrieved April 2017]

https://www.ellibs.com/fi/books/publisher/0/opetushallitus [retrieved April 2017]

In Finland for children from ages 7 to 11, Science, along with health education, is part of Environmental Studies. From 11-13 years, pupils can then specialise in two areas (from either Physics and Chemistry or Biology and Physical Geography) with a similar time allocation; from the age of 13 onwards, pupils can study individual subjects.

Curricular content is structured around topics rather than big ideas and there are strong links between the illustrated learning experiences and curricular aims; consequently, this framework appears to promote deeper learning of fewer concepts in comparison to others considered here.

The 2004 core curriculum (basic education) is specified in terms of *broad aims* with *more detailed statements of objectives and core content* and *descriptions of good pupil performance* at ages 11, 13 and 16. Progression between these points must be inferred as it is not described in the documentation; this would require that teachers' understanding is sufficiently developed to shape formative assessment that effectively supports future learning.

In the case of *scientific practice*, objectives suggest that learning should move from developing care in observing and recording properties with a range of tools/techniques through to describing and interpreting, using more complex equipment. At this stage, learners would also be expected to carry out small scale investigations independently.

New Zealand
Technologies
4 to 18 years old

http://nzcurriculum.tki.org.nz/The-New-Zealand-Curriculum/Technology [retrieved March 2017]

http://elearning.tki.org.nz/Teaching/Curriculum-areas/Digital-Technologies-in-the-curriculum [retrieved July 2017]

The New Zealand technologies curriculum is split into eight overlapping levels, each of which can span between 2 and 4 years. Three main strands run through these levels

- technological practice
- technological knowledge
- the nature of technology

Each of these has sub-strands with specific achievement outcomes at each level and indicators of progression. From 2018, these strands and sub-strands will be developed through five different contexts:

- computational thinking for digital technologies
- designing and developing digital outcomes
- designing and developing materials outcomes
- designing and developing processed outcomes
- design and visual communication.

Specific *progress points* and *annotated exemplification of pupils' work* at different stages are given for the first two of these contexts. This may suggest that already existing achievement indicators and indicators of progression were less capable of supporting learning and assessment in the creation of digital rather than in the case of physical artefacts.

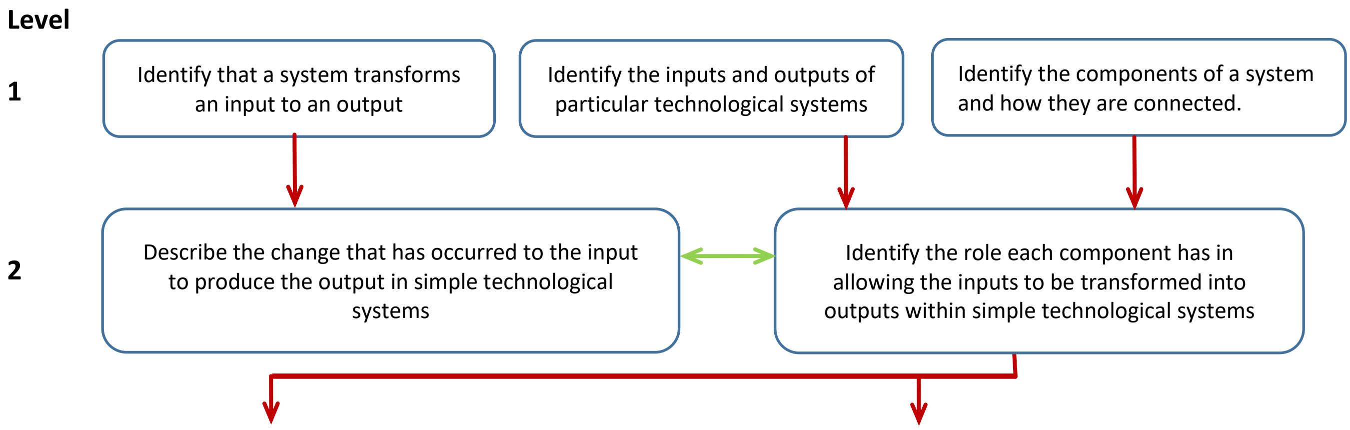
Of particular interest is the inclusion of *network diagrams of progression indicators* (see *Figure 12*) to *illustrate links and interdependencies within a level and links to future learning.*

Figure 12

Components of Technological Knowledge: Indicators of Progression

Informs within a level
Progression to following levels

Technological Systems



These may act as useful tools to support planning for progression. However, the more generic nature of statements – without additional exemplification – assumes that teachers have the relevant domain knowledge to know what acceptable performances look like at different stages.

Ontario
Science and Technology
6 to 13 years old

http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec.html [retrieved March 2017]

From Grades 1 to 8, Design & Technology is part of the Science & Technology Strand of the curriculum. In grade 9 there is a general Technology subject; this leads into the study of specialised areas in grades 10 to 12 in school/college/university: e.g. communications, computer technology, manufacture, hairstyling, health care and transportation.

Progression is defined as the extension and deepening of learners' understanding of six fundamental concepts of Science and Technology:

- matter
- energy
- systems and interactions
- structure and function
- sustainability and stewardship
- change and continuity

As learning progresses, learners will apply their understanding with increasing sophistication. Big Ideas relating to the fundamental concepts are defined as '*the broad, important understandings that students should retain long after they have forgotten many of the details of something that they have studied*'. These feed into the overall expectations with extended detail and learning experiences which are described for each grade.

Progressive skills continua are defined both for discrete aspects of scientific inquiry and for technological problem solving; these continua are described as consisting of five stages (*beginning* > *exploring* > *emerging* > *competent* > *proficient*). Interestingly, however, development through the five phases is outlined in tables of four (not five) columns of descriptive rubrics and somewhat limited exemplification of increasingly sophisticated performance. Thus, for 'initiating and planning' within technological problem solving, progress in sophistication relates to such matters as identification, solution selection, planning and reasoning.

For knowledge and understanding and for general skills such as investigation and application, progression is articulated through four stages of increasing effectiveness (for skills) and four stages of increasing levels of knowledge or understanding. In both the skills continua and the additional curricular aspects, statements of progression are limited and largely relative (e.g. 'with limited', 'with some', 'with considerable'…) and, if considered without exemplification, would be unlikely to support formative assessment and future learning effectively.

Scotland
Computing Aspect of Technologies
4 to 15 years old

https://education.gov.scot/scottish-education-system/policy-for-scottish-education/policy-drivers/cfe-%28building-from-the-statement-appendix-incl-btc1-5%29/Experiences%20and%20outcomes [retrieved June 2017]

https://education.gov.scot/improvement/curriculum-for-excellence-benchmarks [retrieved June 2017]

Like New Zealand, Scotland has recently strengthened the area of the curriculum which deals with the digital aspects of technologies. This has involved a revision of the statements of Experiences and Outcomes, which describe curricular expectations, and the publication of benchmark statements to help teachers assess the level that a pupil is working within. There are five of these levels (early, first, second, third, fourth); during their Broad General Education (3-15), learners are entitled to learning that is specified by all of the experiences and outcomes up to third level; they may also access a number of the fourth level Experiences and Outcomes in the final years of Broad General Education (aged 14-15); the selection of these will be dependent on their achievement to date and on their intended choices of certificated courses in the Senior Phase (15+).

The two major divisions for the area of Computing are Digital Literacy and Computing Science. The three 'organisers' of Digital Literacy are:

- Using digital products and services in a variety of contexts to achieve a purposeful outcome
- Searching, processing and managing information responsibly
- Cyber resilience and internet safety

The three 'organisers' of Computing Science are:

- Understanding the world through computational thinking
- Understanding and analysing computing technology
- Designing, building and testing computing solutions

Computing Science gives equal weight to each of these three organisers. Their order in the document suggests that learning in the first two strands is important for developing fluency in the third. The focus and development through each organiser suggest learners will come to understand more complex concepts and patterns of interaction, independent of a particular language or tool, before they implement them in their own solutions.

Each organiser comprises at each level one to three statements of experiences and outcomes. Associated benchmarks can be used to indicate how securely learners have met these requirements. Benchmarks use performance orientated verbs for cognitive actions such as *recognises*, *identifies*, *describes* and for physical actions such as *creates*, *collects* and *simplifies*.

USA
Science & Engineering
Ages 3 to 18
https://www.nextgenscience.org/framework-k-12-science-education [retrieved March 2017]

https://www.nextgenscience.org/resources/evidence-statements [retrieved March 2017]

The Next Generation Science Standards (NGSS) in the USA use *performance expectations*, linked by cross-cutting ideas:

- patterns
- cause and effect: mechanism and explanation
- scale, proportion and quantity
- systems and system models
- energy and matter: flows, cycles and conservation
- structure and function
- stability and change

across four core domain areas:

- physical sciences
- life sciences
- earth and space sciences
- engineering, technology and applications of science

These four areas contain thirteen *disciplinary core ideas* (e.g. Matter and its interactions, Heredity, Earth's place in the universe, Engineering design). These performance expectations are to be understood in terms of increasing depth. Learners demonstrate performance through scientific and engineering practices. For each of these aspects, there is a *description of possible progression* over time, informed by *evidence of how learners progress*.

Each disciplinary core idea has four *grade band end-points* (summarised in *Table 13*) which sometimes have boundary conditions describing what will and will not be considered. Grade bands provide a scaled system for assessing learners' progress in the exploration of phenomena, from understanding individual features through to using and reasoning with accepted scientific models.

Table 13

> 7yrs	Macroscopic items that can be experienced and observed with naked eye.
7 > 10yrs	Invisible macroscopic items that can't be directly experienced and invisible microscopic items without considering their size.
11 > 13yrs	Cellular/atomic level without details of their inner structures.
14 > 17yrs	Subcellular and subatomic items.

These descriptions form the basis of *integrated statements of learner performance expectations*. These appear to include *tasks*, *criteria* and the *relevant core ideas, practices* and *cross-cutting concepts*.

The standards themselves are aimed at curriculum designers in individual states and have been criticised as containing too much content. There is some evidence in documents discussing assessment that the designers recognise a need to create rubrics or progress maps that detail intermediate and partially correct performances leading up to an end point usually based on the sophistication of understanding and ability to reason scientifically at the expected level. Descriptions of observable features of student performance have also been produced for each grade level which include indications of whether the pupil has been supported by the teacher or peers.

USA
Computer Science
Ages 3 to 18

https://k12cs.org/ [retrieved July 2017]

The Kindergarten to Grade 12 Computer Science framework superficially appears similar to the Next Generation Science Standards in terms of being organised using three aspects called *core practices*, *concepts* and *cross-cutting concepts*; but there are several important differences. The emphasis, in terms of detail, is focused mostly around the core practices rather than the concepts; the cross-cutting concepts are not described separately in detail but are instead embedded in the concept descriptions where appropriate. This reflects both the creation orientated nature of most Computer Science courses and the lack of research into how learning develops within Computing in general and Computer Science in particular. Core practices have a definite end point but the description of development is vague and it is unclear when learners are expected to develop more sophisticated forms of practice.

Like the Next Generation Science Standards, the concepts are organised within four end points: up to age 7, between 7 and 10 years old, between 11 and 13 years old and at age 18. Within Computing Systems and Networks and the Internet, one of the main patterns visible within these descriptions is a move from directly observable behaviour and hardware through to gradually more detailed models of the hidden layers underneath. In the descriptions for Data and Analysis another pattern is visible: the move from understanding high level behaviour through to more functional descriptions and finally to the underlying structures on the computer system itself.

For each of the concepts there is an overview of why, and the ways in which, the concept is important, followed by similar overviews for the sub-components and then the end points. These are each composed of a *concept statement*, *elaboration* and *examples* with optional boundary statements about what is not expected and a note of crosscutting concepts and other concepts within the framework to which this concept relates.

Observations & Considerations

- Almost all frameworks include statements that relate to learners' demonstration of understanding and application of big ideas.
- NGSS is the only framework that appears to be shaped by systemic use of research on learning progressions, though there insufficient research on learning progression in computing to draw definitive conclusions.
- In New Zealand, there is some evidence to suggest that using separate strands to describe the practices of Science and Technology in documentation can lead to these being treated separately in classrooms.
- Most frameworks provide snapshots of expected learner performance at different stages but few detail progression in learning between these, which would be of use where a learner is unable able to meet some of the end point requirements.
- Very few frameworks articulate stage expectations in terms of sufficiency for future learning (e.g. The learner is ready to…).

Science

- Patterns of progression specific to the Science domain:
  - Phenomena to be investigated at different ages and stages appear to be organised by scale, moving from Macro- through Micro- to Nano-scale
  - Similarly, phenomena to be investigated at different ages and stages appear to be organised by the extent to which they can be directly observed and experienced by learners or not
  - Scientific reasoning generally follows the pattern of moving from
    - irrelevant/no idea to
    - logical reasoning from everyday life to
    - incorrect reasoning using scientific terms and concepts to
    - partially correct reasoning without much justification to
    - correct with incorrect justification to
    - correct reasoning with suitable scientific justification.
- Big ideas most often relate to matter, energy, systems and interactions, structure and function and cause and effect.
- Common practices including scientific reasoning and/or argumentation and experimental investigation and/or inquiry skills.

Technologies

- Patterns of progression specific to the Technologies domain:
  - Understanding how digital systems operate generally moves through
    - identifying and describing observable behaviour to
    - learning and relating the behaviour to specific functions to
    - understanding the underlying structure or mechanism in more detail.
  - As learners create physical or digital products the complexity, techniques and number of the steps involved increases with experience; the level of teacher support tends to reduce as learning develops.

- In computing, big ideas generally include algorithms and their basic building blocks, understanding data and data structures, and developing a more detailed model of the functions of individual and networked computers.
- Network maps (e.g. New Zealand) identify interdependence more explicitly, which, if augmented with more cross-strand linkage and detailed exemplification, would likely benefit formative assessment.
- Common practices include modelling and designing computational solutions, creating computational artefacts and being able to test, evaluate and refine these to meet better a range of user and performance requirements.
- Increasing effectiveness features as a discriminator of progression for problem solving in design and technology (Ontario).
- Additional guidance for the Scottish framework in computing recommends that building understanding of particular computational concepts and of how aspects of the systems or languages work should happen slightly before, or alongside, the ability to develop effective computing solutions, using those concepts independently.

Integration between Science and Technology

- The extent of integration of Science and Technology varies:
    - Science and Technology are treated as one area in the early years in Ontario
    - Science and some aspects of Technology blended together at all levels for the NGSS in the USA
    - they are defined separately in New Zealand, Scotland and Finland.
- Science and the Technologies have very different overall aims: balanced progression would avoid either focusing on Technology experiences with some scientific concepts or focusing on Science with some technology applications.

Science and technology: Research Review

Introduction

This report reviews some of the key research available in helping to understanding learning progression in areas of science and technology. As far as possible, it has been structured around the key areas of learning in the Science and Technology AoLE and gives insight into how progression is conceptualised and what is known about shifts in pupil learning.

Science

Nature of Science Education

Science Education plays a powerful role in allowing pupils to explore and understand the workings of the natural world. Its most widely accepted aim is to develop pupils' *scientific literacy* (Roberts, 2007). However, DeBoer (2000) notes the considerable disagreement over exactly what this should mean for science education: he describes the development of scientific literacy, in response to changing societal circumstances, from the importance of understanding science and the work of scientists following World War 2, through addressing a 'poverty' of scientific knowledge, to understanding science and scientific enterprise within its societal context. These more recent ideas of scientific literacy are noted by Erduran and Dagher (2014) as promoting the development of pupils' scientific reasoning in addition to conceptual understanding. Whilst Hand *et al.* (1999) argue that scientific literacy involves learners developing a range of wider habits of mind and ethical and civic dispositions, scientific understanding and knowledge and reasoning appear to play a central role. Holbrook & Rannikmae (2009) argue that science education can be expected to allow pupils to develop a range of skills and values and to solve problems of a scientific nature and is hence more than understanding the nature of science.

Most recently, OECD (2017) argues for the importance of scientific literacy for all as humanity faces such challenges as global warming, endemic poor health, malnutrition and sustainable development; the impact of these is felt in daily lives as well as globally. In the context of the PISA assessment programme, 'scientific literacy' is defined as:

> *knowledge of both science and science-based technology, even though science and technology do differ in their purposes, processes and products. Technology seeks the optimal solution to a human problem, and there may be more than one optimal solution. In contrast, science seeks the answer to a specific question about the natural, material world. Nevertheless, the two are closely related.* (p. 20)

OECD (2017) proceeds to argue that scientific literacy includes three areas of competence:

- explain phenomena scientifically (content knowledge)
- evaluate and design scientific enquiry (procedural knowledge)
- interpret data and evidence scientifically (epistemic knowledge).

Our understanding of learning across these aspects, as well of scientific reasoning and knowledge, benefits from extensive research interest. Kuhn (2010) describes 'scientific reasoning' as 'the intention to seek knowledge that transforms implicit theory revision into scientific thinking' (p. 499);

Erduran and Dagher (2014) consider that scientific reasoning features in particular cognitive practices that result in modelling, explaining and predicting. Many of these, such as modelling, can be quite demanding for pupils (e.g. Lehrer & Schauble, 2000) and require abilities such as pattern recognition, reflection (Bullock *et al*., 2009), understanding how hypotheses and evidence are related (Zimmerman, 2007) and curiosity in asking questions about things not yet known (Kuhn, 2005; Nayfeld *et al*., 2011; Jirout & Clahr, 2009; Jirout & Clahr, 2012). For primary pupils, there is evidence that proficiency in reasoning is linked to depth of conceptual understanding (Pollmeier *et al.*, 2017). Koerber *et al*. (2017) suggests that children's scientific reasoning moves through three hierarchical levels from naïve through intermediate to advanced. Such findings may be helpful when thinking about learning progression.

Learners develop knowledge of content which is structured and defined in a number of ways. Erduran and Dagher (2014) present a 'theories, laws and models' (TLM) framework that describes content that pupils can interrelate to generate scientific explanations and build knowledge. In chemistry, for example, atomic theory, periodic law and the atomic model allow the structure of matter to be explained; in many ways, these relate to 'Big Ideas' in science. Bernholt *et al*. (2012), argue that a big idea must possess explanatory power and/or scale that help in explaining a range of phenomena as well as being accessible by pupils and allowing them to think in powerful ways. Additionally, big ideas should provide a foundation for learning at a later stage. Several studies identify big ideas and unitary concepts either across science as a whole (e.g. Harlen & Bell, 2010) or in sub-areas such as astronomy (e.g. Lelliott & Rollnick, 2009). These include the model of matter, gravity, energy, and natural selection. Whilst these do specify what should be in a curriculum, they are concepts through which pupils can develop a deep and integrated scientific understanding rather than discrete knowledge of ideas in science.

The following sections identify some key findings and insights about learning progressions. These are often developed around 'big ideas' or unifying concepts and can incorporate practices such as scientific reasoning.

Progression of Learning within Specific Aspects of Science

Work on the development and validation of learning progression in science is widespread (Duncan *et al.*, 2016, Todd & Kenyon, 2016, Todd *et al.,* 2017). Krajcik *et al.* (2014) argue that learning progressions must include:

- big ideas
- levels of understanding
- validated assessments
- instructional components
- boundaries, rationale and connections.

This interim report recognises that there has been extensive work over a period of years into the development of children's understanding of scientific concepts and practices. Thus, the Children's Learning in Science Project (1984) (CLIS), based on a constructivist model of learning, explored children's own ideas around the science topics they cover in school science lessons, mainly in early secondary education, and used this to help improve the way teachers develop students' scientific understanding. One of the aims of CLIS was to provide a longer term perspective on changes taking place in students' understanding over the compulsory school years. The Primary Science Processes and Concepts Exploration Project (1990) (Primary SPACE) investigated learners' ideas about science concepts. The results were used to provide teachers with descriptions of what they were likely to find if they explored the ideas of their pupils and to develop trial materials to help teachers to plan activities to take learners; ideas as a starting point in classroom work.

This interim report seeks to draw some key provisional insights from examples such as the atomic/molecular model of matter (e.g. Archer & Arcà, 2014), genetics (e.g. Todd *et al,* 2017; Elmesky, 2013; Roseman *et al*., 2006), ecological systems (Gunckel *et al*., 2012a), natural selection (Furtak, 2012) and energy (Duit, 2014). Learning progressions are considered 'hypothetical' until validated, and often refined, with pupils (see Duschl *et al.*, 2011). In the following sections, validated studies are drawn upon as far possible to inform upon how learning may progress in life, physical, earth and space sciences and scientific practices.

The PISA programme (OECD, 2017), designed to assess learners at one point in their learning, describes progression in terms of a scale of competence, founded on Webb's depth of knowledge taxonomy. The seven levels of the scale are intended to describe terms of the extent to which students use content, procedural and epistemic knowledge to provide explanations, design and evaluate scientific enquiries and interpret data in various situations. The planned opportunities which would move learners from lower levels of achievement to reach higher levels are not explored as is to be expected given that programme focus is on assessment.

Life Science

Many of the progression frameworks in this area tend to describe learning by moving from concrete thinking to abstract thinking and/or changing scale of phenomena. In the Next Generation Science Standards, for example, novice stages involve macro-level concepts (e.g. organisms) and advance with growing expertise to micro-level concepts (e.g. cells). These scales also reflect the shift from concrete to abstract that is both familiar and, in some ways, intuitive. However, Elmesky (2013) presents a hypothetical Kindergarten to Grade 12 learning progression for genetics that introduces some simple cellular and inheritance concepts at an earlier stage to encourage greater links between the macro and micro-scales. This is based on evidence from, among others, Toyoma (2000) and Inagaki & Hatano (2004) that learners are capable of more sophisticated reasoning at earlier stages than frameworks typically suggest. This progression consists of three main phases:

1. Early primary: gradually developing the ability to classify things as living/non-living, animal/plant, and finally unicellular/multicellular; understanding the basic relationship between structure and function and inherited traits of offspring.
2. Late primary to lower secondary: understanding cell-splitting and genetic inheritance as trait expression.
3. Middle to upper secondary: exploring the concept of genetic inheritance as protein expression.

Ergazaki *et al*. (2015) show that pre-school children are capable of quite sophisticated scientific reasoning about inheritance, something often considered to be too abstract for them. These studies suggest there may be implications for how scale is used and the development of understanding by moving from concrete to abstract thinking. Simons and Keil (1995) highlight that the foundations and precursors of abstract ideas can indeed be developed at earlier stages; Duschl *et al*. (2007) find further evidence that children's abstract thought processes are often precursors to more concrete ideas. Relying on the use of simplified models at early stages can feed misconceptions at later stages of learning.

Drawing on four key existing frameworks, Todd *et al*. (2017) tested a learning progression for genetics comprised of 12 constructs including 'proteins do the work of the cell', 'cells express different genes', and 'DNA varies between and within species'. Significant learning was observed along each of these constructs as pupils' knowledge developed; learners progressed least in their understanding of meiosis, allele arrangements, chromosomes and chromosome combinations. Rather than simply building knowledge of different concepts, the study shows that more developed expertise requires that pupils understand the interrelationships between the genetic, meiotic and molecular models (see Stewart, Cartier & Passmore, 2005).

Recent studies creating learning progressions related to water, carbon and bio-diversity noted that the big ideas had an aspect of ethical decision-making as well as subject understanding (Gunckel *et al.,* 2012b; Jin & Anderson, 2012; Mayes *et al.*, 2014, Spencer, 2016). Moreover, learners' ethical perspectives were culturally influenced, which suggests that learning progressions should focus socio-culturally as well as the cognitively. McGinnis & McDonald (2011) review work on learning progression in more socially-orientated dimensions of science such as climate change.

Physical Science

While some studies explore smaller ideas, the particle nature of matter and energy form two of the key ideas in this area. The former facilitates the understanding of a range of other processes and phenomena such chemical bonding and phase change (e.g. Chui & Wu, 2013), whilst the latter constitutes a unifying concept across science (Duit, 2014).

Merritt *et al*. (2008) present a 6-stage progression framework for the particle model of matter based upon existing research and empirically tested learning gains with 6th grade pupils. As shown in *Table 14*, developing complexity moves from descriptive and mixed models (1-3) through to partial and then complete models (4-6).

Table 14

Level [of Complexity]	Category	Particle Model
6	Complete Particle	All relevant substances are made up of particles. Particles are identified as atoms/molecules. The particles are in motion relevant to a particular state, for example, in the gaseous state, there is empty space between the particles and the particles move randomly.
5	Basic Particle	All relevant substances are made up of particles. There is empty space between the particles. The particles are in motion.
4	Incomplete Particle	A substance is made up of particles. There is empty space between the particles.
3	Mixed	Combines both particle and continuous ideas. The substance is made up of particles within a continuous medium.
2	Continuous	No notion of particles
1	Descriptive	Describes what is happening in words and/or draws an exact replica of phenomena
0	No response	No response or nonsense response.

Useful insight can also be gleamed from Black & Wilson (2010) who use the particle model of matter to develop 'roadmaps' to learning. Though not progression frameworks per se, they attempt to map conceptual dependency useful to planning learning for progressive understanding. Several other studies also examine how conceptual understanding develops.

Liu & Lesniak (2006) show that learners' descriptions of understandings generally progress from characteristics they can perceive, uses and benefits, through physical properties and change, to chemical properties and, ultimately, the particulate model. Similarly, a recent study by Hadenfeldt *et al.* (2016) shows that more sophisticated and complete understandings of matter required an understanding of: (i) structure and composition, (ii) physical properties and change, (iii) chemical reaction, and (iv) conservation.

At a finer conceptual level, Johnson (2013) shows that learners find understanding gases, liquids and solids progressively difficult and speculates that misconceptions and relative difficulty might be mitigated by a substance based approach to teaching (rather than structuring learning around solids, liquids and gases). Additional insight into phase changes by Chiu & Wu (2013) identified early, middle and late development trends using seven models of phase change, whilst Morell and Wilson (2016) found evidence of three levels of explanation of chemical change.

As a unifying concept, there is evidence that pupils hold misconceptions about energy (e.g. only things in motion have energy), but also that there is a degree of consensus about how learning progresses. Herrmann-Abell & DeBoer (2014) evidence a spread of misconceptions helpful in ordering understanding for a range of ideas (e.g. knowing that motion energy depends on speed comes before knowing motion energy depends on mass). They also recognise that novice learners tend towards more human-centric understandings.

Notably, relatable and human-centric understandings appear elsewhere in the early stages of understanding. Duit (2014) reviews key learning progressions (Liu & McKeough, 2005; Driver *et al*., 1994; Neumann *et al*, 2013; Liu & Park, 2014), which collectively evidence understanding shifting from forms and sources of energy to which learners can relate to transformation, degradation and, finally, to conservation. Such evidence is important to shaping progression frameworks.

Earth and Space Science

A number of useful studies have explored learning progressions for celestial motion and the formation of the solar system. Plummer & Krajcik (2010), for example, present four learning trajectories (sun's path of motion, motion of moon, pattern/visibility of stars with seasons, appearance of the moon), each of which has its own explanatory model that they argue should collectively allow pupils to progress towards a more sophisticated understanding of 'celestial motion'.

Importantly, such progression does not represent how learners' understanding naturally develops (Plummer, 2012). Arguably, the sophistication of explanation that can be achieved depends also upon pedagogical sequences and approaches that address earlier barriers to later understanding. There is, for example, evidence of order-of-presentation effects where learners move more easily from naïve to more scientific understanding of daily celestial motion (earth, sun, moon, stars) when they know about the relative scales of entities and cosmological distances first (Plummer, 2012). In a review of studies, Mills *et al.* (2016) highlight related difficulties with explaining phenomena such as seasonal variations. These studies raise questions about whether simplifications of particular models used at earlier stages of teaching might inhibit future understanding. Moreover, Plummer *et al*. (2015) found that children's tendency to omit the role of gravity in planet formation inhibited more sophisticated understanding and that instruction should include this from an earlier stage. Such evidence suggests that, where possible, consideration should be given to the relationship between learning progressions and associated pedagogy.

Computing

Nature of Computing Education

Progression frameworks in science (Corcoran *et al*., 2009; Duschl *et al*., 2011; Heritage, 2008; Merritt *et al.,* 2008) and learning trajectories in mathematics (Clements and Sarama, 2004; Ellis *et al.*, 2016; Land and Drake, 2014; Stephens *et al.*, 2016) contain a wealth of information regarding possible models of progression. However, this type of understanding is at a much early stage for computing generally and, in particular, computing science (Webb *et al*., 2017). As many different countries around the world (Hubwieser *et al*., 2012) move towards a model of providing some computing science for all learners, it has become increasingly important to identify suitable learning goals (Rich, Strickland and Franklin, 2017).

Much of the existing work on how learners' understanding develops is focused either within the domain of computational thinking (Wing 2006) or programming (Lister, 2016). Wing (2011) defines computational thinking as 'the thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information processing agent'. She also argues that the abstractions formed in computing are different to those formed in mathematics or physics because they deal with more complex situations which often have many interacting parts and generate a wide range of possible outcomes. Wing (2008) goes on to explain that 'In working with rich abstractions, defining the 'right' abstraction is critical'. Colburn and Shute (2007) also argue that the use of abstraction in computer science is fundamentally different from mathematics as it is concerned with understanding and creating patterns and levels of interaction both within and between computers and humans. There is also debate (Stein, 1999) about whether the current dominant, calculation based, model of computing defined by the simple input-process-storage-output view of Von Neuman and Turing adequately captures the interactional nature of modern computing. This, and the failure to acknowledge and build on learners' cultural knowledge as users of technology (Kolikant, 2011), may explain why learners often fail to connect with traditionally defined computing science curricula.

Guzdial (2016) argues that understanding computing requires developing a consistent mental model of the computer – what it can and cannot do. Ben-Ari (2001) also claims that a model of a computer must be explicitly taught; otherwise students will inevitably develop their own haphazard and non-viable mental model. Given the large number of layers of abstraction that typical computer systems are built upon (Gobbo and Benini, 2014) this would initially seem an almost impossible task within the context of school education. However, this model, often referred to as the notional machine (Du Boulay 1986), only needs to be sufficient to support the understanding of the structure and actions of an application, system or programming language, rather than reflecting the lowest levels of computer operation (e.g. logic gates manipulating bits). The need to develop learners' ability to trace code (Griffin 2016; Kumar 2013; Lopez *et al*., 2008; Nelson *et al*., 2017; Venables *et al*., 2009) to improve code writing skills, even in early programming environments like Kodu (Touretzky *et al.*, 2017), lends further weight to the idea of the importance of explicitly sharing and developing notional machine understanding in computing.

A big challenge is that the model of computation learners experience determines the type of notional machine understanding they need to develop at any particular point in time. For example, the underlying model of computation for Kodu (Touretzky *et al.*, 2017), Scratch (Resnick *et al*., 2009), Snap (Harvey & Mönig, 2010) or an environment specifically for building scientific simulations like Star Logo TNG (Begel & Klopfer, 2007) work in very different ways to many text-based programming languages (Kelleher and Pausch, 2005). Early programming environments tend to be event-driven and object-based with many sets of instructions attached to the objects executing in parallel as a set of interacting influences. This contrasts with the mostly sequential and explicitly coordinated nature of procedural or object-orientated text-based programming languages (Armoni *et al.*, 2015). Fortunately, there are a number of shared concepts between most block-based and textual languages. Several studies (Armoni *et al*., 2015; Grover *et al*., 2014; Weintrop and Wilensky, 2016) have shown that starting with block-based programming in primary and early secondary has a positive effect when transitioning to text-based languages when teachers consider how to effectively bridge between them.

Progression of Learning within Specific Aspects

Abstraction is often identified as being central to computer science (Hazzan, 2008; Rich, 2017; Wing, 2008) but has a multitude of different meanings (Colburn, 2007). It can refer to aspects of a particular piece of software or different processes people undertake when creating computational solutions. To achieve more sophisticated thinking, there are three distinct skills in abstraction (Hill *et al.*, 2008) that learners benefit from gradually developing:

1. Conceptual abstraction: the ability to move back and forward between the big picture and smaller details.
2. Formal abstraction: how to remove or simplify details in the problem domain in order to create a workable computational solution.
3. Descriptive abstraction: how to identify the most important characteristics in order to generalise a solution so that it can solve a greater range of problems.

The development of programming ability is still an active area of research; several attempts to adapt generic frameworks of cognitive development, such as Bloom's or SOLO taxonomies, to the field of computer science have had varying levels of success. There is also a growing body of empirical work, summarised in Teague (2015), which examines the behaviours of novices at different stages of their development of programming knowledge:

1. In the beginning, the computer has powers of interpretation and the learner cannot identify and distinguish between different parts of the programming language – built-ins, variables, literals, function and procedure calls, etc. Later on, they start to understand the sequential nature of code and the relationship between a variable and its value.
2. They focus on specific parts of the code and can only trace code line by line, using concrete values to understand its behaviour. They struggle to write code to undo an effect or reverse an action and cannot refactor the code while retaining the same behaviour. Explaining in plain English what a piece of code does is difficult as is seeing how different parts work together to create a more complex action.
3. They can trace code abstractly without having to substitute in concrete values and can explain code in plain English. They can write code to undo an effect or reverse an action and reason about loops without just focusing on the beginning and end states.

These stages were found to be sequential but with overlapping waves that related to whether the programming constructs and techniques needed were familiar or just newly introduced. Linked to this is wider evidence of links between decoding, tracing, explaining and code writing skills (Lopez *et al*., 2008; Venables *et al.*, 2007; Tan and Lister, 2009). Although not a strict hierarchy, basic identification of concepts within code is linked to tracing ability and this, along with explaining code, makes a large contribution to being able to independently write code (Lopez *et al.*, 2008; Venables, *et al.*, 2007).

Within the context of primary and secondary education, a number of studies assess the relative difficulty of particular programming concepts (Seiter & Foreman, 2013). Young learners can create programs, using coarse grained movement within a 2D grid (Franklin *et al*., 2017), events, sequences of costume changes and movements, unconditional and fixed repetition, and simple conditional statements that do not use Boolean operators. More difficult concepts, even for late primary stage children and early secondary stage, are the initialisation of multiple sprite properties, complex conditionals with Boolean operators, simple variables, lists and procedures (Aivaloglou *et al.*, 2017; Franklin *et al*., 2017; Rivers *et al*., 2016; Seiter & Foreman, 2013). As contexts for learning, stories, animations, games and simulations reflect increasing complexity of programming concepts and appeal to the broadest range of learners. Curricular approaches based on teaching behavioural patterns, rather than constructs, such as Scalable Game design (Repenning *et al*., 2015) provide one possible way to motivate and scaffold the gradual development of the understanding of computational concepts.

Design and Technology

Nature of Design and Technology Education

Research in Design and Technology (D&T) remains limited when compared with educational fields such as science and mathematics and, with relatively few studies that explicitly consider the nature of learning progression, this continues to be debated and is not yet well-understood (Barlex, 2007; Keirl, 2015; Mawson, 2007). Furthermore, tensions are evident. As the literature is limited, a range of sources and older studies are purposefully included as well as key contributions by Jones, Kimbell, and Compton & Harwood.

In contrast to science education, in which pupils seek to develop an understanding of the existing natural world and universe around them, D&T is concerned with the designed or human-made world and with the creation of that which does not yet exist (De Vries, 2005). According to Barlex and Rutland (2003), D&T 'engages pupils with thinking about the made world and how they might intervene to change it' (p. 171). This generative dimension of D&T means that it is insufficient for a pupil to build up knowledge and understanding about or related to technology; it further requires them to use their understanding in ways that shape effective technological solutions. It requires pupils to understand and re-conceptualise (Stevenson, 2004), rather than simply apply, a wide range of knowledge and understanding from diverse fields, including psychology, economics, markets, ethics, aesthetics, engineering, mathematics and science. Importantly, this 'bringing to bear' of factors by pupils towards a successful end is referred to as 'operationalisation' and may play an important role in progression for this subject area. De Vries (2005) argues that while truth is the ultimate condition for science, effectiveness is the ultimate condition for technology.

Barlex (2017) states that D&T allows pupils the unique opportunity to develop a technological perspective on the consequences of technological outcomes and activity as well as the capability to design and make. These evaluative and creative dimensions are extensively reflected elsewhere (e.g. Solomon & Hall, 1996; McCade, 1990; Williams, 2000). In addition, others promote the socio-cultural dimension of technology education; shifting its locus from its historical vocational roots (e.g. Petrina, 2000, Williams *et al*., 2015). Pupils' engagement with this spread of learning in D&T requires that they develop and use knowledge, skills and dispositions in an often heavily situated and contextualised way (Hennessy & Murphy, 1999). Doing so contributes greatly to the four purposes articulated in *Successful Futures* (Donaldson, 2015). McCormick (1997) recognises the place of conceptual (knowing that) and procedural knowledge (knowing how) in D&T; although what constitutes 'technological knowledge' is not fully understood, it is thought to have a large procedural dimension that becomes more implicit and 'hidden' as proficiency increases (Herschbach, 1995). In classrooms, this is commonly evident in practical work. Hill & Wicklein (1999) validate and extend a range of intellectual and cognitive processes identified by Halfin (1973) from the analysis of expert and pupil technological activity. These include analysing, predicting, designing, measuring, managing and visualising and are used cyclically by pupils in problem solving and design activity (Mioduser & Kipperman, 2002). In examining these, it is necessary to recognise that conceptual understanding and processes cannot be readily separated in learning.

Progression of Learning within Specific Aspects

Problem solving, particularly Design, has come to feature prominently within technology as it facilitates generative and evaluative dimensions of the subject. It provides a means by which pupils can develop and use knowledge, understanding and skills towards realising a technological solution (Middleton, 2005). It is also closely linked to creativity. Despite creativity being widely explored in D&T research, progression in associated learning is not yet well understood. It may be, for example, that shifts can occur in novelty of idea, materials and complexity (Denson *et al.*, 2015) or aesthetic, technical or constructional creativity (Rutland & Barlex, 2008). Arguably, forms of diversity, novelty and synthesis play a role in all of these. A significant study by McLellan & Nicholl (2011) demonstrates that fixation effects (the natural tendency to adhere to a limited set of ideas or notions) limit pupils' diversity during design activity (for fixation, also see Jansson & Smith, 1991; Purcell & Gero, 1996). One implication of this might be that progression involves pupils overcoming cognitive fixation in a way that allows them to engage in a more varied range of considerations. The study by McLellan & Nicholl suggest pedagogy plays a significant role in this and others have argued that overly sequential or linear approaches to design stifle creativity (e.g. Liddament, 1996; De Vries and Tamir, 1997; Roberts and Norman, 1999; Compton & Harwood, 2003). Some useful insight into progression and assessment of creativity are explored for education generally by Spencer *et al*. (2012).

From a capability perspective, Kimbell (1994), considers progression in design quite broadly as increasing sophistication and complexity. This is in part because he believes that viewing progression in more holistic terms, with additional description, is more reliable and valid when summatively assessing and judging pupil work (see Kimbell, 2012). Similarly, Moreland & Jones (2000) urge teachers to focus on processes, concepts and products *integratively* to develop a holistic and comprehensive picture of student progress. Cross (2004, p. 431) recognises 'integrated design strategies' as a feature of successful expert-level design.

While holistic approaches to painting a picture of progression may be useful for summative assessment, there is evidence that holistic learning outcomes are less effective in supporting formative interactions between pupils and teachers (Compton & Harwood, 2003). These findings arise from extensive exploration of progression in D&T in New Zealand. A key contribution from this body of work is a set of empirically validated and exemplified 'components of practice' as a means of articulating progression (Compton & Harwood, 2005). These include 'brief development', 'planning for practice', and 'outcome development and evaluation' and attempt to capture the interrelation of achievement outcomes as a function of pupil performance. More recently, Compton & Compton (2011) refined indicators of progression for the 'Philosophy of Technology' strand of D&T in the NZ curriculum using pupil/teacher interviews.

Design and make tasks can be both extended and complex. Additional insights are given by studies that compare pupil performance, either at different educational stages or within a given task, typically involving a conceptual and practical phase. As with Kimbell (1994) and Compton & Harwood (2005), these suggest that rather than progression being reflected in the development of discrete packets of knowledge and understanding, it is better reflected in the depth, complexity and interrelatedness of factors in pupil thinking when *operationalising* knowledge and understanding. In fact, Compton & Harwood (2005) argue that viewing progression in terms of knowledge and understanding is not particularly useful in technology education as, in the absence of a clear understanding of what constitutes 'technological knowledge', much of this is native to other fields. Importantly, however, this stance on indicating progression does not mean that knowledge and understanding should not be defined within the curriculum. As a subject, D&T is often criticised as conceptually under-developed and overly procedural; careful consideration is required in determining the role of, and relationship between, different types of knowledge. Valuable insights into this are found in studies by McCormick (1997), Ropohl (1997) and Banks & Plant (2013).

Jones (2009) posits that progression must move beyond binary judgements of 'can' and 'cannot', and that it does not constitute doing something extra and different. He presents four categories of progression (Jones & Moreland, 2003) tested with 8 and 12 year olds:

(i) the nature of technology
(ii) student technological practice
(iii) generic
(iv) specific conceptual, procedural, societal and technical aspects.

Interestingly, it was shown that more developed learning involved:

- consideration of a greater number of functional alternatives, conflicts in demand and relationships between variables
- more developed use of technical language and an ability to operationalise more task variables
- active consideration of several variables (rather than just a single variable) in relation to suitability of materials and functional effectiveness
- a greater ability to predict material suitability for given functional requirements
- greater use of compare and contrast processes in material choices
- encapsulating greater level of consideration in drawings, with a greater likelihood of integrating these with written content and visual representation from more than one aspect in 3D rather than 2D
- an ability to identify more positive and negative societal impact beyond those affected most immediately.

These shifts reveal the types of detail and complexity to which Kimbell (1994) refers. Two further studies, McLaren & Stables (2008) and Morrison-Love (2015), augment this and suggest that reflection and metacognition are associated with more developed learning. The former, undertaken with pupils transitioning from primary to secondary school (10-13 years old), demonstrated that higher performers engaged in a deeper level of reflection of their own work and of that of others. Data revealed higher performers gave more consideration to aspects such as idea feasibility and considered a greater variety of factors when doing this than lower performing pupils did. Though the number of factors is highlighted in all three studies, Compton & Harwood (2005) caution that variable count alone does not indicate the depth or quality of pupil interaction and is, by itself, insufficient as a measure of progression. McLaren & Stables report more generally that lower performing pupils appeared to be less aware of their own learning, again suggesting that, in this context, metacognition may be significant.

Morrison-Love (2015) compared higher and lower performing pupil groups at age 12-14 years who completed the same design and make task. This study examined the real-time in-task interaction and task outcomes for pupils and reported similar findings to both Jones (2009) and McLaren & Stables (2008). Here, higher performing pupils made more extensive use of what Morrison-Love terms ‘declarative reflection’ and, more notably, ‘analytical reflection’. The former of these refers to general judgements (e.g. ‘that’s good’ or ‘ that’ll work’), whilst the latter reveals knowledge of relationships between variables associated with the developing solution or task context (e.g. ‘moving that part will make this part more rigid’). Critically, the use of analytical reflection requires a deeper qualitative knowledge of the developing solution and indicates more developed learning and understanding. Additionally, more successful groups:

- spent longer in the conceptual development of ideas prior to construction
- had a more secure grasp of objective knowledge about structures
- translated more prior conceptual understanding into their physical solutions (a form of modelling), with greater practical efficacy.

During solution development, the process was managed more pro-actively with fewer negative managerial and social traits. Mawson (2007) identified that a positive disposition towards risk taking was associated with a higher level of achievement for pupils in their first 3 years of school. Risk taking (also discussed by Keirl, 2004), and thirteen other possible lines of progression including autonomy (from teacher as source to autonomous decision-making), creativity (constrained to generative) and problem-solving (simple to complex) are theorised by Martin (2003), though no evidence is present of validation in practice. These are, however, useful as they conceptualise less and more developed learning in characteristic aspects of D&T. In the case of problem-solving in D&T, ill-defined problems (see Frensch & Funke, 1995) generally require deeper and wider engagement by pupils as the understanding of the problem and the solution co-evolve; this is recognised by Cross (2004) as characteristic of expert-level design.

As well as elements of design thinking, these forms of technological activity encapsulate aspects of graphics and practical skills, knowledge and processes (see Baynes, 1992). Evidence on progression in sketching is limited though, as noted by Danos & Norman (2011) – drawing on Kellogg, Gaitskell, Lowenfeld – it does appear to develop through a number of fairly consistent stages from scribbling (circa 1-2+ years) through symbolic/schematic/pictorial stages (circa 5-8 years) to realist and natural stages (circa 12-16 years). Within and across these stages fine motor skills develop with various media and, in the latter stage, children begin to use light, shadow, 3-dimensionality and visual exploration. However, insightful exploration of this within Design & Technology classrooms is also limited. In this context, sketching requires interaction between the imagined and something that could exist in the physical world (Baynes, 1992). Welch *et al.* (2000) show that sketching is not something pupils naturally engage with to explore design ideas (favouring, for example, 3-dimensional modelling); they recognise that pupils find visualising (or imaging) and then sketching (or modelling in 2D) ideas on paper demanding. In a primary school study of technological capability, Anning (1993) notes that children struggle to master scale, spatial orientation and overlap and that there is some evidence they can represent forms more easily after they have constructed or physically interacted with them.

Key Considerations

Learning progressions can be thought of as frameworks of achievement – statements that support learners in reaching more sophisticated levels of understanding. Collectively, the studies reviewed demonstrate that this does not happen by chance. Learning progressions in science and technology involve considering dependencies between different ideas, concepts, contexts for learning, reasoning, misconceptions and pedagogy. Doing so will help to more reliably shape the form, structure and order of the achievement outcomes that help pupils to build deeper understanding in effective ways. Possible considerations about this include:

- How might existing learning progressions (e.g. genetics, energy) be used to shape possible learning progressions for science and technology?
- How might learning progressions be designed to avoid known misconceptions (e.g. introducing true scale/complexity before simplified models)?
- How can achievement outcomes reflect what is understood about the nature of more sophisticated learning in science and technology and how, if at all, do they capture links with pedagogy?
- In Design and Technology and Computing, how might learning progressions capture deeper understanding of key concepts and avoid being overly procedural?
- What is the role of modelling and what should the balance be between pupils using models to develop understanding and creating models of their own?
- Should systematic thinking and spatial abilities be integrated to assist with the understanding of scientific and technological ideas?
- Which programming paradigm or paradigms and concepts provide a firm foundation for future study in Computing and also allow learners to transfer their learning to other areas of Science and Technology?

Section 4: Conclusions and Framework for Decision Making

Introduction

This section of the report is in four parts.

- Part 1 draws together major themes emerging from evidence analysed in Sections 1 and 2 of the report.
- Part 2 relates key messages to *Successful Futures*.
- Part 3 states fundamental principles which will underpin decisions within each AoLE Group.
- Part 4 provides evidence derived from the review relevant to key questions each AoLE will consider as they take decisions about the development of progression frameworks.

This **research** report is intended to support thinking across and within the AoLE groups as ideas of progression are developed and shared across Wales.

Part 1: Major themes

Progression matters for learning

The crucial function of the curriculum is to identify for each AoLE what matters in order to achieve the overall purposes of the Welsh curriculum, viz., to enable each young person to be

- an ambitious, capable learner, ready to learn throughout life;
- an enterprising, creative contributor, ready to play a full part in life and work;
- an ethical, informed citizen of Wales and the world;
- a healthy, confident individual, ready to lead a fulfilling life as a valued member of society.

Within the curriculum for each AoLE description of progression is important:

- for teachers to have an overview of the curriculum
- for learners to see a bigger picture and relate what they do on a day to day basis to a broader understanding of what matters
- as the basis of decisions about next steps in learning and pedagogy.

The research review suggests that, to achieve these three purposes effectively, descriptions of progression should be structured in terms of learning development such as beginning learner to expert in a domain, rather than in terms of predetermined statements of standards related to age or stage of education.

Descriptions of progression serve two main purposes

The research and national framework reviews suggest that descriptions of progression can usefully be of two broad kinds, interrelated but with the following separate purposes:

- **Broad statements providing an overview of the journey from beginning learner to expert in a domain**.
  - These descriptions summarise succinctly what matters over time within the domain.
  - They can guide teachers' large-scale planning over an extended period of students' education.

  - They can show students and teachers how current work relates to longer term aims and so avoid students seeing their learning as fragmented and with little sense of clear purpose.

- **Detailed description of progression in learning within topics in a given domain**
  - Specifying the knowledge, skills and capacities which students acquire and practise in the process of working towards the learning described in the broad statements.
  - These detailed descriptions should enable the teacher and the learners to identify in assessment for learning dialogue what has been achieved and the next immediate steps to ensure further successful learning.

Evidence emerging from the research and frameworks reviews suggests that different countries have taken different approaches to the presentation of national curricula and assessment arrangements. In Wales, it will be important to consider how best to address both the above purposes in a way that would promote clarity, eg, allowing teachers and learners to have a sense of the overall learning journey using broad descriptors whilst more detailed information on learning related to the overall descriptors is contextualised within professional learning. Such an approach should create clear links between the national framework and local practice, providing an effective basis for

- developing teachers' discussion and deep understanding of learning
- exploring means of responding to the voices of learners and promoting their ownership of learning
- exploring the potential of assessment for learning and pedagogical action to ensure success
- demonstrating ways in which day to day work builds towards achievement of what matters in the AoLE, as defined in succinct broad curriculum descriptors.

Successful curriculum and assessment development is only possible if contextualised in professional learning.

Successful development and enactment of learning progression frameworks developed for Wales will depend on an inextricable relationship between development of curriculum and assessment and professional learning.

Part 2: Relating AoLE Review Findings to *Successful Futures*

The ideas presented in *Successful Futures* form the principles from which curriculum, pedagogy, models of progression and assessment in Wales are to be developed and offer a touchstone against which emerging proposals can continue to be evaluated. These principles serve as touchstones for the CAMAU project processes.

Progression is characterised in *Successful Futures* in terms of increasing achievement in a range of aspects of learning such as: breadth, depth, complexity, level of abstraction, mastery of techniques, sophistication, accomplishment and skill, application, challenge and independence and confidence: this increasing achievement will be evident for both disciplinary knowledge and wider competencies. *Successful Futures* recognises the diverse needs of learners and is clear that the curriculum purposes can be met in a wide variety of ways and allow for wide variations in the experiences of individual children and young people. Each child's learning continuum functions as a journey through the curriculum; while the road map will be common to all learners, this journey should allow for variety of pace, diversion, repetition, and reflection, as appropriate for each individual to make progress in learning. These aspects of progression are all identified in the six reviews in section 2 as being visible to some extent and at some points in both the findings of research and national policy statements, but the review found no existing national system where all these issues had been fully addressed.

Similarly, learning is defined in *Successful Futures* through the concept of progression, represented as a coherent continuum without separation or interruption. The continuity that the new curriculum places at the centre of learning describes a holistic approach to the development of the individual, including experiential learning that is valuable in and of itself. The characterisation of progression embedded within Successful Futures as the vision for education in Wales is not fully evident in any one country's policy or one theoretical model.

The Curriculum for Wales, therefore, is breaking new ground and will need to bring together multiple forms of evidence, for example, research where it exists as documented in the research reviews, teacher and pupil understandings of progression, samples of pupil work that show progression, and insights from other national frameworks, in order to create bespoke progression frameworks for each AoLE tailored to the needs of young people in Wales.

By revisiting the elements of the *Successful Futures* vision for progression outlined in section 1 of this report we can summarise relevant findings of the six reports in section 2 (see *Table 15*). Each of the 12 points summarised in this table may help inform decision-making within each AoLE group as well as across the system.

Table 15

	Element of the vision for progression embedded within *Successful Futures*	Summary comment from section 2 reviews
1.	Phases and key stages should be removed in order that progression can be continuous, increasing the potential for higher attainment by minimising transitions.	Evidence from research considered in some reviews supports this principle: if progression steps represent significant aspects of learning, then reference to specific ages/stages/phases is at least difficult, and maybe inappropriate. There exist some frameworks which do not prescribe attainment by age or grade.

	Element of the vision for progression embedded within *Successful Futures*	Summary comment from section 2 reviews
2.	Progression in each Area of Learning and Experience should be based on a well-grounded, nationally described continuum of learning that flows from when a child enters education through to the end of statutory schooling at 16 and beyond.	Reviews report that some progression frameworks run through the whole of a child's learning while others are specific to particular stages (e.g. primary, early secondary). The latter may be marked by discontinuity. Some research reviewed considered the whole continuum; other research reviewed investigated progression in the shorter term. The latter may inform the former.
3.	Learning should be an expedition, with stops, detours and spurts rather than a straight line. Progression is a 'road map' for each and every child/young person's progress in learning though some children and young people will progress further and/or faster than others.	Although some countries do outline tightly prescribed linear progression, there is considerable evidence from research that non-linear progression (sometimes 'spiral') is either to be expected or is necessary. This is recognised in some policies. The question of moving forwards and backwards in learning is raised in some reviews, as is the notion that there may be multiple paths of progression that different children may take.
4.	Progression Steps will be described at five points in the learning continuum, relating broadly to expectations at ages 5, 8, 11, 14 and 16 (staging points for reference rather than universal expectations – but expectations should be high for all learners).	Research considered in some reviews questions the value of progression steps which represent significant aspects of learning referring to specific ages/stages/phases as at least difficult, and perhaps inappropriate.
5.	Progression Steps are made up of a number of achievement outcomes linked to what matters in the curriculum and linked to the four purposes ('I can' statements). Literacy, numeracy, digital competence and wider skills should be embedded as well as elements of the Cwricwlwm Cymreig.	The reviews provide evidence on the nature of 'achievement outcomes'. Some progression frameworks contain many statements of achievement, an approach which presents both practical and educational difficulties: difficult to manage and detailed prescription is unlikely to be consistent with flexibility in individuals' learning. Very broadly stated outcomes may be open to a breadth of interpretation and be perceived by teachers as unsupportive. First person learner statements are uncommon.

	Element of the vision for progression embedded within *Successful Futures*	Summary comment from section 2 reviews
6.	Achievement Outcomes should not be a checklist of knowledge or skills and should incorporate effective pedagogy.	The reviews provide accounts of research evidence which points up the potential disadvantages of this 'checklist' approach. While some countries do adopt this 'checklist' approach there exist in at least some curricular areas in some countries models of progression which avoid this approach.
7.	Achievement outcomes should inform next steps and be framed as broad expectations achievable over a period of time (approximately 3 years).	While a number of countries monitored progression across periods of time longer than a year, there was less clarity about how achievement outcomes might explicitly inform next stages in learning.
8.	Achievement Outcomes should use 'I can', 'I have' (and 'I am ready to') statements to describe progression (not over specified or overly vague – this may vary across AoLEs).	The reviews found that use of first person statements is rare in the countries examined. Typically, third person statements referred to the past 'The learner will have developed…' or present 'The learner is able to…'. There seem few statements that could be equated with 'I am ready to…'
9.	Assessment (relevant and proportionate) should be focused on learning intentions and progression in relation to the four curriculum purposes and based upon the intentions set out in the Achievement Outcomes at each Progression Step within each Area of Learning and Experience.	There was some evidence that tensions could arise from seeking to incorporate within achievement outcomes both learning directly related to the discipline and evidence related to broader statements of learning such as the four purposes.
10.	In each AoLE the Achievement Outcomes at each Progression Step will need to encapsulate the most important aspects of learning, take account of the ways in which children progress in different kinds of learning and recognise what they need to be able to know and do to move securely to the next stage.	This issue is noted in some of the reviews: some progression frameworks reviewed would seem to be inconsistent with aspects of this aim, those which have many statements of achievement for example. In many countries statements of standards (or similar) focused on attainment to date and made little reference to next stages of learning.

	Element of the vision for progression embedded within *Successful Futures*	Summary comment from section 2 reviews
11.	Professional judgement is central to assessment (formative assessment with relevant summative information collected and used formatively within classrooms and schools).	The research and policy reviews undertaken here found less evidence for the use of assessment to inform school evaluation than for its use to inform learning.
12.	Schools should use teacher assessment of progression systematically, together with other sources of evidence, to inform their self-evaluation for school improvement purposes.	The reviews found less evidence for the use of assessment to inform school evaluation than the use of assessment to inform learning. This applies both to research and policy reviews.

Part 3: Principles

Building from the evidence emerging from the review of national frameworks and the research literature, a number of principles emerged that might be used to take forward the progression aspirations of Successful Futures.

Principle 1

The four purposes should inform and be evident in learning progression frameworks and achievement outcomes.

The six reviews in Section Two recognise that each AoLE has specific characteristics, reflected in both research and existing national frameworks. It will be important that learning progression frameworks in Wales recognise these characteristics. In some of the frameworks reviewed, the 'main aims' of the curriculum are articulated at the start and then elaborated in detail in a description of the curriculum or in a description of learners' expected achievement (e.g. learning or achievement outcomes, standards, descriptions of progression) or in descriptions of both. A learning progression framework, the progression steps within it and associated achievement outcomes must reflect or encapsulate what the designers of the curriculum most value in the process of educating young people**.**

Principle 2

Progression frameworks must relate to what matters

Each progression framework should focus on the knowledge, skills and attributes which have been identified within each AoLE as the heart of successful learning in each domain and must encompass the four purposes of the curriculum.

Principle 3

Learning progression frameworks will place the development of learning at their heart rather than focusing on content or activities.

In the past insufficient attention has been paid to progression in learning with negative consequences for learners and teachers who perceive learning as fragmented and with little sense of clear purpose. This leads to problems with practice in Assessment for Learning where understandings of where a learner is and where a learner might next progress to are commonly not linked into a bigger picture of what matters. Reviews emphasised the interdependency among pedagogic approaches, content and assessment in how progression is described.

Achievement outcomes at each progression step should encapsulate the most important aspects of learning, take account of the ways in which children progress in different kinds of learning and recognise what they need to be able to know and do to move securely to the next phase of learning in that framework.

Principle 4

Progression frameworks should serve two main purposes: broad statements and detailed descriptions

Each AoLE will develop broad statements to provide an overview of the learning journey over time and more detailed statements related to individual topics, themes or other aspects of learning. A little like Russian nesting dolls, the more detailed progression statements should be linked clearly to the broad progression statements and the broad statements should be derived from what AoLEs have identified as what matters.

Principle 5

National progression frameworks should enable and support schools to develop curriculum and assessment practices to suit local circumstances

It is important that broad progression statements are written in a way that allow schools to have the flexibility to ensure that they can relate the curriculum to local circumstances as they maintain high levels of challenge for all learners.

Principle 6

Successful curriculum and progression development requires professional learning

It is important that professional learning builds on available evidence: this involves bringing together research understandings with practice insights in the emerging policy context of Successful Futures. Professional learning will stimulate and support teachers to recognise, build on and develop their pedagogical insights and practice. There are opportunities for professional learning to be built around the development of the national programme rather than simply learning about the national programme. For example, the evidence base to build more detailed progression statements does not exist in all areas. One function of the professional learning programme should involve groups of teachers working together to help build a better evidence base whilst learning about the new curriculum and assessment arrangements.

Principle 7

Where possible progression frameworks should be informed by research evidence

Consistent with the policy aspiration of Successful Futures achievement outcomes should describe significant progression steps within a learning progression framework. Achievement outcomes should not be a checklist of knowledge or skills and should incorporate effective pedagogy; they should inform next steps and be framed as broad expectations achievable over a period of time (approximately 3 years).

Part 4: Evidence derived from the review which may help to inform decisions to be taken within each AoLE Group

Here, questions arising from the review related to the principles identified above were identified. These were offered as a stimulus for thinking within and across AoLEs as they made proposals to the Coherence Group on how progression frameworks might best be developed.

1. What are key features of research-informed progression?

Each of the AoLE reports refers to and supports Heritage's (2008) argument noted in section 1 that

> *'By its very nature, learning involves progression. To assist in its emergence, teachers need to understand the pathways along which students are expected to progress. These pathways or progressions ground both instruction and assessment. Yet, despite a plethora of standards and curricula, many teachers are unclear about how learning progresses in specific domains. This is an undesirable situation for teaching and learning, and one that particularly affects teachers' ability to engage in formative assessment.'* (p.2)

Common conceptual features of progression frameworks were summarised in Section 1. Heritage (2008) argues that all models of progression conceptualise progression as a continuum of increasing sophistication of understanding and skills as young people move from 'novice to expert'. This concept is explicit in some of the national frameworks and may underpin others; however, there is a range of understandings of the nature of development from novice to expert. Some learning progression frameworks adopt a developmental view, inviting teachers to conceptualise learning as a process of increasing sophistication rather than as new bodies of content to be covered within specific grade levels; others detail content or very specific skills to be developed at each stage. It seems that approaches may vary from AoLE to AoLE: whether this is the result of different epistemological models or of tradition is unclear. No definition of learning progression contains references to grade or age level expectations, in contrast to many standards and curriculum models as learning is conceived as a sequence or continuum of increasing expertise.

Implicit in progression is the notion of continuity and coherence. Learning is not seen as a series of discrete events, but rather as a trajectory of development that connects knowledge, concepts and skills within a domain. Issues related to interconnection of knowledge, concepts and skills across a domain – or domains – are considered in the individual AoLE reviews; these demonstrate differences between AoLEs, some associated with the range and fit of the domains within each AoLE, some associated with differing balances among knowledge, skills and dispositions. Learning progressions are accommodating. They recognise that, commonly, learners do not move forward at the same rate or with the same degree of depth and progression. This issue was consistently acknowledged in each of the AoLE reviews. A number of existing frameworks do not appear to allow learners to move forward at different rates.

Learning progressions enable teachers to focus on important learning goals, paying attention to what a learner would learn rather than what a learner would do (the learning activity). The learning goal is identified first and teaching, pedagogy and assessment are directed towards that goal. 'Consequently, the all too common practice of learning being activity driven rather than driven by the learning goal is avoided.' (Heritage 2008 p.5). Clear connections between what comes before and after a point in the progression offer teachers a better opportunity to use assessment to calibrate their teaching, to address misunderstandings or to develop skills, and to determine what would be important next steps to move the student forward from that point.

2. Who might key audience(s) be for Learning Progressions?

Learning progression frameworks provide teachers with an overview of the curriculum and provide learners with a bigger picture which allows them to relate what they do on a day-to-day basis to a broader understanding of what matters. The AoLE reviews set out the intentions for the articulation of progression and achievement that can be summarised as follows:

> Achievement Outcomes and any associated description of learning progression should enable teachers to know what kinds of knowledge, skills and aptitudes they should aim to develop with learners at all stages of their learning journey. Achievement Outcomes should enable both teachers and learners to see the next steps to be taken.

The purpose, scope and structure of the progression frameworks within and across AoLEs will need to be clear to those who will use them prior to developing their content.

As noted in Section 1, Black *et al* (2011) make a strong case for the centrality of teacher assessment. This is well supported in the reviewed literature and international models where the potential for rich evidence of progression and better standards of validity and reliability than national or state tests are noted. However, each AoLE review highlights that, as Black *et al* (20011:106) suggest, attaining a position where teacher assessment fulfils this promise may require significant professional development. Lambert (2011) also raises the issue that the actual understanding (and perhaps even the actual relevance) of level descriptors is often questionable. Lambert cites the difficulties that teachers have in identifying work to exemplify certain levels, implying an uncertainty about what constitutes a level (and therefore arguably progression).

Heritage (2008) reminds us that many learning progressions are written primarily for teachers and tensions can arise if a single learning progression attempts to serve too many purposes. For example, problems can arise if it is assumed that the same degree of granularity (level of detail) will serve both long term planning and assessment to support immediate next steps. The degree of granularity in a learning progression designed to ensure that teachers have an overview of progress from novice to expert is very different from the degree of granularity necessary to enable teachers to support learning formatively: the latter would require a far more detailed analysis of progress in learning.

Learning progressions can also be written in ways which provide a framework for learners to understand their own learning journeys. Such models were not explicitly noted in the AoLE review reports. Heritage (2008) argues for the importance of learners being aware of longer term goals and the relationship between those and their day to day progress. Increased involvement in learning occurs when teachers share with the students what their longer-term goals are and enable them to participate in evaluating the degree to which they have met the goals.

3. How detailed should the descriptions be? (described in research literature as 'granularity')

There are different understandings about what is meant by progression in learning. It is important to make a clear distinction between learning progression as providing an overview of the long journey from emerging to expert in a domain and as detailed insight into the expectations of immediate progression in learning within a topic in a given domain. Both are necessary and inter-related but different in their purpose, scope and level of detail. Both should help teachers and learners to see, and indeed to develop habitual awareness of, the appropriate next steps, as dialogue and assessment for learning take place during the learning process. Heritage (2008:2) suggests that greater attention should be paid to the different levels of specificity used to articulate the curriculum. Some curricula specify detailed objectives to be mastered at each grade in sequence. When the curriculum is described in this level of detail, 'grain size', it may be difficult to see how these many discrete objectives connect to bigger, organising concepts; learning can become little more than a checklist of things to be learned. Curricula organised around core concepts or 'big ideas' and sub-concepts offer better opportunities for a stronger relationship between formative assessment and learning goals. However, Heritage (ibid) argues that care also needs to be taken with this approach for too often 'big ideas' are not brought together as a coherent vision for the progressive acquisition of concepts and skills. Without a coherent vision the potential for teachers to have a broad overview of learning in a specific domain is restricted.

The AoLE reviews include some detail about specific models for progression which teachers may employ; these may be domain-specific or applicable more generally.

All of this implies the need for consideration not only of the determination of the central aspects of achievement in the AoLE but also of the appropriate (that is, helpful and manageable) levels of specification of description of achievement. If the central aspects are described in 'lean' statements, then it will be necessary to consider the most appropriate format: e.g. succinct broad statements, possibly with a small amount of expansion; or narrative descriptions. It will also be necessary consider where more detailed guidance and support for teachers about progression, next steps and pedagogy should be located and how this could be used? If descriptions of achievement are detailed, it will be necessary to consider how these can be used effectively to support assessment for learning and progression, given the issues about manageability which have been raised.

There is evidence from several countries reviewed that exemplification of standards through learner work significantly reduces the level of abstraction. Descriptive statements alone do not always make clear what performance/behaviours at a given level would look like in a classroom and this is a potentially powerful way of addressing this issue. The use of such material to inform professional learning requires consideration. Several of the reviews raise the issue of the most appropriate location of detailed guidance for teachers about progression, next steps and pedagogy: within the curricular/progression framework itself or in associated material available to teachers as part of their continuing professional development? Related to this is the question of how such material can be most effectively used to support professional learning.

4. Steps in a learning journey?

The issue of relating learning progression frameworks to ages, stages or even phases has already been referred to. Research argues that this should not be the case on both fundamental and instrumental grounds. As the groups develop an empirically well-founded learning progression framework where achievement outcomes describe learning necessary to make further progression, how will they address the issue of descriptions of achievement which are related to phases?

The reviews of international frameworks demonstrate how some frameworks seek to differentiate the performance of learners' who are at the same chronological or grade stage by using a grading system or mark. This may take the form of such phrases as *Not Yet Within Expectations*, *Meets*

Expectations (minimally), *Fully Meets Expectations* and *Exceeds Expectations* or a mark such as: *1 = limited effectiveness, 2 = some effectiveness, 3 = considerable effectiveness* and *4 = a high degree of effectiveness or thorough effectiveness*. This matter may be related to the level of specification or the number of stages of development employed in a framework. A possible justification for the kinds of grading or marks systems shown may be that very broadly defined frameworks do not give teachers and learners enough detail in deciding on next steps in learning. An obvious potential disadvantage is the danger of labelling learners and the associated motivational issues. Such grading approaches are usually linked to statements of standards which themselves may be linked to age and stage; there is powerful evidence that such approaches divert teacher and learner attention away from learning to simplistic models of attainment.

The reviews demonstrate that existing frameworks can provide ungraded descriptions of complex achievement and interacting skills. These may be supported by desirable guidance and support for pedagogy and assessment for learning through additional associated material and by encouraging continuing professional development activities.

5. How might the progression frameworks relate to previous frameworks?

During the process of review it was noted that the former National Curriculum in Wales and the Literacy and Numeracy Frameworks used progression frameworks which took some account of pupils' varying pace of progress. This raises the prospect that there may be some value in looking at earlier local models of curriculum and learning progression in the writing of new achievement outcomes. However, it was also noted that practice must align with the new intentions for the curriculum in Wales: in particular, the requirements to address the four purposes; the fundamental importance to learning of ensuring that curriculum, pedagogy and assessment are coherent and aligned; and the need to move from backward focused statements of standards to forward focused statements of achievement. This has implications for the development of learning progression frameworks which support effective learning.

While considering descriptions of performance it is worth noting the Review of the National Curriculum in England (2010-2014) was highly critical of the previous levels-based system. In this context, best-fit judgement failed to recognise major gaps in children's knowledge and contributed to superficial coverage of the curriculum because the levels-based system encouraged learners to move on to new content without secure grasp of key areas.

6. Relationship with literacy, numeracy and digital competence frameworks?

The Languages, Literacy and Communication review notes that *Successful Futures* explicitly states that the achievement outcomes and progression framework for Languages, Literacy and Communication should take appropriate account of the national Literacy Framework. There are therefore important decisions to take about how the development of the Languages, Literacy and Communication learning progression framework may relate to the Literacy Framework. Parallel issues will apply in the articulation of progression for numeracy with Mathematics and Numeracy and for digital competency and the computing aspect of Science and Technology. All AoLE groups will wish to consider how achievement in these three frameworks and in other cross-curricular aspects may be reflected in their learning progression frameworks.

7. What view do we have of the developing child and young person?

The place of child development within the domain and associated expectation for progression in learning is raised in several reviews. Pellegrino (2017) suggests that although learning progressions are not developmentally inevitable, they may be developmentally constrained. This issue was noted in some AoLE reviews and was of particular importance for the H&WB AoLE review. It may be that this issue is more broadly applicable, especially in the earliest years of learning. When considering progression (e.g. in H&WB), links have been made to research in child development. While child development differs from progression in learning within a domain, developmental stages are closely tied to achievement within H&WB: a young child typically cannot run, regulate emotions, navigate social situations or demonstrate self-control as well as an older child. Teachers may draw on knowledge of child development to understand what typical development looks like within the physical, mental, and social domains, identify when pupils seem to be developing atypically and provide support to maintain the progress of all learners. Progress in domain-related learning relates to developing metacognition and self-efficacy; this observation underlines that there is a complex relationship between children's progress in the H&WB and their progression in other AoLEs.

While it is argued that research undertaken on cognition and learning has led to the emergence of highly developed descriptions of progression in particular curricular areas, specifically science, reading and mathematics (Pellegrino 2017), the evidence from several of the AoLE reviews is that this is often at a micro or detailed level (e.g. one topic) rather than over a longer time scale. Learning progressions can be developed through tracking the actual development of thinking/learning during a sequence of learning or topic. The premise of these 'learning progressions' is that they allow the teacher to understand the ways in which learners progress in their thinking or skill development in order to track progress. This approach would seem to have the potential to produce evidence based learning progressions which would act as a usable version of level descriptors and would support a genuinely formative process of checking current attainment against a known progression and the setting of targets for improvement. However, it should be noted that such progressions are extremely complex (taking 2-3 years to produce) and that a large number of these may be needed in order to cover 'big ideas' within any curriculum area.

Children and young people are beings not becomings. The four purposes describe what all children and young people should become and achieve through statutory education as well as how they are perceived and positioned to experience the curriculum. *Successful Futures* (p.22) argues that:

> *'statements of curriculum purpose need to be formulated carefully so that they have integrity, are clear and direct and become central to subsequent engagement and development; in that way they can* ***shape the curriculum and suffuse practice*** [authors' emphasis]*. Common understanding of why we are doing what we are doing is a powerful starting point from which to determine what it is we need to do and how we are going to do it'.*

Recommendation 2 (p.23) states:

> *'The school curriculum should be designed to help all children and young people to develop in relation to clear and agreed purposes. The purposes should be constructed so that they can directly influence decisions about curriculum, pedagogy and assessment'.*

The purposes therefore tell us about how children should experience their curriculum day to day. Each child's learning continuum functions as a journey through the curriculum; while the road map will be common to all learners, this journey should allow for variety of pace, diversion, repetition, and reflection, as appropriate for each individual to make progress in learning. There is therefore a greater responsibility for schools and teachers to ensure that learning is child-centred, since the details and pace of each journey are set according to the requirements of the learner, always in order to ensure challenging, sustainable and effective learning takes place.

As children and young people move through the education system in Wales they must not be viewed as *aiming towards* the four purposes, but rather must be seen *as living the four purposes* during their time at school – the purposes, then, are not simply goals to be reached at the age of 16, but are also descriptions that inform how we 'position' children throughout their education in schools in Wales.

8. What view do we have of pedagogy?

The notion of 'child-centred' learning and children 'working at their own pace' can imply a pedagogic role that is facilitatory; that is, the role of the teacher is to facilitate the child or young person to lead their own learning or set the pace and/or direction of this learning; the teacher does not take a pro-active role in progressing this learning. It is suggested here that such a view of pedagogy in the new curriculum will be unhelpful. Wales has experience of significant curricular innovation in the shape of the Foundation Phase, introduced in 2008. Recent evaluations (Siraj 2014; Welsh Government 2015) have indicated that poorly understood models of appropriate pedagogy hampered the success of the innovation that, where effectively implemented, has had positive impact on learner outcomes.

Successful Futures provides clear guidance on what is meant by appropriate pedagogy:

> *Pedagogy is about more than 'teaching' in the narrow sense of methods used in the classroom. It represents the considered selection of those methods in light of the purposes of the curriculum and the needs and developmental stage of the children and young people.*

Teachers will draw on a wide repertoire of teaching and learning approaches in order to ensure that the four purposes are being fully addressed and that all learners are engaged and the needs of individual learners are recognised. Teachers will avoid labelling teaching approaches; rather they will consider their appropriateness in terms of purpose. Approaches will encourage collaboration, independence, responsibility, creativity and problem solving in authentic contexts which will draw on firm foundations of knowledge. Approaches will employ assessment for learning principles and make use of scaffolding, modelling and rehearsal.

In order to enact the vision set out in Successful Futures it may be helpful to signal *intentional pedagogic approaches* throughout. That is, the teacher, with the support of appropriately articulated progression frameworks, undertakes to work intentionally with each learner in the direction of progress and to maintain a focus on pace and ambition throughout this process. AoLE groups will wish to consider how this approach may be facilitated by the learning progression frameworks which they develop.

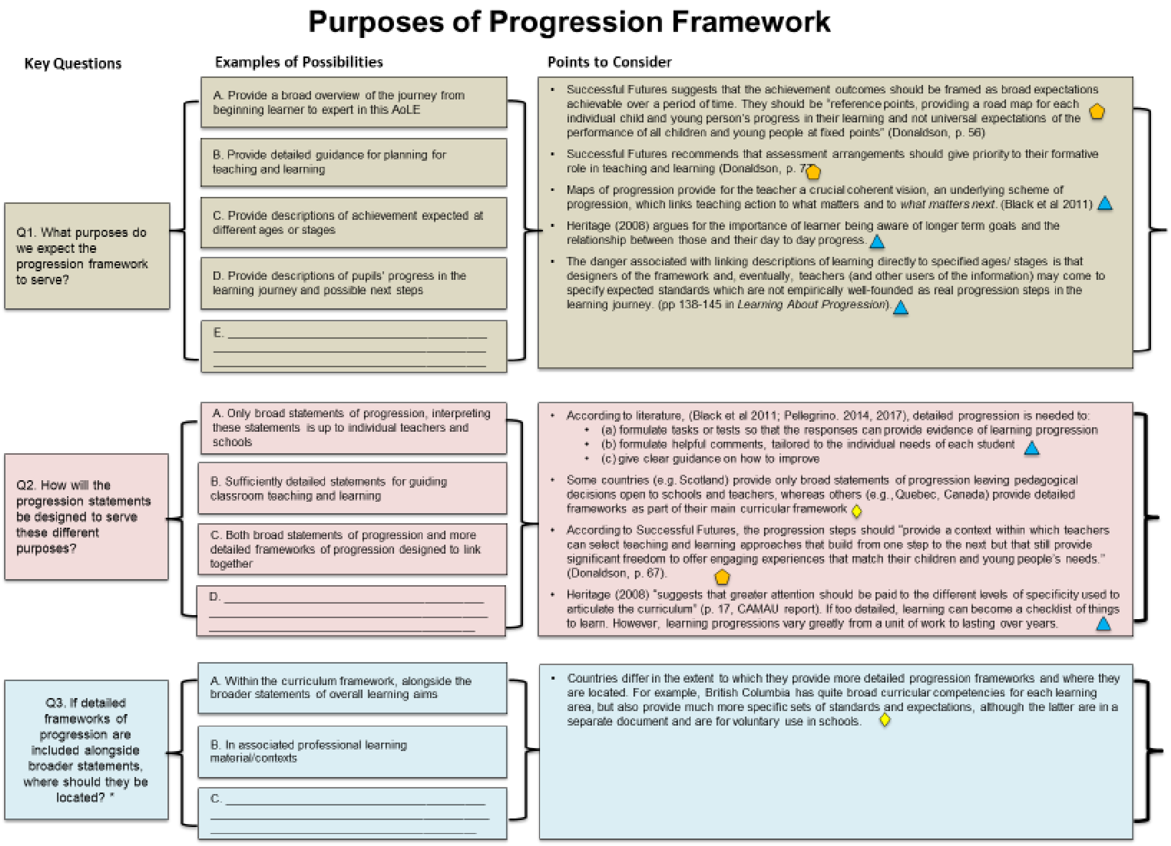
In conclusion

This research report, following the first seven months of work of the CAMAU project, is offered to the education community of Wales and, specifically, to the Pioneer Networks in the spirit of subsidiarity as set out in Successful Futures. The report reviewed evidence from a range of national curriculum and assessment frameworks and evidence from research on progression both as it relates to curriculum and assessment and in the context of the six Areas of Learning Experience. In this final section key ideas emerging from the various evidence sources were used to develop principles. These principles may be used in a number of ways, eg, as a touchstone to check that as ideas develop they remain consistent with original aspirations. Analysis of the evidence pointed to a number of possible alternatives approaches to the design and development of progression frameworks. To remain consistent with the concept of subsidiarity, these alternatives were offered as decisions to be taken. Each decision was structured around questions to be addressed, each supported by available evidence to promote better informed decision making. Each AoLE considered carefully the evidence available and made proposals to the Coherence Group. In the majority of cases it was possible for groups to agree a single proposal, however, in a small number of cases, two alternative proposals as to how a particular issue should be addressed were submitted from the same group. An example of a decision tree can be found in *Figure* 13 below. Further examples of decision trees from different AoLEs are provided in Appendix 3.

The decision tree approach was very well received by AoLE members and the proposals submitted to the Coherence Group provided them with a strong evidence base from across AoLEs to allow collective, well informed decisions to be taken.

The next and final CAMAU research report will begin by examining the agreed progression framework and will consider the development and enactment of its principles as they begin to emerge in practice.

Figure 13: Decision Tree



* Q3 follows from Q2 and is only relevant if the preferred possibility for Q2 is B or C

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Appendix 1

CAMAU Project

International Policy Review Guidelines

<u>STEP 1: Notes on progression for the country</u>

Name of Country:

Year the curriculum was written/published/updated:

Website(s) where materials were found:

How is the curriculum structured? E.g., Is there a curriculum document as well as achievement outcomes or are these combined? Are there supporting materials for teachers? Is there one curriculum across all ages or is it split into primary and secondary?

How many stages/levels/benchmarks are included? Are they aligned with specific years?

What components/subjects/themes related to the AoLE are covered in this country's curriculum? What seems to be missing?

How does the documentation define 'what matters' in this AoLE? Does this include content knowledge, competencies, skills, etc? What is the balance between knowledge and understanding, skills, attributes, and capabilities?

How is progression defined? Is it defined explicitly or implicitly? You may need to look outwith the statements themselves at the supporting documentation and introductions to the curriculum. Give some specific quotes or examples.

Are key progression points identified as expected standards for specified ages? Or as descriptions of knowledge, skills, capabilities needed for further progression in learning? Or is it some combination?

What form do statements of progression take? Are they detailed or broad? Are they in pupil-first language or written for the teacher? Provide some examples.

To what extent does the curriculum for this AoLE seem to align with what is written in Successful Futures? Does it seem to align with Donaldson's vision for progression? Give some examples.

Is there anything else worth noting? E.g., Is there anything particularly unique, innovative, or useful about this curriculum? Are there any aspects of the AoLE that are included in cross-curricular aims? Was there anything within this portion of the curriculum that seems to have connections with any other AoLE?

<u>STEP 2: Summary Statement</u>

Please write a summary of how this country has tried to describe or incorporate progression into their curriculum for the AoLE. Please include your own evaluation in terms of its potential advantages and disadvantages as an example of incorporating progression for this AoLE. This summary should be less than a page (less than 500 words) but can of course be shorter or longer as needed, and should complement the notes you have taken above.

STEP 3: Collating Across Countries

We will combine the information you have provided for each country into one document and write an overall summary statement comparing across the countries. We will then send this final document out for your feedback to make sure your country is represented appropriately and to seek your insight on

Appendix 2

Guidelines for H&WB Literature Review

Aim:

To describe what published evidence exists that might inform our understanding of how pupils progress within the domain of health & wellbeing

Scope:

Successful Futures defines the scope of this AoLE as: "This Area of Learning and Experience draws on subjects and themes from PE, mental, physical and emotional well-being, sex and relationships, parenting, healthy eating and cooking, substance misuse, work-related learning and experience, and learning for life. It is also concerned with how the school environment supports children and young people's social, emotional, spiritual and physical health and well-being through, for example, its climate and relationships, the food it provides, its joint working with other relevant services such as health and social work, and the access it provides to physical activity."(Successful Futures, p. 45). Our review, in line with Successful Futures, will aim to cover these core areas of the field. In accordance with the health and wellbeing report that the AoLE presented in June 2017, we will also include a brief overview of character education, which is somewhat aligned with the competencies that the teachers deem important: readiness, reflectiveness, resilience, respectfulness, resourcefulness and responsibility.

Thus our review will examine what evidence exists on progression in pupils' learning related to the following themes:

- physical education, physical literacy, physical wellbeing (Nanna)
- mental wellbeing and mental health (Sarah Stewart)
- healthy relationships, peer relations, sex, and parenting (George Wardle)
- nutrition, including healthy eating and cooking (Kara)
- substance misuse, abuse, and personal safety (Sue James)
- work-related learning and learning for life (Rachel Bendall)
- character education (Kara)

Stage 1: Finding Literature:

It is important to by systematic in the steps that we take so that we can communicate to others how we conducted our review so that it can be evaluated by others, be replicated if desired, and also to allow for consistency across the members of the group. In order to do this, we should follow the following guidelines:

1) Independent search with keywords: It is recommended that we use Ebscohost or a similar academic database and keep track of the keywords that we have used to search for literature. Certainly we should search for "progression" but be aware that it may not be a word that is commonly used so additionally we may look for similar keywords such as "child development" or "developing" + various keywords for the topic we are exploring. When looking through results, we can scan the title and abstracts to decide what may be relevant, and we should keep a running list of the sources that we plan to review. If a source sounds particularly relevant but one of our Universities do not have access we can use interlibrary loan to try to obtain the relevant source.
2) Expanded search: The next set of searches will involve exploring the work and authors that are cited within the original sources we have found. For example, one paper (such as the article by Margaret

Heritage) may cite very useful literature that we can then follow up with, or we may start to recognize some names of authors who are experts in our area and can do an author search within Ebscohost to explore their work. Again, we should keep track of the process we have used and keep a running list of the sources we plan to review.

3) Advice from Professors: We will ask our professorial consultants to also recommend papers or authors that would be relevant for our purposes.
4) Collegiate advice: If we come across something that may be relevant, share with one another. If we have a colleague who studies this topic, ask them. Keep track of which sources were recommended in this manner.

During this phase it is important to consider screening and excluding any papers that seem less useful. We may want to keep a list of all the papers we have considered and the ones we end up using for the review. Given our short time frame, the important thing is that we read enough core pieces in the area in order to begin describing with some confidence what is known in this area of progression.

Stage 2: Analysis for the Review:

Our literature review should be a synthesizing statement about the broader literature within a particular area that answers some critical questions related to progression (rather than just a summary of individual articles). It should be clear that this is an informed perspective and evaluation of the field, citing relevant sources for each point that we are making. When it is helpful we can use quotes and specific examples from the literature, or to create tables to help make points of comparisons or contrasts.

Next, using the papers that are relevant, we will want to report/describe substantial elements from the papers, consider the extent to which they inform our work of progression, note similarities/differences across the papers, and at the highest level, consider the sources themselves and their relevancy.

When reviewing the articles, we may wish to consider the following questions:

- What evidence exists that informs our understanding of progression in this domain?
- In what ways have researchers described how children develop their knowledge/skills/capacities in this area? In other words, how do they model progression? For example:
    - According to the literature, are the changes that children make qualitative jumps (with big steps at key moments) or more gradual sophistication (children seen to gradually add more of the same skills over time)?
    - Is progression linear or could children move backwards and forwards?
    - Do the researchers see children's progression as something that can be impacted on by the environment and open to change, or is it fixed?
    - Is there one path that children seem to take in this area, or are there multiple paths? Do the researchers acknowledge that children may have different paths based on the context in which they grow up/learn?
    - Are there different models of progression for the same topic and to what extent do they overlap, complement, or conflict?
- To what extent does the literature focus on how children develop in terms of their knowledge/understandings vs. behaviours/skills?
- To what extent is the progression that is described at a micro-level (for one lesson/unit) or at a macro-level (across multiple years)?
- What ages are covered when describing how pupils learn in this area? Which ages seem to be missing or receive less adequate attention?
- What is the theoretical background of the relevant literature (e.g., education, public health, psychology, etc.)? We may get some insight by looking at the journal it is published in as well.

- Importantly, what seems to be missing in this area? What do we still not know? Is there not a lot of research on this topic?
- To what extent could the research in this area help to inform models of progression that could be useful for teachers and for learners?
- What can we use from this literature for our purposes of writing a framework of how children progress in this area?

This literature review will serve two purposes. 1) to inform teachers about what is known in the literature that may inform their understanding of progression in this area, 2) to be a systematic review that would be appropriate for journal publication.

Stage 3: Writing the Review:

What will the overall review look like? Proposed outline for the literature review:

A. Introduction with description of H&WB for Wales based on Successful Futures
B. Literature reviews for each of the sub-areas we propose to examine
C. Overall summary comparing and contrasting literature across areas as well, as well as evaluation of the scope and depth of literature on progression in the H&WB area, and unanswered questions
D. Implications and issues, based on the literature, for creating assessment frameworks of progression in H&WB

How long should the review be? The overall review for our AoLE will likely be approximately 6-10 pages but could be up to twice as long if we happen to find a lot of relevant literature. That means approximately 1-2 full page per sub-area (about 500-1000 words if using Arial 12pt single spaced), with an understanding that some will be longer and others will be shorter depending upon what is or is not available.

Most of the work is done before writing, through coming up with a list of relevant sources, reading the literature, taking notes, and reflection and synthesis. Our point is not to be comprehensive but to read enough core pieces in each area in order to begin describing with some level of confidence what is known in this area. What we end up writing is a concise critique and summary of the literature in this area. Readers can refer to our cited sources if they want to learn more.

How many sources should I read? Again this depends strongly on each of our topics and what is available in the literature. We may be making several points that need to be justified by sources but the sources are only peripherally related to the main topic in which case we could have dozens that we are drawing upon for each part of the review. Or we may find just 3 or 4 highly relevant sources that cover the topic in great depth that we are focusing on and deem this to be sufficient for the sub-area.

Appendix 3

Mathematics & Numeracy: Points in the Journey

Points in the Journey

Possibilities

Q1. How do you identify beginning and end points in the journey?

A. Beginning point - The skills/ understandings/ dispositions/ experiences young pupils bring to the classroom

B. End point - What a Welsh citizen should know/be able to do within the AoLE

C. End point – Requirements for transition into different phases of the education system, e.g., higher education, vocational education

D. Beginning point Pupils assessed for their starting point using formative assessment and taken forward from the point they are at.

Q2. Do different parts of the journey start at different points?

A. No, all skills, understandings, and/or competencies are represented at every step in the progression framework

B. Yes, some skills, understandings, and/or competencies may begin at later points in the journey or end at earlier points in the journey

C. ______________________________

Q3. How do you break up the journey in ways that make the best sense for learning, e.g., number of progression points?

A. Five points in the learning continuum, relating broadly to expectations at ages 5, 8, 11, 14 and 16 (staging points for reference rather than universal expectations)

B. The number of points may differ across learning depending upon the number of conceptual shifts that mark sophistication/development in the learning journey

C. Descriptions of learning linked to each grade level, similar to standards

D. Descriptions of learning needed to move into different phases of education, e.g., primary, secondary, subject choice

E. ______________________________

Points to Think About

Points to consider for identifying the journey starting point
- According to Successful Future (p. 53), 'Initial Progression Steps should take full account of guidance on Routes for Learning'
- Black et al. (2011) suggests that you "start from a learner's existing understanding'
- Not all young pupils enter the classroom with the same experiences, meaning some flexibility may be required
- ______________________________

Points to consider for identifying the journey end point
- Elective/non-core subjects in some countries mean pupils leave the system with different types of specialised knowledge
- Identifying an end point as a minimal competency/skill/understanding may not allow all students to see the next step for reaching for their full potential, especially if they reach the highest progression at a young age
- According to Successful Futures (p. 54), the curriculum should enable most children and young people to reach, or go beyond, each Progression Step
- ______________________________

- Students can increase in knowledge/skills at any point in their learning experience and even young children can develop skills or have experiences that set the basis for future learning.
- Similar to Option B, some country's curricular frameworks (e.g., Quebec) that were reviewed do not introduce certain skills/understandings until later points in the journey and/or do not continue them through the full progression framework
- Other countries that were reviewed repeat the same skill/understanding at multiple steps in order to represent that learning is happening over a longer period of time
- ______________________________
- ______________________________

- Successful Future recommends Option A (see p. 53). There are also five progression points in the learning continuum in Scotland.
- Research on progression appears to align more closely with Option B, in the sense that many of the progression frameworks that were reviewed across AoLEs have no indication of age and range widely in the number of steps they have. On a continuum of learning you may need more, or fewer, points depending upon the skill/understanding.
- Having the same number of points across each skill/understanding may be easier practically in terms of coherence across teachers and schools, but may require a compromise in terms of representing meaningful shifts in each skill/understanding, the latter of which is ideal for assessment for learning
- Many countries tend to follow Option C (e.g., Australia, British Columbia), with some exceptions (e.g., New Zealand has 8 steps/points in the learning journey). However, Option C is critiqued in the literature as it links to grade level expectations (Heritage, 2008).
- ______________________________
- ______________________________

Choice and Rationale

Rationale for Choice of Possibilities for Q1
Beginning Point - The teacher needs to use formative assessment to acknowledge what the learner has already achieved/ experienced / dispositions so they can assess the 'readiness' of the learner to continue their journey. (Singapore).
End point – Step achieved / reached towards the Four Core Purposes and the signal for where the next step will be.

Rationale for Choice of Possibilities for Q2
No, all skills, understanding, and/or competencies are represented at every step in the progression framework due to the way maths builds on the previous step. Each step is appropriate to the child's stage of development and introduced through play etc as appropriate. This is true for all "What Matters" within the Maths and Numeracy AoLE.

Rationale for Choice of Possibilities for Q3
Choose B – Discussion – evidence from practitioners during CAMAU research. We agree.
Point A – Discussion - Why are the ages chosen? 5 allows a child to settle into primary at the end of Reception. 8 acknowledges the infant / junior school situation and allows children to settle in a new school but then 11 when children move from primary to secondary is separating the two stages again. Dislike the clear distinction and not a journey more of a reaching different end points.

Point C – Discussion – Teachers needs guidance children do not need to be labelled and Welsh government label schools.

Point D – Discussion – Different phases of education seperating us too much still. 'Not our problem' idea.

AoLE proposal

Example: The aspect of the learning journey should be structured as… because…
Question 1 How do you identify beginning and end points in the journey?
The group proposes...
The teacher needs to use formative assessment to acknowledge where the learner is at , at the beginning of the journey. This will need to identify what the learner has already achieved/ experienced and the dispositions they have so they can assess the 'readiness' of the learner to continue their journey. (Singapore).
Step achieved / reached at the end of the journey should be measured against what steps the learner has taken towards the Four Core Purposes and the signal for where the next step will be.

Question 2 Do different parts of the journey start at different points?
The group proposes..
All skills, understanding, and/or competencies are represented at every step in the progression framework due to the way maths builds on the previous step. Each step is appropriate to the child's stage of development eg introduced through play etc as appropriate. This is true for all "What Matters" within the Maths and Numeracy AoLE.

Question 3 How do you break up the journey in ways that make the best sense for learning eg number of progression points?
The group proposes....
The number of points may differ across learning depending upon the number of conceptual shifts that mark sophistication/development in the learning journey. This is evidenced from practitioners during CAMAU research. This is continous formative and summative assessment rather than just a point at a certain age for each child.

We dislike the clear distinction by age as not a journey more of a reaching different end points.
Teachers needs guidance for stages of development. Children do not need to be labelled and Welsh government then measure or label schools at artificial points of time. Support should be given to learners and schools without publicly shaming.

If we only assess different phases of education it is still separating primary and secondary schools too much and becomes the 'Not our problem' idea.

Implications for other decisions to be made about progression:

Expressive Arts: Progression as Interdisciplinary or Disciplinary

Progression as Interdisciplinary or Disciplinary as the Journey Develops

Key Questions

Q1. To what extent should progression be mapped in interdisciplinary terms (e.g., for the AoLE) or subject specific within the AoLE?

Possibilities

A. Fully interdisciplinary within the AoLE

B. Subject-specific progression frameworks, e.g. learning progressions described for each subject in the AoLE

C. Changing from interdisciplinary within the AoLE to more subject-specific as students transition to later phases of schooling

D. Changing from subject-specific to more interdisciplinary within the AoLE as students transition to later phases of schooling

E. Progressions are described simultaneously for the area and for the specific subjects, i.e., AoLE-wide progression steps alongside disciplinary progression steps

- Fully interdisciplinary within the AOLE whilst providing opportunities to develop greater disciplinary knowledge and skills (post 14)

Points to Consider

- Some countries reviewed (e.g. Scotland Humanities) have learning area that remains throughout schooling
- Other countries (e.g. Australia, Alberta, and Northern Ireland Humanities) have separate elementary and secondary curriculum
- SF says that there is a trend towards emphasising the ability to apply learning across subjects and a disposition to do so effectively (p23).
- SF recommends that the curriculum 3-16 should be organised into Areas of Learning and Experience and have an identifiable core of disciplinary or instrumental knowledge (p.38). Progression in each AoLE should be based on a continuum of learning that flows from when a child enters education through to the end of statutory schooling at 16 and beyond (p.53).
- Having separate curricula and/or assessment guidelines for different stages of schooling may have implications for learners' transition into secondary school and for the extent to which the separate curricula complement one another.
- Reviews report that some progression frameworks run through the whole of a child's learning while others are specific to particular stages (e.g. primary, early secondary). The latter may be marked by discontinuity.

Progression as Interdisciplinary or Disciplinary as the Journey Develops

Choice and Rationale

Rationale for choice of possibility

- A core progression that stays all the way through however there needs to be a modular system post 14 in order to allow students to choose according to their particular interest and/or talent.
- Could there be complimentary vocational pathways – EA and specialist modules?
- All children will be studying EA beyond 14 – but only some will specialize in particular disciplines?
- Schools will need examples i.e lead creative school case studies
- The creative processes identified in the three pillars are interdisciplinary
- The curriculum 3-16 should be organized into Areas of Learning and Experience and have an identifiable core of disciplinary or instrumental knowledge (SF p.38).
- Progression in each AoLE should be based on a continuum of learning that flows from when a child enters education through to the end of statutory schooling at 16 and beyond (SF p.53).

AoLE Proposal

AoLE proposal

Example: The aspect of the learning journey should be structured as… because..

The learning journey should be fully interdisciplinary within the EA whilst providing opportunities to develop greater disciplinary knowledge and skills (post 14) in order to provide opportunity to apply learning across disciplines. This will be based on a continuum of learning that flows from when the child enters education to the end of statutory schooling at 16. Post 14 there should be opportunities for pupils to develop more disciplinary knowledge, skills and understanding through a modular approach.

Progression comes from gradual use and re-use of known skills and could also involve a qualitative jump. It is not a linear process, different learners will progress in markedly different ways as they experience EA activities. The learning environment and the quality of teaching are important factors in facilitiating progression. Qualitative and contextualised descriptive approaches to assesing acheivments and progression are key factors in this AOLE.

Implications for other decisions to be made about progression:

Science and Technology: Purposes of Progression Framework

Purposes of Progression Framework

Key Questions | **Examples of Possibilities** | **Points to Consider**

Q1. What purposes do we expect the progression framework to serve?

Examples of Possibilities:

- A. Provide a broad overview of the journey from beginning learner to expert in this AoLE
- B. Provide detailed guidance for planning for teaching and learning
- C. Provide descriptions of achievement expected at different ages or stages
- D. Provide descriptions of pupils' progress in the learning journey and possible next steps
- E. ____________________

Points to Consider:

- Successful Futures suggests that the achievement outcomes should be framed as broad expectations achievable over a period of time. They should be "reference points, providing a road map for each individual child and young person's progress in their learning and not universal expectations of the performance of all children and young people at fixed points" (Donaldson, p. 56)
- Successful Futures recommends that assessment arrangements should give priority to their formative role in teaching and learning (Donaldson, p. 77)
- Maps of progression provide for the teacher a crucial coherent vision, an underlying scheme of progression, which links teaching action to what matters and to *what matters next*. (Black et al 2011)
- Heritage (2008) argues for the importance of learner being aware of longer term goals and the relationship between those and their day to day progress.
- The danger associated with linking descriptions of learning directly to specified ages/ stages is that designers of the framework and, eventually, teachers (and other users of the information) may come to specify expected standards which are not empirically well-founded as real progression steps in the learning journey. (pp 138-145 in *Learning About Progression*).

Views of AoLE Group?

Q2. How will the progression statements be designed to serve these different purposes?

Examples of Possibilities:

- A. Only broad statements of progression, interpreting these statements is up to individual teachers and schools
- B. Sufficiently detailed statements for guiding classroom teaching and learning
- C. Both broad statements of progression and more detailed frameworks of progression designed to link together
- D. ____________________

Points to Consider:

- According to literature, (Black et al 2011; Pellegrino. 2014, 2017), detailed progression is needed to:
  - (a) formulate tasks or tests so that the responses can provide evidence of learning progression
  - (b) formulate helpful comments, tailored to the individual needs of each student
  - (c) give clear guidance on how to improve
- Some countries (e.g. Scotland) provide only broad statements of progression leaving pedagogical decisions open to schools and teachers, whereas others (e.g., Quebec, Canada) provide detailed frameworks as part of their main curricular framework
- According to Successful Futures, the progression steps should "provide a context within which teachers can select teaching and learning approaches that build from one step to the next but that still provide significant freedom to offer engaging experiences that match their children and young people's needs." (Donaldson, p. 67).
- Heritage (2008) "suggests that greater attention should be paid to the different levels of specificity used to articulate the curriculum" (p. 17, CAMAU report). If too detailed, learning can become a checklist of things to learn. However, learning progressions vary greatly from a unit of work to lasting over years.

Views of AoLE Group?

Q3. If detailed frameworks of progression are included alongside broader statements, where should they be located? *

Examples of Possibilities:

- A. Within the curriculum framework, alongside the broader statements of overall learning aims
- B. In associated professional learning material and/or contexts
- C. ____________________

Points to Consider:

- Countries differ in the extent to which they provide more detailed progression frameworks and where they are located. For example, British Columbia has quite broad curricular competencies for each learning area, but also provide much more specific sets of standards and expectations, although the latter are in a separate document and are for voluntary use in schools.
- Some frameworks (eg, in New Zealand and, in UK, the CLPE Scales for Reading and Writing) exemplify how detailed description of progression, exemplification of it through student work and pedagogical guidance on appropriate next steps can be built into professional learning material/activities.

Views of AoLE Group?

* Q3 follows from Q2 and is only relevant if the preferred possibility for Q2 is B or C

Purposes of Progression Framework

Rationale

Rationale for choice of possibility for Q1

A – too vague, will lead to inconsistencies between / within schools; however "aspirational" for the profession; only realisable if assessment / accountability doesn't mandate set progress; just marker points for the end of the journey; requires "milestones"

B -- too restrictive / prescriptive; doesn't allow customisation, prevents localised SOWs, doesn't encourage flexibility; does not support 4 purposes; would remove creativity

C – links to age / stage potentially hold back most able and/or be unattainable for least able / ALN; too similar to what we have now; doesn't reflect the learners journey; markers are a good thing (not age though)

D – Allows individualised progress regardless of ability; most relevant to the aims of the new curriculum; any "next steps" need to be carefully crafted; markers needed for end of "stage" points

Other – Combination of CD (age or stage) with key "milestones" particularly at Primary to secondary transition
-- Pen portraits of "most" learners should be... created for each stage

Rationale for choice of possibility for Q2

A – Desirable (is the system mature enough for this?); time would be an issue here; required professional development and time; too broad; practically, will lead to inconsistency; broad statements + more detail about short term, medium and long term;

B – Useful for ensuring consistency across the system; too prescriptive; narrows experiences; "sufficient" is difficult to define (NQT, non-specialists, struggling teachers)
C – Broad statements open to interpretation; potential inconsistencies;
D – Australian model;

Other – Needs to be in one document; long term aims, plus medium term detail
-- Need to ensure does not become "tick box"
-- Big Ideas + Progression framework combined

Rationale for choice of possibility for Q3

one document for teachers
Both A and B are needed. Single curriculum AoLE document should be used as part of professional learning

Other

-- Needs additional (external) exemplification
-- Needs to be one document
-- Leadership documents needs to be consistent (specification of time)
-- Need paper and flexible electronic versions

AoLE Proposal

Example: The aspect of the learning journey should be structured as… because…

"The aspects of a learning journey should be structured as a single, integrated document in support of an AOLE. Each "What matters" statement should be combined with broad expressions of pupil progress and reference to key achievements at set points along that journey."

The AOLE feels it is vital to avoid under specification of progress details and guidance as this will not provide the structure necessary to ensure that all teaching and learning is suitably aspirational and rigorous. Whilst the AOLE is conscious of key pedagogies it feels that providing detailed guidance for teaching and planning will too intimately link the "curriculum" with methods of delivery, and as such reduce the flexibility in the classroom. The groups feels that in addition to the progression journey and in line with Successful Futures, "reference points" are essential (suggest Primary > Secondary Transition) to ensure suitable progress for all learners, regardless of their place within the education system.

The AOLE feels the statements of progression need to be broad enough, yet sufficiently detailed (Black et al) to meet the needs of teacher subsidiarity and the "4 purposes", whilst maintaining consistency and rigour thorough the system – without reducing progression to a "checklist"

The AOLE feels it is unnecessary to produce an additional, detailed framework and that all statements of progression are embedded within each What Matters statement.

List of additional documents available online

1. References to 'progression' in *Successful Futures*
2. Health and well-being: links to national curricula
3. Health and well-being: examples of progression statements
4. Humanities: links to national curricula
5. Examples of Religious Education Progression Statements in Scotland

These documents are available at
https://www.dropbox.com/sh/tgtjidlcuze9zt7/AABP34QNYEPcelJsjwlklBrGa?dl=0

Note also that analyses of individual country frameworks in the various curricular areas are available from the CAMAU project team.