Report on the consultation on the draft Background Paper and Brief for the review of Leaving Certificate Physics, Chemistry, and Biology

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NCCA
An Chomhairle Náisiúnta Curaclaim agus Measúnachta
National Council for Curriculum and Assessment

Contents

1. Introduction

The Background Paper for the Review of Leaving Certificate Physics, Chemistry, and Biology was approved for consultation by Council on the 24th of September 2019. The NCCA consultation process ran from the 1st of October to the 1st of November 2019 and consisted of the following elements:

- an online questionnaire
- focus group meetings
- written submissions
- student voice consultation events.

The aim of the process was to hear the open and honest views of all stakeholders on the Background Paper and Brief for the Review. The main areas of focus in the consultation included:

- the purpose of Leaving Certificate science education
- the opportunities and challenges presented by recent policy initiatives
- important aspects addressed in a contemporary science curriculum
- specifying knowledge in a coherent curriculum
- continuity and progression from Junior Cycle
- coursework assessment.

1.1 Online questionnaire

An online questionnaire and the draft Background Paper and Brief for the Review of Leaving Certificate Physics, Chemistry, and Biology were made available on the NCCA's website, www.ncca.ie . The online questionnaire remained open for 4 weeks beginning on the 1st of October 2019 and was publicised through the NCCA website and social media. There were 472 completed responses. Members of the Physics, Chemistry and Biology subject development groups were also asked to promote the consultation through their various networks.

1.2 Focus Group

Regional focus group meetings were hosted in three regional venues as follows:

- The Clayton Hotel, Lapps Quay, Cork – 21st October
- The Ashling Hotel, Dublin – 23rd October
- The Maldron Hotel, Sandy Road, Galway - 24th October

Attendance was by open invite through expressing interest on an online registration form. Everyone who expressed an interest in attending was invited to attend. In total 51 participants attended across the events. Whilst the majority of attendees were teachers, some representatives from third level institutions were also in attendance. Each of the focus groups was supported by two NCCA Education Officers. One member asked questions and facilitated the group conversations while the other took notes. See Appendix 4 (p.58) for the focus group questions.

1.3 Written Submissions

Participants were invited to make written submissions to the consultation by email. A total of 3 submissions were received from the following organisations:

- The Institute of Physics in Ireland (IOP)
- The Irish Science Teachers Association (ISTA)
- The Science programme from St. Angela's College, Sligo

A further three individual submissions were also received.

1.4 Student Voice consultation

Three Student Voice consultations were held in schools across different regions. Sampling of participants was opportunistic and stratified according to student experience. Students selected were from across senior cycle, on the basis they were either choosing to study, or were currently studying, one or more of Physics, Chemistry, Biology. A total of six focus groups were held, organised according to student year group - TY, 5th and 6th years. A total of 62 students were consulted. Each focus group was supported by two NCCA Education Officers. One member asked questions and facilitated the group conversations while the other took notes. See Appendix 5 (p.59) for the student voice consultation questions.

Data across all research instruments was inductively coded and followed a thematic analysis approach (Braun & Clarke, 2012). Feedback from participants from each research instrument will be presented as themes constructed from the data.

2. Feedback from the online questionnaire

In total, there were 472 completed responses to the online questionnaire (see Appendix 2, p.42). As can be seen in figure 3.1, approximately 80% identified themselves as post-primary teachers.

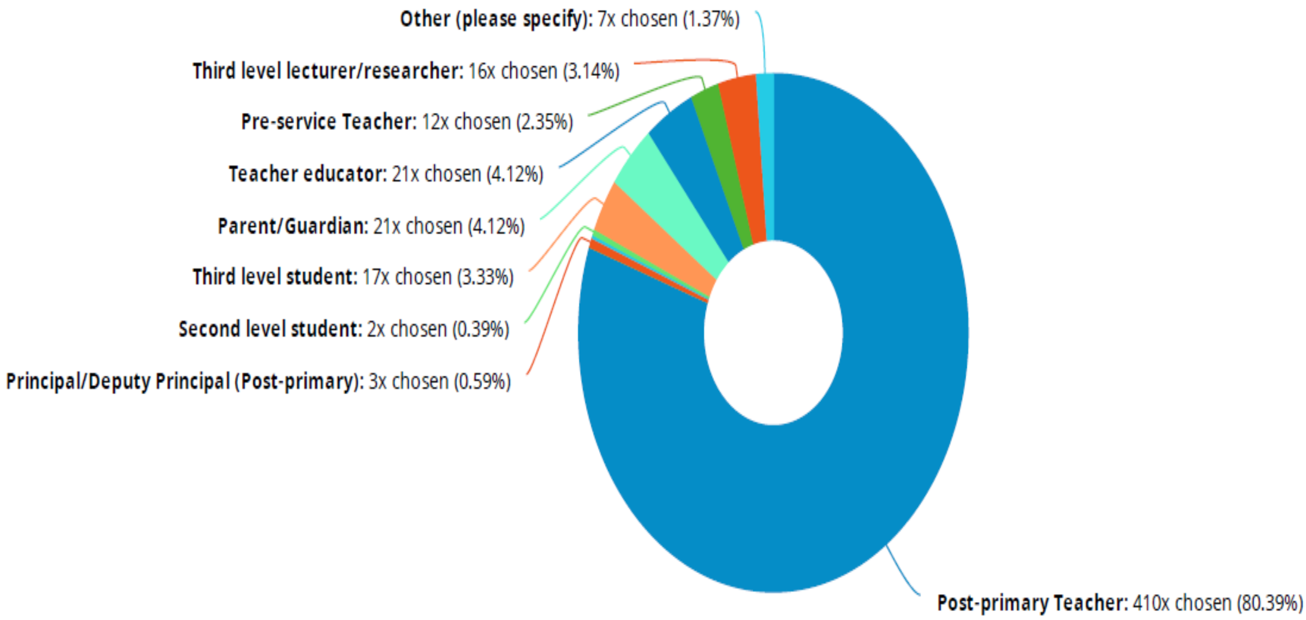


Figure 3.1 Analysis of data from participants in response to question 1 - I am responding as a…

Within this group approximately 66% identified as Leaving Certificate Biology teachers, 34% as Chemistry teachers, 25% as Physics and 13% as Agricultural Science teachers. Almost 93% identified as Junior Cycle Science teachers. The profile of school types reflected the national profile. The list of organisations that responded, and who gave permission for the organisation to be listed, is given in Appendix 3 (p.57).

Relevant quantitative data is presented in the form of statistical graphs. The qualitative data from the open responses was analysed using a thematic analysis approach and is grouped under the following headings:

- The purpose of science education
- Specifying knowledge in a coherent curriculum
- Important aspects addressed in a contemporary curriculum

- Continuity and progression from Junior Cycle Science
- Coursework Assessment
- Views on the brief (Appendix 2, p.42) for the review of Leaving Certificate Physics, Chemistry, and Biology.

3.1 The purpose of science education

Predominantly the purpose of science education was seen as developing scientifically literate students and preparing students for careers in both STEM and non-STEM areas.

> *I agree strongly that there is a 2-fold mission to educate those who wish to pursue a science-related career and also to educate all students to be scientifically literate and well informed about how science permeates our lives.* (Online questionnaire, post-primary teacher, 2019)

Many participants referred not only for the need for a relevant curriculum which includes a focus on current challenges facing society but also the need for developing student's ability to think critically about scientific matters into their futures.

> *Science education should be constantly evolving and the curriculum should be aligned to suit this.* (Online questionnaire, post-primary teacher, 2019)
>
> *I also think that they should be familiar with the scientific process (i.e. how were medicines made, how are medicines made now) and be able to learn about opposing views and to reach an informed balanced conclusion (i.e. on climate change, on caring for the environment, on ethical issues).* (Online questionnaire, post-primary teacher, 2019)

However, some contributions struck a note of caution that the core purpose of science education should be the development of content knowledge.

> *LC science should focus on fundamentals and facts. It should not be based on what is politically and socially fashionable at the time and not on people's views and ethics.* (Online questionnaire, post-primary teacher and parent/guardian, 2019)

Many participants also stated that the purpose should be *to foster a love of science and a curiosity to explore it further* (Online questionnaire, post-primary teacher, 2019), or *to engage young people with the world around them. Encourage them to question everything* (Online questionnaire, post-primary teacher, 2019). Critical and creative thinking skills were seen by many participants as central to purpose, developing an ability *to differentiate high quality rigorous scientific research from hearsay and rumour; the benefits, and limitations, of scientific research.* Enjoyment and stimulation also featured in some contributions, where a balanced, coherent curriculum was seen as necessary to facilitate a multi-faceted purpose.

A holistic approach that stimulates a love of science and awareness of its significance in today's world (Online questionnaire, post-primary teacher, 2019)

[…] a clear framework or narrative, which provides a coherent 'big picture' […] but also presents a clear and coherent progression of learning, in which a deepening understanding is built on secure foundation from earlier study of the discipline. (Online questionnaire, science education outreach body, 2019)

At various points in the contributions, some participants raised their concerns that purpose would be colonised by the race for CAO points.

Unfortunately, it's reality often becomes about getting them enough points to get medicine or veterinary, with little room for inquiry or problem solving or discussion. (Online questionnaire, post-primary teacher and parent/guardian, 2019)

The views expressed on purpose resonated strongly with participants' views on the STEM education policy statement 2017-2026 (section 3 of the online questionnaire). The quantitative data in the figure below shows that igniting curiosity, making informed career choices, linking and applying knowledge and developing critical thinking skills could all be enhanced by curricula that fulfil the purpose articulated by the participants.

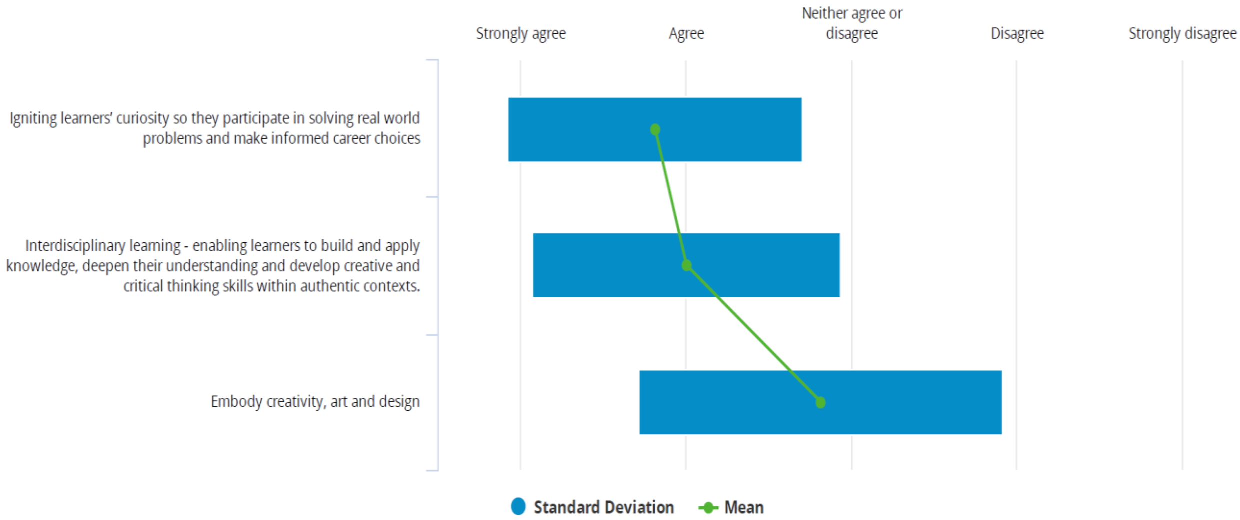


Figure 3.2 Analysis of data from 238 participants in response to their agreement or disagreement that revised curricula could provide opportunities to realise the underlying STEM principles

Some of the 89 contributions to the open response once again resonated strongly with the views expressed on purpose. Many contributions addressed some of the challenges and obstacles to realising the STEM principles, both currently and with revised curricula.

Remember that providing opportunities for problem solving and creativity takes time in classrooms if it is to be done correctly. Teachers cannot do this if courses are very long. There needs to be a balance as students cannot problem solve or be creative all the time either. (Online questionnaire, post-primary teacher, 2019)

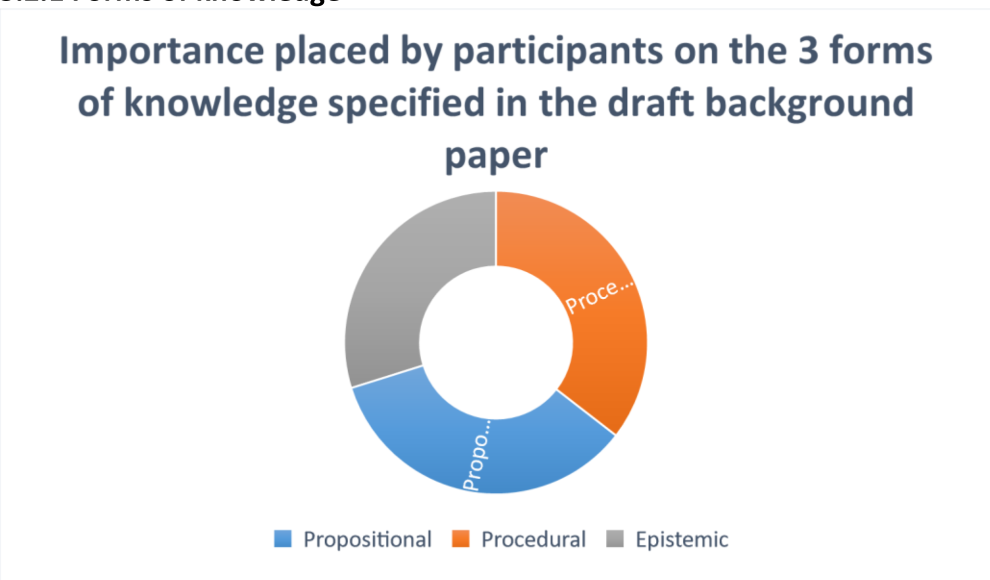
The statements are inspirational. I would love my junior cycle students to be independent learners. However, I only see them twice a week which makes it difficult to scaffold them to become independent learners. I feel like I trying to get more covered in a shorter amount of time. (Online questionnaire, post-primary teacher, 2019)

All sounds good BUT students need to know information/material in order to make choices for their future. There is NO point in having students participate in real world interdisciplinary creative work if they have not been allowed to assimilate the basics (Online questionnaire, post-primary teacher, 2019)

3.2 Specifying knowledge in a coherent curriculum

Chapters 3 and 4 of the draft Background Paper and Brief for the Review of Leaving Certificate Physics, Chemistry, and Biology address the emerging trends and the implications for curriculum design. As part of the consultation on specifying knowledge, participants were consulted for their views on the forms of knowledge and on the understanding and progression of core concepts.

3.2.1 Forms of knowledge



MEAN score across participants (0 Low – 10 High)		
Propositional	Procedural	Epistemic
8.6	8.8	7.3

Figure 3.3 Responses of the 222 participants to the request to What importance do you place on young people acquiring the following forms of knowledge in Leaving Certificate Physics, Chemistry and Biology?

Many of the 58 participants who contributed open responses stated that propositional knowledge should not lose its importance within the broader context of different forms of knowledge. The construction of knowledge as a result of learning facts is often undermined and underappreciated in these documents.

> *When facts are known, and we know how to do something then and only then can we solve problems.* (Online questionnaire, post-primary teacher, 2019)

Some of these contributions felt more strongly that knowledge and facts are synonymous and the most important factor in education is *imparting knowledge* (Online questionnaire, post-primary teacher, 2019). Many contributions stated that all three forms of knowledge must go hand in hand.

> *Need to embed the development of these three knowledge domains in real world contexts* (Online questionnaire, teacher educator, 2019)

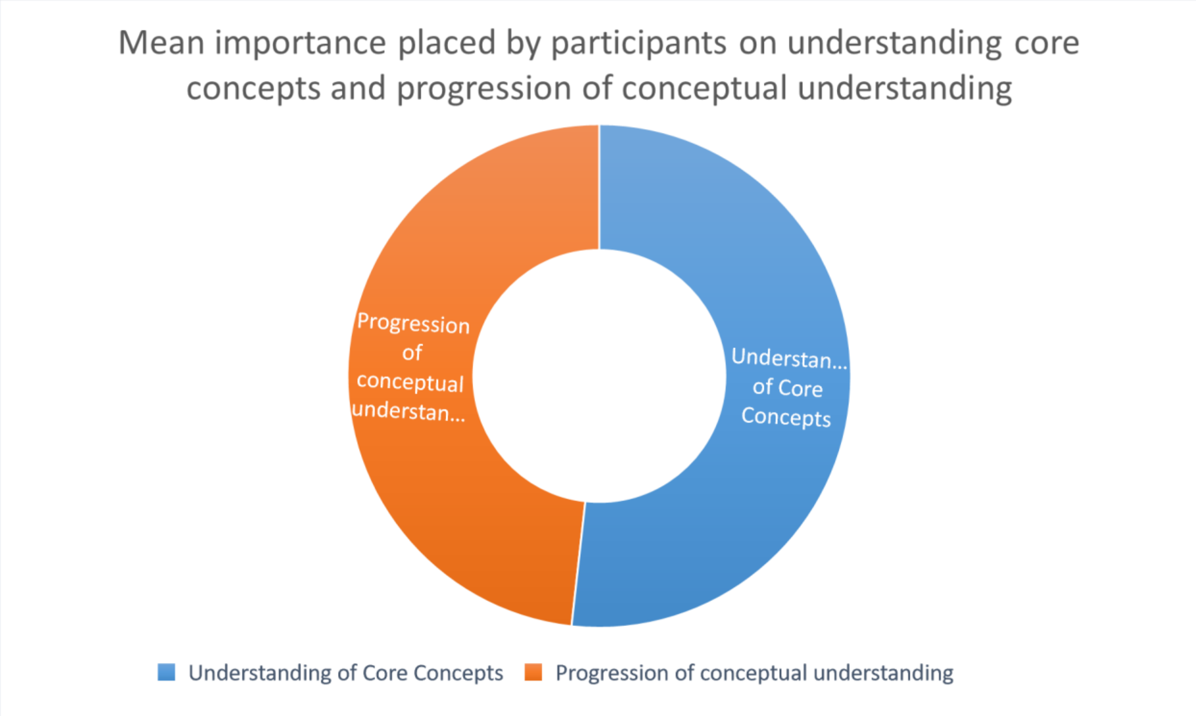
A view regularly expressed, and also reflected in the quantitative data, was on the place of epistemic knowledge.

> *epistemic knowledge of a discipline is best left to third level when students are mature enough, cognitively aware enough and, most importantly, have enough basic knowledge and interest in the subject to pursue a meaningful study of epistemic knowledge of that subject (Online questionnaire, post-primary teacher, 2019).*

Many contributions spoke of the need for knowledge to have relevance and be balanced with the skills of a scientist

> *Students need to have a standard of knowledge , it is more important that they learn how to apply this knowledge and learn skills e.g. analysing data, relevant lab skills. Courses need to be shortened and made super relevant. […] Balance is the key.* (Online questionnaire, post-primary teacher, 2019)

3.2.2 Understanding and progression of core concepts



MEAN score across participants (0 Low – 10 High)	
Understanding of Core Concepts	Progression of conceptual understanding
8.8	8.2

Figure 3.4 Responses of the 219 participants to the request to What importance do you place on the importance of outlining the following when structuring revised curricula for Leaving Certificate Physics, Chemistry and Biology?

In the relevant section of the draft background paper, the work of Harlen (2015) and Millar (2016) provides some examples of how curricular content could be structured to present a body of knowledge in a manner which facilitates learner progression, allows for deeper connections and supports a more coherent curriculum. There was a consensus across the 121 contributions that these were important within a curriculum. In fact, many felt it was *necessary for in-depth insightful pedagogical practice* (Online questionnaire, post-primary teacher, 2019). In some cases, it was expressed that *an insightful, experienced teacher makes those connections naturally* (Online questionnaire, post-primary teacher, 2019). The importance of students knowing this and being made aware of it was re-emphasised across many contributions.

> *All science is linked. Students should realise this and use these links to further their knowledge, understanding and experience of science.* (Online questionnaire, post-primary teacher and teacher educator, 2019)

Some participants argued specificity was necessary for a progressive narrative of conceptual understanding.

> *I do think this is a good idea, but the course content must be clearly defined and well-understood by practicing teachers in order for this to work.* (Online questionnaire, post-primary teacher, 2019)

Many participants felt coherence is achieved through aligning curriculum with assessment - *Specify the facts and theories in a connected way and examine in a connected way* (Online questionnaire, post-primary teacher, 2019). When participants were asked specifically about structuring curricular content, many of the ideas in the previous section were echoed among the 52 respondents to this question. In general, the feedback tended towards a coherent structure with clarity of content and expected outcomes.

> *Progression and linking of topics important but a basic understanding of the topics is also vital, we cannot forget the key facts embedded within scientific concepts.* (Online questionnaire, post-primary teacher, 2019)

> *Have an introductory module outlining the areas of study, showing why each topic is needed for a fuller understanding and how it links to all the other topics.* (Online questionnaire, retired post-primary teacher, 2019)

3.3 Continuity and progression from junior cycle

In section 3 of the online questionnaire, participants were asked to consult on three policy initiatives referenced in the background paper. The Digital Strategy for Schools 2015-2020, the STEM Education Policy Statement 2017 -2026 and Continuity and progression from Junior Cycle Science. The responses to the STEM policy were summarised in the section on purpose and the responses to the Digital Strategy will be summarised in the section on important aspects to be addressed in a revised curriculum. This section will address continuity and progression from junior cycle.

The 128 contributions were essentially split into two perspectives. One perspective was the need for continuity and progression especially from the building blocks and elements, and a continuation of investigative, inquiry-based research.

> *Researching & nature of science, how scientists work, media etc would be a welcome addition to senior cycle. As would linking systems* (Online questionnaire, post-primary teacher, 2019)

> *The "building blocks" are essential and should be repeated until an understanding is present. We cannot assume that every student retains the knowledge from Junior Cert.* (Online questionnaire, third level student, 2019)

I think the idea of Nature of Science within the leaving certificate is excellent, if implemented within teaching and learning (Online questionnaire, post-primary teacher, 2019)

The other more dominant perspective was to discontinue the Junior Cycle Science specification approach, and for revised Leaving Certificate specifications to address perceived deficits in content knowledge that have opened up between junior and senior cycle.

Research skills would be good, however syllabus content would have to be greatly reduced to enable time. (Online questionnaire, post-primary teacher, 2019)

Students missing out big time on the basic principles of science. […] getting teachers to teach about earth and space to students when they received no training and might not have even studied it themselves in college (Online questionnaire, post-primary teacher, 2019)

Junior cycle science has left a lot of gaps that senior cycle science teachers will have to make up. (Online questionnaire, post-primary teacher, 2019)

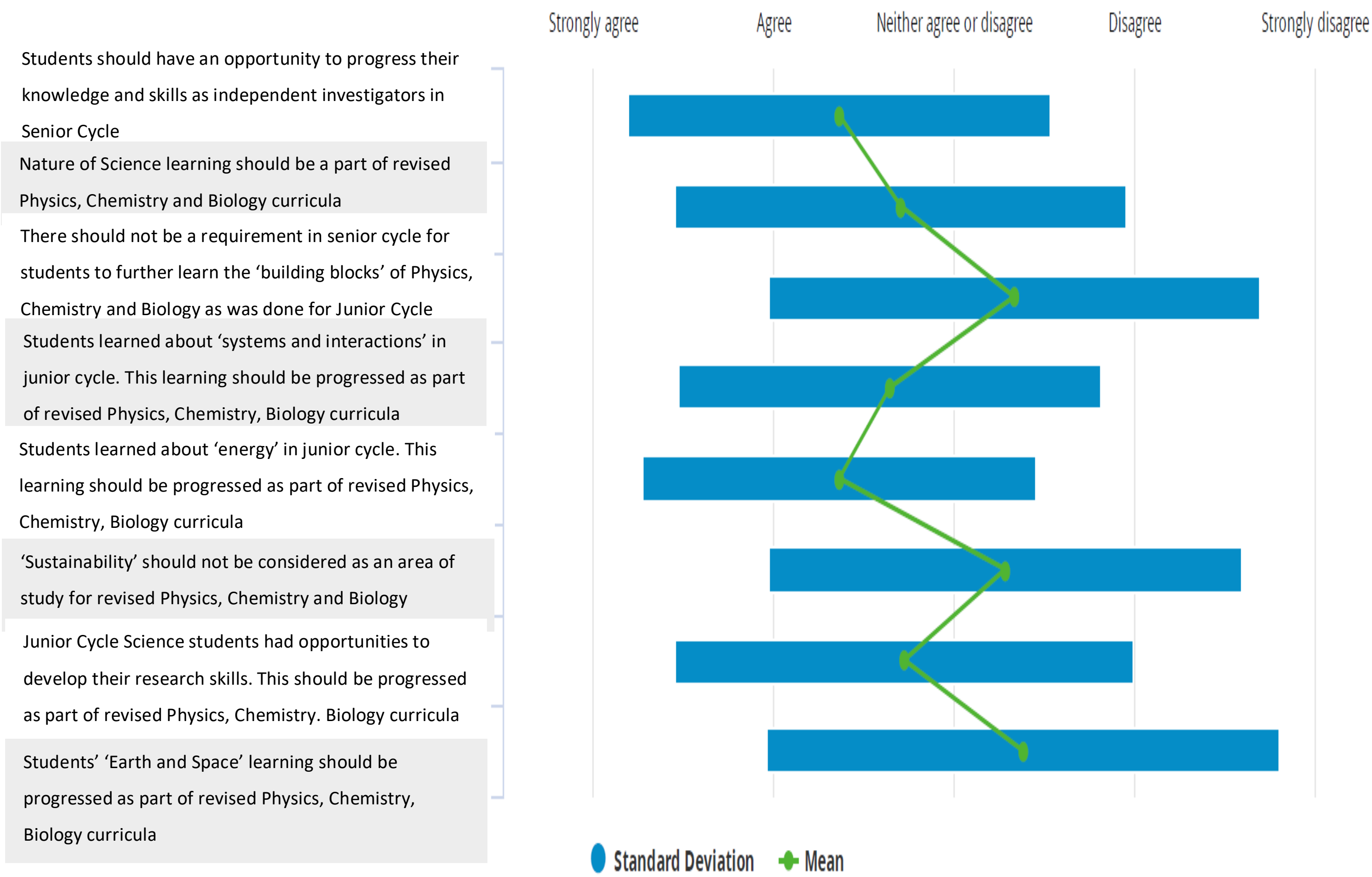


Figure 3.5 The response of 236 participants to the prompt To what extent do you agree or disagree with the following statements related to continuity and progression from Junior Cycle Science?

3.4 Important aspects addressed in a contemporary curriculum

In section 4 of the online questionnaire, emerging trends in science curriculum development were consulted. As part of the consultation on important aspects to be addressed in the review, participants were asked to rank some key areas arising from the paper.

Rank	Choice	Distribution	Score	Times Ranked
1.	Developing a broad knowledge base		1188	210
2.	Developing scientific literacy		1087	213
3.	Preparing students for STEM careers		1034	207
4.	Finding solutions to current and future challenges		835	205
5.	Addressing global challenges		809	205
6.	Promote equity and access (including gender equity)		634	197
7.	Promoting active citizenship		603	199
8.	Other (specify below)		269	112
		Lowest – Highest		

Figure 3.6 The responses of 220 participants to the request to Rank the following areas in order of importance for consideration as part of revised curricula for Leaving Certificate Physics, Chemistry and Biology (1 = most important, 8 = least important):

A common thread across the 80 open responses was the belief that scientific literacy, within a broad knowledge base, would facilitate many of the other aspects that should be addressed.

> *While it is important to encourage the student to move into STEM careers, it should not be the primary objective. This is because scientific literacy and broad knowledge will provide them with the curiosity to develop into a career.* (Online questionnaire, third level lecturer/researcher, 2019)

A common contribution was that core discipline knowledge and core concepts should not be neglected in addressing other aspects considered important to a modern curriculum.

> *You cannot address or solve any problem without having a knowledge base in the first place. Knowledge must come first. Knowledge in their own long-term memory from which they can draw to assist the problem solving.* (Online questionnaire, post-primary teacher, 2019)

There were few specific ideas on relevant global issues or on modern skills for a data rich society beyond requests to make science modern.

> *It is not possible to solve global problems without understanding the processes involved. For example, until the chemical reactions of stratospheric CFCs with ozone etc were understood an effective solution to ozone depletion could not be proposed. Understanding principles is essential in science.* (Online questionnaire, post-primary teacher and teacher educator, 2019)

Some participants elaborated on the *Other* option in the ranking exercise and generally referred to the acquisition of practical skills, critical thinking skills, gender equity in the sciences and digital/technological literacy as other important aspects to be addressed.

In section 3 of the online questionnaire, participants were asked for their views on the Digital Strategy for Schools 2015-2020

Figure 3.7 The responses of 249 participants to the request to rank the extent they agree or disagree that revised curricula should provide opportunities for students to utilise their skills as both creators and consumers of digital artefacts from the above examples.

Many of the 136 participants who contributed open responses felt digital technologies can be useful when used correctly and appropriately.

> *Digital tools should be used only to enhance learning. Understanding the process, the context and content involved. Nice population graphs are useless if you don't know why we use them or what they illustrate in them of the ecosystems and*

organisations they represent. Sometimes the long road is more educational. (Online questionnaire, post-primary teacher , 2019)

Use of programs and language used in modern science, develop an understanding of how models can be used (Online questionnaire, third level student, 2019)

A common response was a lack of resources of both equipment in schools and of in-service training for teachers. Some contributions pointed to the time that often needs to be given to become proficient as a digital creator and often as a consumer.

Computer based modelling would in my opinion be outside the scope of a science leaving Cert course. Plus, would it not overlap with the new computer science subject? (Online questionnaire, post-primary teacher, 2019)

The idea of implementing all this technology is wonderful and I think it would enhance the learning. (e.g. for the biology photosynthesis experiment I always get the students to do an online simulation so they will see it actually working.) However there has to be the funds to back it up. Unless the department is willing to deliver a class set to each school there's too many other costs to be considered to be introducing things we can implement in other ways. (Online questionnaire, post-primary teacher , 2019)

3.5 Coursework Assessment

The brief for the review specifies the integration of a coursework assessment component allowing for the assessment of inquiry-based learning, critical thinking and elements of experimental investigation, into each of the three subject specifications. In this section of the online questionnaire, participants were asked for their views on four different aspects of coursework assessment. Broadly these aspects were duration, tasks, weighting and location of the coursework assessment.

3.5.1 Duration

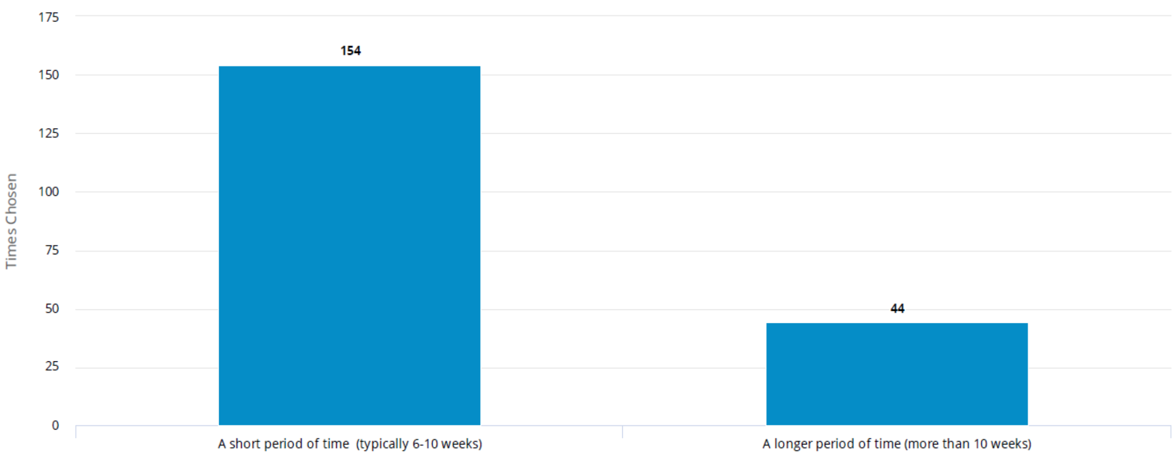


Figure 3.8 The response of 198 participants to the statement - Coursework Assessment should be conducted over:

A shorter period of assessment was favoured for a variety of reasons. The main reasons were to facilitate a focussed approach to the coursework and the logistics of managing it in the school calendar.

> *If these assessments take place over a long period, it will be at the expense of other content and also the time taken to develop the skills for these assessments.* (Online questionnaire, post-primary teacher, 2019)
>
> *Shorter period gives rise to a more focused and definite outcome for learner* (Online questionnaire, post-primary teacher, 2019)

Many felt a longer period would not benefit students or teachers and would impinge negatively upon the curriculum.

> *Considering the leaving cert programme is run over a two-year period, allowing coursework assessments to take up more than ten weeks would mean a high degree of time constraints on the rest of the course.* (Online questionnaire, post-primary teacher, 2019)

The participants who favoured a longer period felt it could be more readily accommodated, would enhance research skills and encourage the creation of portfolios. Typically, it was suggested the component would be completed over two years and in some cases completed by the end of 5th year in senior cycle.

> *Coursework over a longer period will facilitate flexibility in its delivery in classroom and allow more time for students under pressure to work effectively with each other and individually.* (Online questionnaire, post-primary teacher, 2019)
>
> *The coursework should be embedded as part of day to day teaching and learning. The student could produce a portfolio of their learning journey, demonstrating their potential from their own personal starting point.* (Online questionnaire, third level lecturer/researcher, 2019)

Some participants did not specify a time period because they considered the nature of the coursework should determine the duration of the time period, or that there should be *a series of courseworks*. There were no participants who thought a coursework component should not be included in revised curricula for Leaving Certificate Physics, Chemistry and Biology.

2.5.2 Tasks

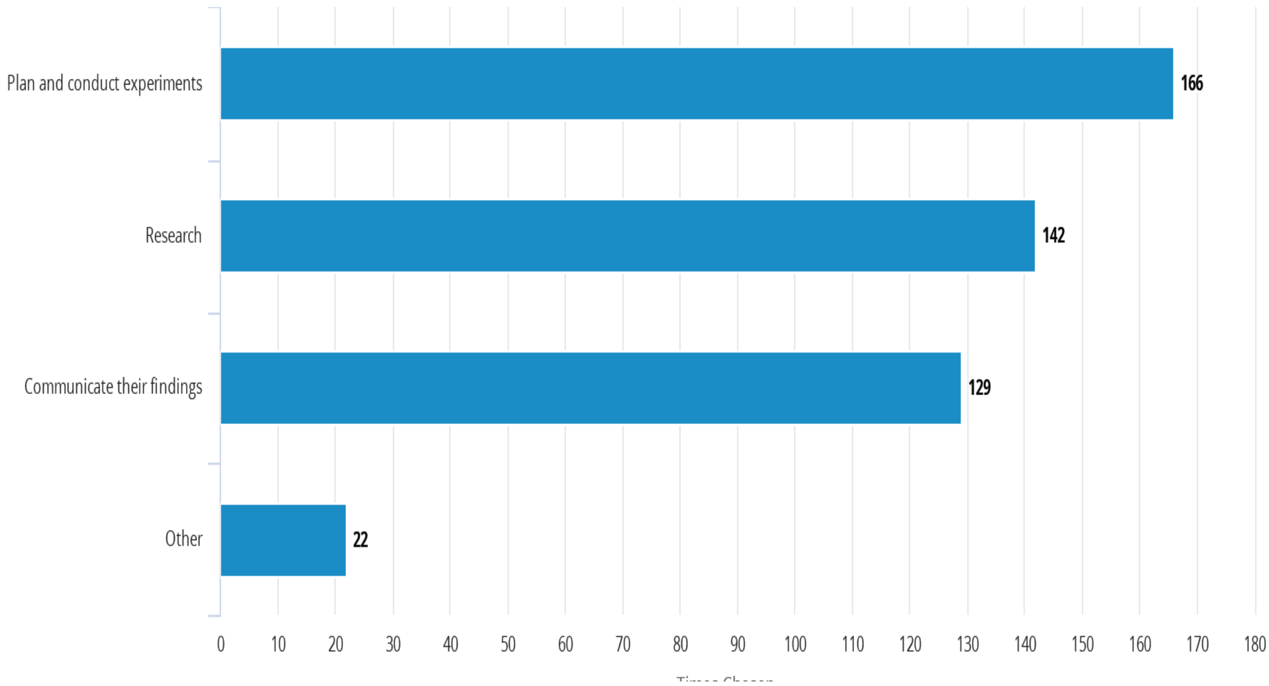


Figure 3.9 The responses of 208 participants to the question Coursework Assessments should allow students an opportunity to:

A thread running through the 80 open responses to this question was the interconnectedness of all three options (planning, research and communication). A common observation by participants was the hierarchical nature of knowledge and how this determines which aspects of coursework could be carried out by students. Many felt practical laboratory skills vital to acquire in senior cycle.

> *Science is a practical subject. Research is important but conducting experiments is vital for students to gain an understanding of what they are doing and why.* (Online questionnaire, post-primary teacher, 2019)

Research opportunities were seen by many as a chance to deepen understanding of propositional knowledge and simultaneously broaden knowledge beyond the curriculum.

> *Research into an area of the curriculum* (sic) *in more detail or a Science Theory which they have an interest in that is not necessarily thought* (sic). (Online questionnaire, post-primary teacher, 2019)

The ability to write an investigative report was considered to be important in developing scientifically literate students.

> *Also, from my experience of the CBAs I can see that many students' research and communication skills are severely [limited] - these should be further developed in order for them to be prepared for third level and the working world.* (Online questionnaire, post-primary teacher, 2019)

There were some mixed views on progression and continuity from classroom-based assessments (CBAs) in junior cycle. Further, many expressed misgivings and concerns about the lack of resources in school laboratories and computer rooms, and how it would impact the completion of coursework.

3.5.3 Weighting

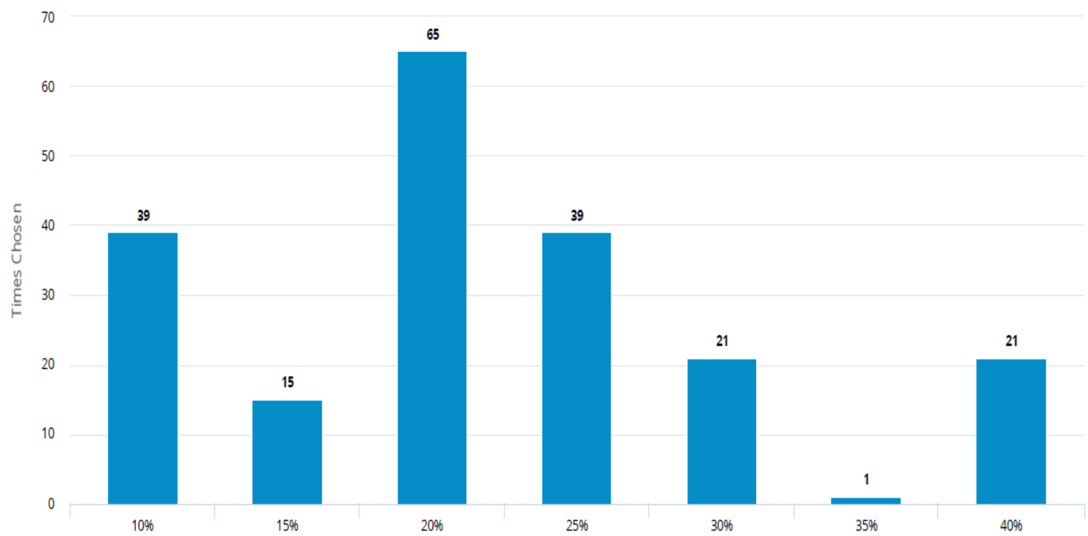


Figure 3.10 The responses of 201 participants to the prompt: The weighting of a coursework assessment towards the final grade for the subject should be:

The mode of the weightings offered was 20%. The wide range of opinions on the percentage weighting was accompanied by an equally wide range of reasons for choosing a particular percentage and simply having a coursework component as part of the assessment.

> *The subjects become more attractive to students if a solid percentage is on offer for practical assessment. Existing format very dated. Time for reform and practical component makes for a well-rounded student equipped for life after 2nd level* (Online questionnaire, post-primary teacher, 2019)

> *The cruelty of a 100% terminal exam is beyond words. To condense 14 years of learning into a 3-hour exam is not appropriate. It encourages rote learning and the*

'grinds' culture - none of which contribute to scientific growth of learners. The in-depth and lifelong learning that could be built into a coursework assessment is huge. (Online questionnaire, post-primary teacher, 2019)

If it's only 6-10 weeks, then it should not be worth more than 20%. It's enough to take pressure off the exam and to allow students to demonstrate their new skills and build confidence. (Online questionnaire, post-primary teacher, 2019)

Coursework assessments should be at least 20% to 30% otherwise students will not engage with it properly. (Online questionnaire, post-primary teacher, 2019)

3.5.4 Location

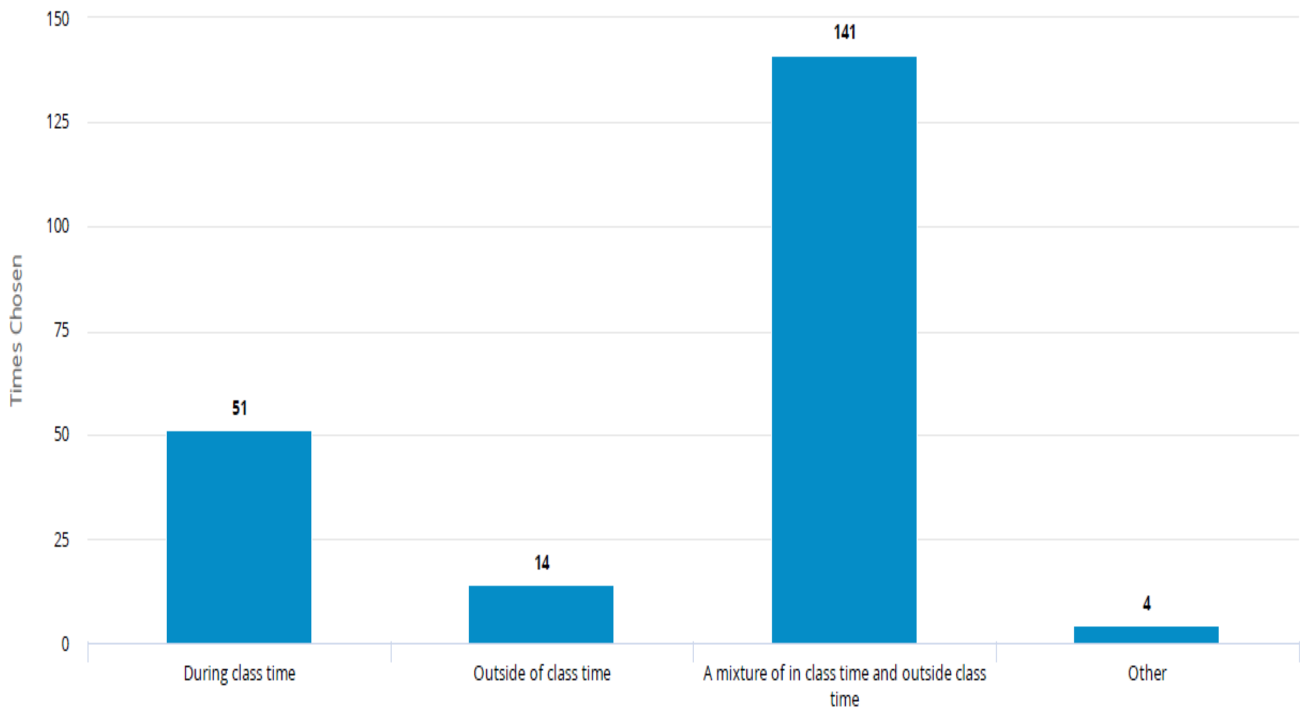


Figure 3.11 The responses of 210 participants responded to the prompt Coursework should be completed:

The 87 open responses to this question gave some insights in to why a mixture of in-class time and outside class time was the modal response for the students carrying out their coursework.

the 'inside class time' option is attractive in terms of fairness, as it means the work is largely the students own. But it can limit the scope of work (as not all practical work can be done in a classroom), and be artificial (if background research is part of a task, how can we meaningfully tell students not to read anything at night in preparation work) (Online questionnaire, post-primary teacher, 2019)

Authentication of the work and availability of resources (computer and science laboratories) were the most common reasons for in-class completion. However, the constraint on self-directed research and possible field work was seen as a major disadvantage, unless there was provision for students working outside class-time.

> *If the course work is field based, then this would have to be out of school hours. It also allows student to work on their own initiative and problem solve. Also, to develop their own ideas and perspectives* (Online questionnaire, parent/guardian, 2019)

3.6 Views on the brief for the review

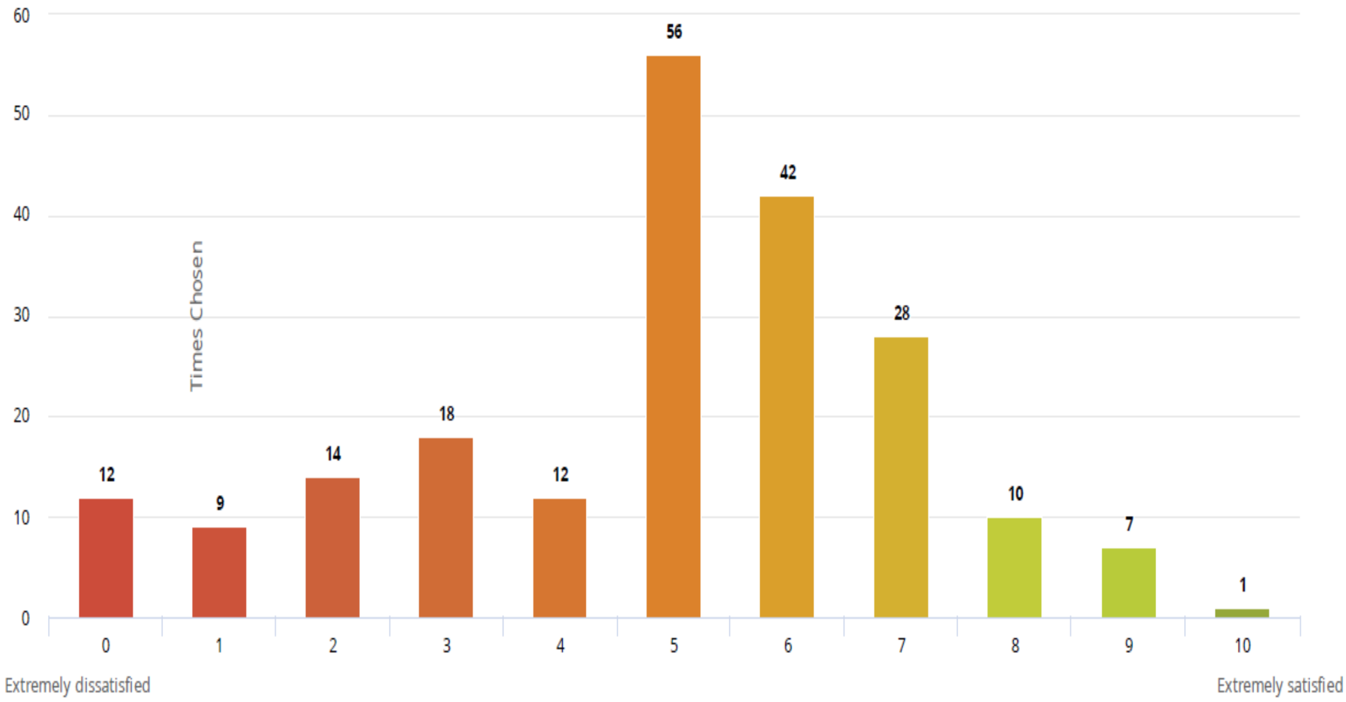


Figure 3.12 209 participants rated their overall level of satisfaction with the brief.

One of the main views and concerns expressed in the 102 open responses to this question, was that the perceived openness of the learning outcomes for Junior Cycle Science would transfer into the senior cycle specifications.

> *The idea of learning outcomes is good in general but the vague style of those used for science has caused many problems. If the senior cycle learning outcomes were more specific and less open to interpretation, I could see it as a positive.* (Online questionnaire, post-primary teacher, 2019)

> *I believe we need a detailed specific well outlined curriculum at Leaving Cert level. There is no room for learning specifications or unpacking learning outcomes.* (Online questionnaire, post-primary teacher, 2019)

Some participants felt the lack of detail in the science specification has led to fragmentation and confusion causing *differences between what teachers are teaching in each classroom* (Online questionnaire, post-primary teacher, 2019). There were some views that the current syllabi worked very well and were well respected internationally. There were calls for *no confusion over what should be taught/learned* (Online questionnaire, post-primary teacher, 2019), so as to avoid reduction in curriculum and assessment standards. While many participants acknowledge the function and relevance of the science specification at junior cycle, there were strong views expressed for a different form of specification at senior cycle.

A common view was that a reduction in the scope of the topics was required to accommodate the inclusion of coursework and the inclusion of more relevant topics. *The curriculum should be specific but probably reduced if changes are implemented* (Online questionnaire, post-primary teacher, 2019), with appropriate levels of details and *it is really important that high quality supports are put in place (not just identified)* (Online questionnaire, post-primary teacher and parent/guardian, 2019). Some participants were very specific about the need for early intervention support, including the publication of *several sample exam papers at the outset of the roll out of any new courses [and not persist with the current model of one sample paper released within the year the subject is to be examined]* (Online questionnaire, post-primary teacher, 2019).

There were mixed views on the level of detail provided in the brief. Some felt it lacked emphasis on the degree of curricular content that would be provided and was perhaps too aspirational for the classroom. Others felt it captured current, important issues of relevance to Leaving Certificate science subjects.

Summary

472 participants completed the online questionnaire, of which 80% identified as predominantly post-primary science teachers. The online questionnaire consultations were analysed under a number of themes:

- Purpose of science education

The purpose of science education was seen as developing scientifically literate students and preparing students for careers in both STEM and non-STEM areas. Many of the aspirations complemented the first two STEM principles, with many participants expressing a desire for students to be curious, life-long critical thinkers about scientific matters.

- Specifying knowledge in a coherent curriculum

Propositional and procedural knowledge were generally equally valued with some caveats around epistemic knowledge as being more suited to 3rd level. Understanding core concepts and a progression of conceptual understanding were equally valued. An interconnected narrative was seen as important as long as there was clarity and detail.

- Important aspects addressed in a contemporary science curriculum

Consistent with purpose, there was a general consensus that a broad-based curriculum that develops in-depth scientific literacy skills would form the basis of achieving other important aspects such as career awareness and critical thinking skills. Many participants asked to not neglect core concepts and skills with a curriculum that aims to cover too much without sufficient depth.

- Continuity and progression from Junior Cycle

There were two perspectives offered. One perspective was to continue with the building blocks approach and progress an evidence-based research component. The other was for a more detailed specification where teachers did not have to continue to interpret or unpack the learning outcomes and the deficits in knowledge would have to be addressed by a revised curriculum.

- Coursework assessment

In the four areas consulted upon, there were many in favour of a 20% weighting for a coursework component, completed through a mixture of in-class and out-of-class time, conducted over a focussed, relatively short period not exceeding 10 weeks. There was generally a welcome for an assessment beyond a written assessment, though many reservations on how to protect the integrity of such an assessment. Some participants expressed a desire for no coursework component, contrary to the brief.

- Views on the brief for the review

Following some of the contributions on continuity and progression from junior cycle, many contributions expressed concerns that there would be a lack of specificity in the revised curricula and that teachers would have to interpret the learning outcomes. There were mixed views on the brief itself, being described as relevant and thorough yet also vague and lacking specifics on content.

3. Feedback from the focus groups

While a broad range of participants attended the focus group sessions, the majority were involved with the current syllabi (Physics (1999), Chemistry (1999), Biology (2001)) to some degree. Teachers who currently teach Junior Cycle Science and Leaving Certificate Physics, Chemistry and Biology were well represented at these focus groups as were third level lecturers in science education. While the focus group questions were drawn from the online questionnaire, the group dynamic allowed for a more flexible approach to questioning, facilitating direct feedback on the issues and providing more scope for delving into particular areas, including:

- the purpose of Leaving Certificate science education
- coursework assessment
- areas to be addressed in contemporary curricula for Leaving Certificate Physics, Chemistry, Biology.

The focus group questions are available in Appendix 4 (p.58)

Participants were asked about their initial impression, having read the Background Paper for the Review of Leaving Certificate Physics, Chemistry, Biology. There was a wide range of responses ranging from concern and scepticism through to a tentatively positive and welcoming response.

When asked their thoughts on the purpose of Leaving Certificate Science education there was unanimous agreement it should be to develop scientifically literate citizens. Participants recognise twenty first century citizens need to be able to use science to interpret the world in which they live and solve the complex problems they will face in the future.

> *The science subjects should move away from rote learning. Students should develop skills that prepare them for real life and to use the skills to interpret what is going on in real life. Currently they are learning biology but don't necessarily understand it or can apply it to real life*

There was a lot of discussion about the practical dimension of science and participants expressed a view that they did not want a situation to arise where the new specifications might be perceived as doable without engaging with practical work.

> *A big part of science is developing the skill of doing science because of the way science is examined at the moment students don't value the time spent doing practical work*

Investigative skills you could learn without the hands on doing of the experiments. Students in SC science are good at analysing data but not good at actually doing practical work

There was a recognition that the assessment has a huge influence on what happens in the classroom and an acknowledgment that deciding how to reward practical work through the assessment would be a challenge for those developing the specification.

If you can answer all questions on experiments without ever doing an experiment, then why would you do experiments. The challenge will be how to reward practical skills [in the examination]

Whilst mandatory practical work has been the solution to this problem in the past participants didn't necessarily want to see a list of mandatory practicals.

Don't want mandatory practicals but there must be something that forces people to do practical work. The practical nature of the course should be checked in WSE it should be clear that the students are engaging with practical work otherwise we can't stand by the qualification

It was noted that something as simple as a reward of 10% towards the examination marks might place more value on the skills developed during practical work.

Shouldn't let cynicism drive the system - if there is a requirement to do experiments and a 10% pay-out in the exams then that is good […] we can still assess more deeply in the written exam the practical course doesn't need to end in the practical work if you have to sign off on it

Participants agreed with the sentiments in the Background paper about striking a balance between the different types of knowledge specified. There was a perception that currently the emphasis in examinations is on recall of facts.

The current style of questioning is recall. It should be far more problem-solving style of questions not just recall...students for example may still be asked about a very specific point in history - we are trying to solve problems in chemistry not regurgitate facts

The word specification is misused it is far from specific

In relation to the use of Learning Outcomes to specify the knowledge that is of most worth, participants spoke about the challenges that this method of specification presents when preparing students for a high-stakes examination. It was agreed that clarity was needed in how the learning was specified and that there would be a need to specify the depth of knowledge required. It was clear that participants did not want an over specified curriculum with some participants equating the call for depth of treatment to exam coaching.

> *A direct translation of depth of treatment is …this is what you have to do to do well in the exam. It's depth of knowledge is what we want*

There was feeling that the current syllabus is very atomised and that this was not a desirable for the new specification.

> *We need something less prescriptive then we had, the current Biology syllabus is very shallow*

A suggestion was made to look at how DCU modules are specified.

> *Look at DCU modules they have a list of indictive content along with broad LOs*

The importance of aligning the exam with the Learning Outcomes was highlighted.

> *An awful lot of this comes back to the importance of examinations. I understand the philosophy of not teaching to the test but teach to the test is only bad if they test is narrow*

Participants felt that some of the clarity called for could be achieved through sample assessment items and called for these items to be released at the same time as the specification as happens in other jurisdictions.

> *We need to see sample examination questions in advance*

A number of opportunities and challenges were noted in response to the question about the inclusion of a coursework assessment component for Leaving Certificate Physics, Chemistry and Biology.

> *Lot of opportunities for differentiation and it could be quite inclusive, students with different learning styles have opportunity to display what they have learned - it could be displayed in different media*

Whilst participants welcomed the inclusion of a coursework component there was an element of cynicism that schools would find a way for their students to get the best mark *like old coursework B in Junior Cycle*. The idea of a *roadshow* was mentioned as a cause for concern; presentations to teachers by external bodies or individuals of "correct" approaches to coursework that could be replicated in classrooms, running counter to student choice and classroom context. It was hoped this would not happen at senior cycle and measures could be put in place to stop such practices interfering with the integrity of the assessment.

It should help sell LC Science subjects, an opportunity to get some marks before the final exam I was good at that at JC 20% in the bag I'm doing that subject

Whilst discussing what a coursework component might look like participants had many ideas;

Thematic brief that they could use research skills and practical skills and communicate it in a particular way record it and get up and present it.

There was a strong desire that this component should not become formulaic and it should be moderated externally

Maybe do research like if you were writing a scientific paper and bringing in more skills from further science

The practical nature of science was again highlighted, and participants had suggestions as to how the assessment of practical skills might take place.

Teachers swap within schools and they don't observe their own students. We pair up and act as lab technicians for each other this would involve standardisation like with the CBAs in JC

It was noted that the approach to assessment taken by The International Baccalaureate had a lot to offer by way of assessment and a similar approach might be beneficial to the Irish system.

The way it is assessed incorporates a lot of different elements discussed the terminal exam has 3 papers –short questions on core content, practical skills and an extended response paper. It has internal assessment similarities to CBA 1 and 2 it is teacher assessed.

Design and implement a research question they are interested in, marked by teachers and moderated. Lots of guidance assessed by a rubric where students fall into 4 different brackets the positives from that assessment approach could be beneficial to the system.

The need for continuity from junior cycle was noted and participants gave suggestions as to how the learning from the Nature of Science strand at junior cycle could be assessed at senior cycle

Looking at continuity from JC and within the sciences; physics, chemistry and biology Q1 could be a NOS question.. What is wrong with the way this experiment was carried out? why is this not a good level of analysis? critiquing scientific data give scientific data to analyse and this would be similar in all 3 subjects…

Summary

- Purpose of science education

In keeping with the other research instruments, the focus group participants saw the purpose of Leaving Certificate science education as developing scientifically literate students. The practical nature of science and its importance was emphasised, and a range of views were offered on the rewarding of practical work.

- Specifying knowledge in a coherent curriculum

There was agreement with the sentiment in the Background Paper about striking a balance between different types of knowledge. Participants felt that clarity was needed in specifying the learning in Learning Outcomes, but that caution should be exercised to avoid over-specification. Alignment of examinations with Learning Outcomes was also desired.

- Continuity and progression from Junior Cycle

As was found across the consultation, participants favoured the continuation and progression of Nature of Science learning into Leaving Certificate Physics, Chemistry and Biology.

- Coursework assessment

In general participants welcomed the introduction of a coursework component. They idea of a “roadshow” of presentations for teachers in response to coursework components was something that participants wish to avoid as this could lead to game playing. There was also a strong desire to avoid the coursework becoming formulaic with suggestions of thematic briefs and students pursuing their own research questions discussed.

4. Feedback from written submissions

Feedback from written submissions spoke to a range of areas related to the background paper, with a number of ideas and notes of caution stressed by different participants.

4.1 Purpose and future directions

There were a range of perspectives on the purpose of science education. Whilst some felt the primary purpose of Leaving Certificate Physics, Chemistry, Biology was to prepare students for third level entry, there were others who saw it as progressing students as STEM learners with appropriate development of knowledge, skills and understanding. Some also noted the importance of promoting a positive view of the sciences and their impact on culture:

> *We warmly welcome the review of the draft specifications for Leaving Certificate biology, chemistry and physics by the NCCA. The draft background paper is clear, concise and presents the background and evolution of these syllabi succinctly. We agree the new syllabi should further develop curricular coherence igniting students' curiosity and progressing their knowledge and skills as independent researchers within STEM environments. (St. Angela's College, Sligo)*

> *The majority of students taking LC Chemistry (17% of the LC cohort) do so because they need the subject for 3rd level courses – in science, technology/engineering or medical courses. (email submission)*

> *We believe it is important the curriculum supports the development of long-lasting skills, knowledge and understanding, and also promotes a positive view of physics and its cultural contribution. (IOP)*

Stemming from these perspectives, a number of suggestions were offered on areas to be addressed as part of contemporary curricula. These included:

5.1.1 Access and engagement

Some submissions spoke about the difficulty students encounter when engaging with certain subjects, e.g. Physics, due to its mathematical grounding and perceptions of being conceptually abstract. It was also felt student engagement would be enhanced through centralising the relevance and societal impact of science in the curriculum:

> *Many students have misconceptions (alternative conceptions) in science deriving from their own experiences and from what they have been taught previously….Teachers should be aware of the main misconceptions identified by science education research in the main areas of chemistry (perhaps in*

supplementary materials). These should inform the statement of outcomes in the specification, the depth of treatment and suggested practical work, and the assessment. For example, asking students to state a definition should be accompanied by a question which tests the understanding of the underlying concept. (email submission)

Students also need to know the relevance and societal impact of the science and so the specification should have an explicit focus on STS [science through society] and on context-based content. (email submission)

The value of practical work was emphasised as increasing student engagement and skills development. The submissions gave pause for thought on how we come to understand the nature of practical work and its place in coursework. Some felt contemporary curricula should incorporate practical work that allows for students to develop their thinking and research skills in a digital world, alongside 'practical' skills. Others saw practical work as a means to develop the skills of science through the practices of science, leading to proficiency for coursework assessment. Caution was advised, specifically in relation to coursework, to ensure a fair and level playing field for all students:

We would like to see a new coursework component that will recognise the balance between traditional experimental activities, digital activities and research-based activities (St. Angela's College, Sligo)

While practical work is an important part [of the practices of Physics]….it is not the only part. Physics is also an intellectual exercise….explanations of observed phenomena are based on thinking ('minds on') as well as doing ('hands on'). (IOP)
It should be skills through science not science through skills. A checklist of transferable skills should be provided and linked to the core content to ensure their delivery. Inquiry skills should be embedded in the course from the start, equipping students to do literature or lab-based project work in the final year of the course. (email submission)

… the question is, how can we put robust measures in place [for coursework assessments] to ensure that absolutely no unfair advantage is given to candidates who may profit from "expert advice" which is not available to all? (email submission)

4.1.2 Framing of curricular content

Participants felt student access to and engagement with Physics, Chemistry, Biology would be enhanced through appropriate framing of curricular content. Ideas were offered on approaches to structuring the curriculum to facilitate this, including:

Continuity and progress from Junior Cycle, cognisant of perceived gaps:

NoS [Nature of Science] should provide an underpinning framework, building on the junior science course, and should be integrated into the delivery of the course and practical work, not as a stand-alone topic (email submission).

We believe this review process is a great opportunity to align with and build on the new Junior Cycle Science which promotes practical based learning so the students can further develop their research skills… We suggest that a contemporary Leaving Certificate science curriculum could contain common strands within biology, chemistry and physics providing continuity from Junior Cycle Science with 'Sustainability' and perhaps consider new strands like 'Biomedical Innovations', 'Climate Change' or 'Sports Nutrition'. (St. Angela's College, Sligo)

The course should be designed to follow on from the junior science course. However, as it stands the gap between junior science and leaving certificate science has increased and students are less well prepared in subject content (many topics previously covered in junior science are not there) and in practical/laboratory skills. LC [Leaving Certificate] science teachers will thus have to start from a weaker foundation than at present (email submission).

There was suggestion of specific areas of study valuable for coherence in the curriculum and assessment, e.g. the Doppler effect as a concept connecting waves, space, and the origins of the universe. The IOP suggested a structuring of the curriculum around 'big ideas' about physics and its practices, of physics and its explanations and from physics in applications:

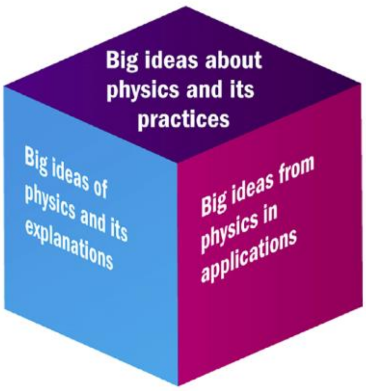


Figure 5.1 Structuring Physics around 'big ideas' (Tracy, 2018,

4.2 Perspectives on specifying knowledge

A number of submissions spoke directly to the specifying of knowledge in future curricula for Leaving Certificate Physics, Chemistry, Biology. Concerns were expressed over the lack of clarity in the learning outcomes of Junior Cycle Science, leading to inequity amongst schools when preparing for examinations and in the topics taught across the three years. There is a repeated call for more detail at Leaving Certificate, often referred to as depth of treatment, beyond that detail which is prescribed in the learning outcomes for junior cycle:

> *Learning outcomes alone are not sufficient to allow the teacher to decide what to teach and for the students to know what to learn…failing to specify what is required from teachers and students might well lead to less practical work being done, especially if there is no formal practical assessment (email submission)*

The ISTA offered insights from an online survey they made publicly available, to which they received 762 anonymous responses. Large amounts of selected raw data were shared with NCCA as part of these insights.

> *[T]eachers have major concerns regarding the extent to which they feel that students will be prepared for the study of Leaving Certificate science subjects having studied Junior Cycle science. In particular, these concerns relate to the depth of knowledge, lowering of standards of science, the increased gap between Junior Cycle science and Leaving Certificate science and the concern among physics teachers for the future of their subject (ISTA).*

ISTA's submission indicated that 85% of their anonymous respondents found the "template" of specification design for junior cycle either *unacceptable* or *dissatisfied*, which is *a very strong indicator that teachers in the classroom have found serious problems with the template of the Junior Cycle Science specification* (ISTA). Reasons for these concerns included:

- perceived vagueness of learning outcomes
- unsuitability of a similar template for high stakes examinations in Leaving Certificate
- increased stress being placed on students and teachers.

> *…it would be intolerable and a source of great stress and anxiety to teachers and their students if teachers themselves have to interpret or "unpack" learning outcomes in the new Leaving Certificate biology, chemistry and physics specifications to try to work out for themselves the depth of treatment relating to each learning outcome (ISTA).*

The submission included that recommendations from their 2014 commissioned desktop research (commonly referred to as "The Hyland Report") be implemented in the development of revised curricula for Leaving Certificate Physics, Chemistry, Biology. The full text of the report is available through the ISTA website.

Summary

Written submissions from participants spoke to themes related to the various perspectives in the background paper:

- Purpose of science education

Participants held a range of views on purpose, including preparation for third level entry to agreement with the purpose as outlined in the background paper. It was also highlighted that part of the purpose should be to promote a positive view of Leaving Certificate Sciences, including their cultural contribution.

- Important aspects addressed in a contemporary science curriculum

A range of ideas were offered, including the use of core concepts and contexts in a connected curriculum, the use of "big ideas", and practical work to cultivate a scientific habit of mind whilst also building scientific skills.

- Specifying knowledge in a coherent curriculum

There are frequent calls to specify knowledge in Leaving Certificate at a level beyond what is currently offered in Junior Cycle Science. It is felt by some that teachers are concerned about vagueness in learning outcomes and further prescription may be required beyond teachers "unpacking" learning outcomes themselves.

- Continuity and progression from junior cycle

Suggestions are offered for ways to continue and progress the student experience from Junior Cycle Science. These included common strands across Physics, Chemistry, Biology continued from junior cycle, including the Nature of Science. The value of progressing students' conceptual understanding and research skills through relevant contexts was also noted. Caution is stressed over the potential for a gap in understanding between junior and senior cycle.

- Coursework assessment

A number of views and ideas for coursework were offered. These included literature or lab-based project work and a balance of experimental, research and digital activities. It was also suggested that coursework should be based on skills developed throughout the course through scientific inquiry. Suggestions were offered for ways that practical work could be specified with limited choice. Caution was offered on the need to ensure fairness for all students in whatever approach to coursework assessment is taken.

5. Feedback from the student voice consultations

Students were consulted on their experiences of school science education in line with some of the issues raised in the background paper. Students were asked questions appropriate to their age and stage, and reflective of the issues being consulted on. Examples of areas addressed with students included:

- their understanding of science and its importance in their lives
- their experience of junior cert/cycle science as appropriate including coursework (e.g. Coursework B, CBAs)
- their thoughts on and experiences of Leaving Certificate science.

A full list of sample questions is available in Appendix 5 (p.59).

In opening, students were asked about their understanding of science, its purpose and relevance to their lives. Students valued science as a way of understanding the world and making real world connections. They saw school science as a means by which to understand the world through the pursuit of their interests. Interests in studying science ranged from personal enlightenment to understanding of life and pursuit of future careers. They emphasised the value of being able to make their own decisions as part of their science education:

> *I did science because I was interested in how the world works; I wanted to find out more about earth and space. Science was originally created to make people understand what the world is based on evidence. (TY Student)*

> *I like learning about the body, what happens in our bodies, I'm interested in studying nursing. (TY Student)*

> *How you understand the workings of the world and how things are interrelated and the effects we can have on the environment. (6th year Student)*

> *I'm interested in biology – I want to study occupational therapy- I want to give back to my community and help people. (TY Student)*

Students expressed a number of different motivations for pursuing science in senior cycle. These ranged from the influence of the teacher and family to preparation for further education to positive experiences in junior cycle years:

> *The biggest influencer of whether you take the subject is the teacher (6th year student)*

I enjoyed physics and biology- I'm not thinking of science after school but I enjoy topics (TY Student)

I like genetics in biology and periodic tables in chemistry- also my dad wants me to do it- I like biology more (TY Student)

Student interests spanned a range of areas. In particular students who studied Junior Cycle Science were interested to learn more about the human body and about earth and space. There was broad consensus on the value of experiments both in junior and senior cycle science. Students who sat Junior Certificate Science stressed the value of completing coursework B in giving them independence in their experimental work. A similar sentiment was shared by students who had completed Classroom-Based Assessments (CBA) 1 and 2 in Junior Cycle Science:

I liked Coursework B because it allowed more independence than my other experiments (5th Year Student)

I felt the experience [of CBAs] was good but it should have been part of your exam cos they do take up a lot of your time (TY Student)

Experiments are more hands on, you can see it happen and it makes it easier to understand (5th year Student)

Learning through real life experiments is more entertaining than just taking notes – you're actually doing science (TY Student)

Students unanimously agreed on the importance of connecting the real world of science with their classroom experience and saw the value of research in Leaving Certificate:

I would have said that I would not do science after school but if we heard more from people who are studying it, it would be helpful (5th Year Student)

Spending a day in a science lab – field trips- these have a practical aspect, they help you to see what you're studying science for (TY Student)

Being able to research and reference should be on it [Leaving Certificate Physics, Chemistry, Biology] – it's really important, it's linked to all subjects (TY Student)

The aspects of science which students found challenging related mostly to the amount of content in the curriculum and that the science subjects often do not allow for creativity. Students currently studying Physics, Chemistry, Biology spoke of the challenges in processing large amounts of information without sufficient space and time in class for understanding:

It's the nature of physics that you can't be creative you have to just accept it (6th Year Student)

The course is huge, there's not enough time. It's stressful – the level of understanding needed is hard when the course is so packed (5th Year Student)

Students also highlighted the challenge in bridging conceptual gaps from junior to senior cycle science:

Definitions in junior cycle that you learned off- then sometimes there are different definitions in senior cycle. Like the Bohr model- it's like different concepts in your mind, like relearning – it's hard to connect the two (5th Year Student)

Students had strong views on the inclusion of a coursework component in any revised curricula for Physics, Chemistry, Biology. They saw greater equity for all students through the introduction of coursework in various ways, including:

Reduced pressure on examinations, both in terms of the weighting of marks and the timing:

I do Ag Science and we are given the topic in 5th year (5th Year Student)

We currently do mandatory experiments and we get no marks for them like we did with coursework A and B [Junior Certificate Science]. Maybe we could get 20 or 25% to help take the pressure off? (5th Year Student)

Provide students with opportunities for choice to investigate areas they were interested in:

Something you're interested in is not a chore and you could even progress it from TY (TY Student)

If you are doing research, you might learn something new (6th Year Student)

Promote fairness:

The Leaving Cert gives advantage to people good at learning off at the moment- what about when you're working practically in labs? The practical is important too (5th Year Student)

Maybe coursework would suit different learning styles (5th Year Student)

Students offered ideas for coursework ranging from conducting their own investigations based on a broad prompt, extending science fair project work done in Junior Cycle or TY and a communication component that would allow them to show their understanding of the science concepts they were investigating.

Summary

Student voice consultations revealed a number of important themes related to the various perspectives in the background paper:

- Purpose of science education

Students see the purpose of science education as offering them a means to understand the world through the pursuit of their interests.

- Important aspects addressed in a contemporary science curriculum

Students value a science curriculum that is relevant to their lives, interests and future progressions beyond secondary school. They value connection with the real world of science through a healthy blend of theoretical and practical work.

- Specifying knowledge in a coherent curriculum

Students stressed caution on the amount of information within the curriculum. The consequence of too much information to be learned off by rote is a lack of space for deeper learning and a disconnect between the conceptual understanding built in junior cycle and progression to senior cycle.

- Continuity and progression from Junior Cycle

Students value the opportunity to investigate areas of interest to them. They also appreciate the place of research in the curriculum and feel it should be a part of Leaving Certificate Physics, Chemistry, Biology.

- Coursework assessment

Students feel strongly on the need for coursework assessment in reducing the pressure on the final assessment and promoting greater equity amongst the spectrum of learners of Leaving Certificate Physics, Chemistry, Biology.

Conclusion

The consultation process was very beneficial to the development of the LC Physics, Chemistry, and Biology curriculum specifications. The level of engagement of the respondents must be acknowledged and the NCCA are very grateful for the open and honest feedback received.

The NCCA consultation process ran from the 1st of October to the 1st of November 2019 and consisted of the following elements:

- an online questionnaire (of which 80% identified as post primary teachers)
- focus group meetings
- written submissions
- student voice consultation events.

It was evident from the consultation that a review of the curriculum in each subject is welcome. The most notable finding of the consultation is how views around the purpose of science education coalesced across all the consultation platforms.

The purpose of science education was seen as developing scientifically literate students, who can better understand how the natural world works, and preparing students for careers in both STEM and non-STEM areas. Many participants expressed a desire for students to be curious, life-long critical thinkers about scientific matters, equipped to pursue interests of relevance to their lives. This will inform the development groups as they draft the rationale, aim, and objectives for LC Physics, Chemistry, and Biology.

The consultation findings reveal that participants placed as much value on an interconnected narrative of core concepts as on understanding those core concepts in isolation. There is an imperative upon any revised curricula, where possible, to create a narrative of learner progression that facilitates these connections.

The consultation process revealed many considered concerns, such as the potential for curriculum overload, a lack of specificity in Junior Cycle Science resulting in conflicting interpretations of the curriculum and a feared demotion of propositional knowledge. Nonetheless, there are many beliefs and practices shared across the spectrum of participants which will support the enactment of the revised curriculum specifications. The overarching views on purpose, core concepts, progression of conceptual understanding, the need for an additional assessment component, a common strand in the form of Nature of Science across all three subjects, and the desire for a clear connected narrative would all be commensurate with the research and ideas in the background paper and will inform the work of the subject development groups.

The consultation findings will inform the deliberations of the development groups as they prepare draft specifications, which will be available for consultation in Q2, 2020. Consideration will also be given to the identification of supports necessary for successful enactment, in parallel to drafting the curriculum for each subject.

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Appendix 1 - Brief for the review of leaving certificate physics, chemistry and biology

The review of Leaving Certificate physics, chemistry and biology will involve developing curriculum specifications for each subject in line with the template for specifications for all senior cycle subjects. The key skills of senior cycle and the skills of literacy and numeracy, as appropriate, will be embedded in the learning outcomes of the specification.

The specifications will be completed for Council by autumn 2020.

More specifically, the development of the new specifications will address:

- progression and continuity from Junior Cycle Science
- a curricular balance that underpins propositional knowledge and supports the acquisition of procedural and epistemic knowledge
- sustainability and how such contemporary issues might be explored by learners
- how students will be assessed; the integration of a coursework assessment component allowing for the assessment of inquiry-based learning, critical thinking and elements of experimental investigation, into each of the three subject specifications
- how to widen the appeal of the subjects in order to meet the targets of the STEM strategy and rebalance gender uptakes
- how to encourage student agency and an associated capacity for lifelong learning
- how to differentiate on conceptual depth to meet the needs of a diverse range of students; for example, those who wish to progress to STEM careers through third level or apprenticeships, or those who will pursue other pathways outside STEM but still need to be scientifically literate citizens
- how to embrace technology in the learning, teaching and assessment associated with the specification, in such a way that students are digital consumers and creators
- the identification of supports necessary for successful enactment.

The work of the Leaving Certificate science subject development groups will be based, in the first instance, on this brief. In the course of its work and discussions, refinements of some of these points and additional points may be added to the brief.

Appendix 2 – Online Questionnaire

Consultation on the background paper for review of Leaving Certificate Physics, Chemistry, Biology

Public consultation on the Draft Background Paper and Brief for the Review of Leaving Certificate Physics, Chemistry, and Biology

NCCA An Chomhairle Náisiúnta Curaclaim agus Measúnachta National Council for Curriculum and Assessment

Introduction

The aim of this process is to hear the open and honest views of teachers/parents/students and interested parties on The Draft Background Paper for the review of Leaving Certificate Physics, Chemistry and Biology. This public consultation will involve gathering feedback through this survey, email submissions and targeted focus group meetings.

The NCCA would greatly appreciate your feedback. This feedback will inform further work on the development of the Leaving Certificate Physics, Chemistry and Biology specifications. Please read the draft background paper and brief, which can be accessed here:

Draft Background Paper and Brief for the Review of Leaving Certificate Physics, Chemistry, Biology 2019

Then complete this questionnaire as fully as possible but feel free to skip any item that is not relevant to you.

The consultation survey questions are split into seven areas, which are:

1. I am responding as...
2. The purpose of science education
3. Opportunities and challenges raised by a number of policy initiatives for the review, including
    - The Digital Strategy for Schools 2015-2020
    - The STEM Education Policy Statement 2017-2026
    - Continuity and progression from Junior Cycle Science
4. Emerging trends in science curriculum development
5. Assessment
6. Your views on the brief for the review of Leaving Certificate Physics, Chemistry and Biology
7. Any other thoughts you have on the background paper

Throughout the survey, **hyperlinks** to relevant sections of the background paper are provided for ease of access and reference.

Thank you for taking the time to complete this survey. Your views will help inform the development of subject specifications for Leaving Certificate Physics, Chemistry and Biology.

Privacy Statement

NCCA is committed to protecting your privacy and any infomation you choose to share with us in this survey. The NCCA does not collect any personal data about you through this survey, apart from information which you volunteer. Where you voluntarily provide personal information in response to a questionnaire or survey, the data will be used for research or analysis purposes only. Any information which you provide in this way is not made available to any third parties, and is used by the NCCA solely for the purpose for which you provided it. This survey has been set as 'anonymous'. You can learn more about this by clicking on the 'This survey is anonymous' link, which is at the bottom of every page.

No questions are compulsory and you do not have to share any personal information with us.

In the "*I am responding as...*" section of this survey, we will ask if you would identify your role within education, your school type should it be applicable and if you are responding on behalf of an organisation not already listed.

This survey is being conducted to generate responses as part of the consultation on the Draft Background Paper and Brief for the review of Leaving Certificate Physics, Chemistry and Biology. The survey data will be anonymised and we will ensure that no views that you articulate will be attributed to you or your school/organisation or be reported in any way that would allow you or your school/organisation to be identified.

This information will be removed from the survey once the report on the consultation has been finalised and published. This is estimated to be by the end of November 2019. Should you require a copy of the information you have supplied to us, you will be given the opportunity to download a copy of your answers at the end of the survey after you have clicked on 'Finish'.

Should you have any questions in relation to the collection or use of data in this survey, please contact the NCCA's Data Protection Officer through info@ncca.ie

1. I am responding as a:

- ☐ Post-primary Teacher
- ☐ Primary teacher
- ☐ Principal/Deputy Principal (Post-primary)
- ☐ Principal/Deputy Principal (Primary)
- ☐ Second level student
- ☐ Third level student
- ☐ Parent/Guardian
- ☐ Teacher educator
- ☐ Pre-service Teacher
- ☐ Third level lecturer/researcher
- ☐ Other (please specify)

What year are you in?

- ☐ 1st
- ☐ 2nd
- ☐ 3rd
- ☐ 4th
- ☐ 5th
- ☐ 6th
- ☐ Other

Please specify your area of study/expertise

- ☐ A science related area
- ☐ A non-science related area

- [ ] Other

Please select the science subject(s) you teach

- [ ] Junior Cycle Science
- [ ] Leaving Certificate Physics
- [ ] Leaving Certificate Chemistry
- [ ] Leaving Certificate Biology
- [ ] Leaving Certificate Phys/Chem
- [ ] Leaving Certificate Agricultural Science
- [ ] Other

School type (if applicable)

- ( ) Voluntary secondary school
- ( ) Community school
- ( ) Comprehensive school
- ( ) Vocational school
- ( ) Community College
- ( ) Educate Together school
- ( ) Other (please specify)

I am responding on behalf of . . . (for example, an organisation. Please use only if applicable)

Can we list your organisation as one that has responded to our survey in the report? We will not associate any other data in the report with your organisation.

Yes

No

2. The purpose of science education

Chapter 3 pages 15-21 discusses how changing socio-political contexts have influenced and moulded science education and highlights the importance of having a clear, common purpose to achieving curricular coherence.

What are your thoughts on the purpose of Leaving Certificate Science education?

3. Policy initiatives - opportunities and challenges

Next, you will be asked to provide your views on a number of policy initiatives referenced in the background paper, including:

- The Digital Strategy for Schools 2015-2020
- The STEM Education Policy Statement 2017-2026
- Continuity and progression from Junior Cycle Science

You will be asked to select a response to a range of statements/questions and will also have space to comment.

The Digital Strategy for Schools 2015-2020

Chapter 2 page 12 outlines how The Digital Strategy for Schools 2015-2020 challenges curriculum developers to find opportunities to provide contexts for students to utilise their skills as both consumers and creators of digital artefacts.

To what extent do you agree or disagree that revised curricula for Physics, Chemistry and Biology should provide contexts for students to utilise their skills as both consumers and creators of digital artefacts from the following examples?

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Using computer simulations	◯	◯	◯	◯	◯
Digital tools for data processing	◯	◯	◯	◯	◯
Using shared learning environments for project management	◯	◯	◯	◯	◯
Use of digital sensors	◯	◯	◯	◯	◯
Computer based modelling	◯	◯	◯	◯	◯
Digital graphing tools	◯	◯	◯	◯	◯

Please include any comments you wish to make on how revised curricula for Physics, Chemistry and Biology could provide contexts for students to utilise their skills as both consumers and creators of digital artefacts:

The STEM Education Policy Statement 2017-2026

The STEM Education Policy 2017-2026, addressed in **Chapter 2 page 11**, describes how STEM education, two decades into the 21st century, should meet the needs of those students who will become the next generation of scientists and those who will live and work in a world increasingly shaped by science and technology. It outlines three key principles that will underpin all STEM education initiatives.

To what extent do you agree or disagree that revised curricula for Leaving Certificate Physics, Chemistry and Biology could provide opportunites for the realising of the following underpinning STEM principles?

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Igniting learners' curiosity so they participate in solving real world problems and make informed career choices	○	○	○	○	○
Interdisciplinary learning - enabling learners to build and apply knowledge, deepen their understanding and develop creative and critical thinking skills within authentic contexts.	○	○	○	○	○
Embody creativity, art and design	○	○	○	○	○

Please include any comments you wish to make on the degree to which revised curricula for Leaving Certificate Physics, Chemistry and Biology could provide opportunites for the realsiing of the underpinning STEM principles?

Continuity and progression from Junior Cycle Science

Chapter 2 pages 9-10 addresses Junior Cycle Science. Junior Cycle Science aims to:

"...develop students' evidence-based understanding of the natural world and their ability to gather and evaluate evidence: to consolidate and deepen their skills of working scientifically; to make them more self-aware as learners and become competent and confident in their ability to use and apply science in their everyday lives" (NCCA/DES, 2015, p.5).

Junior Cycle Science students learn about the world of science but also how science works through engaging with the unifying Nature of Science strand and carrying out their own investigations through Classroom-Based Assessments (CBAs). These curriculum and assessment structures support the realisation of the aim of Junior Cycle Science.

To what extent do you agree or disagree with the following statements related to continuity and progression from Junior Cycle Science?

	Strongly agree	Agree	Neither agree or disagree	Disagree	Strongly disagree
Students should have opportunities to progress their knowledge and skills as independent investigators in senior cycle	○	○	○	○	○
Nature of Science learning should be a part of revised Physics, Chemistry and Biology curricula	○	○	○	○	○
There should not be a requirement in senior cycle for students to further learn the 'building blocks' of Physics, Chemistry and Biology as was done in Junior Cycle Science	○	○	○	○	○
Students learned about 'systems and interactions' in Junior Cycle Science. This learning should be progressed as part of revised Physics, Chemistry, Biology curricula	○	○	○	○	○
Students learned about 'energy' in Junior Cycle Science. This learning should be progressed as part of revised Physics, Chemistry, Biology curricula	○	○	○	○	○
'Sustainability' should not be considered as an area of study for revised Physics, Chemistry and Biology curricula	○	○	○	○	○
Junior Cycle Science students had opportunites to develop their research skills. This should be progressed as part of revised Physics, Chemistry, Biology curricula	○	○	○	○	○
Students' 'Earth and Space' learning should be progressed as part of revised Physics, Chemistry, Biology curricula	○	○	○	○	○

Please include any comments you wish to make on continuity and progression from Junior Cycle Science to Leaving Certificate Physics, Chemistry and Biology:

4. Emerging trends in science curriculum development

Chapters 3 and 4 address some emerging trends and issues in the world of science education and the consequent implications for curriculum design. These include:

- Important aspects addressed in a contemporary science curriculum
- Specifying knowledge in a coherent curriculum

Next, you will be asked for your views on these areas.

Important aspects addressed in a contemporary science curriculum

Chapter 3 pages 15-21 considers the opportunities and challenges emerging from the evolution of science education and considers some aspects that should be addressed by a contemporary science curriculum.

Rank the following areas in order of importance for consideration as part of revised curricula for Leaving Certificate Physics, Chemistry and Biology (1 = most important, 8 = least important):

Addressing global challenges	1.
Developing scientific literacy	
Promoting active citizenship	
Finding solutions to current and future challenges	
Developing a broad knowledge base	
Preparing students for STEM careers	
Promote equity and access (including gender equity)	
Other (specify below)	

Please include any comments you wish to make on important aspects to be addressed in a contemporary science curriculum:

Specifying Knowledge in a coherent curriculum

Chapter 4 pages 22-26 discusses the issues involved in specifying knowledge in a coherent curriculum and draws on findings from international case studies (NCCA, 2019). Issues considered in this section of the paper include:
- challenges and opportunities in adopting a 'learning outcomes' curriculum design
- forms of knowledge
- curricular progressions

Next, you will be asked about your views on these issues.

In *Learning Outcomes: An International Perspective* (NCCA, 2019), Professor Mark Priestley outlines some of the pedagogical and cultural complexities associated with implementing a learning outcomes curriculum design. He warns that failure to address the question of what knowledge is of most value may lead to curricular fragmentation. Three forms of knowledge are outlined in the background paper as propositional knowledge (knowing facts), procedural knowledge (knowing how to do something) and epistemic knowledge (knowing about the constructs and defining features of the discipline).

What importance do you place on young people acquiring the following forms of knowledge in Leaving Certificate Physics, Chemistry and Biology?:

Propositional knowledge - knowing facts

Little or no importance Extreme importance

0	1	2	3	4	5	6	7	8	9	10

Procedural knowledge - knowing how to do something

Little or no importance Extreme importance

0	1	2	3	4	5	6	7	8	9	10

Epistemic knowledge - knowing about the constructs and defining features of the discipline

Little or no importance Extreme importance

0	1	2	3	4	5	6	7	8	9	10

Please include any comments you wish to make on the importance of forms of knowledge in a coherent curriculum:

Many international research studies have attempted to generate and realise science curricula that go beyond the acquisition of facts and into a knowledge domain that allows for a deeper, more interconnected understanding of the key ideas all future citizens should encounter in their science education.

What importance do you place on the importance of outlining the following when structuring revised curricula for Leaving Certificate Physics, Chemistry and Biology?:

The level of understanding of core scientific concepts expected

Little or no importance | Extreme importance

0	1	2	3	4	5	6	7	8	9	10

The progression of conceptual understanding expected

Little or no importance | Extreme importance

0	1	2	3	4	5	6	7	8	9	10

Specifying facts and theories in an unconnected way lads to the creation of islands of knowledge and fragmentation. Harlen (2015) and Millar (2016) provide some examples of how curricular content could be structured to present a body of knowledge in a manner which facilitates learner progression, allows for deeper connections and supports a more coherent curriculum.

What thoughts do you have on structuring a curriculum that allows for creating a meaningful, interconnected body of knowledge?

Please include any comments you wish to make on structuring curricular content in a coherent curriculum:

5. Assessment

Chapter 5 pages 28-31 discusses issues involved in assessing learning. It draws on findings from the SEC trial of practical assessment (2018) and points to commissioned research for an international perspective on coursework and practical assessment in senior secondary science (NCCA, 2019).

Select a response to the following statements:

	A short period of time (typically 6-10 weeks)	A longer period of time (more than 10 weeks)
Coursework assessments should be conducted over:	◯	◯

Please tell us more:

	Plan and conduct experiments	Research	Communicate their findings	Other
Coursework assessments should allow students an opportunity to:	☐	☐	☐	☐

Please tell us more:

	10%	15%	20%	25%	30%	35%	40%
The weighting of a coursework assessment towards the final grade for the subject should be:	◯	◯	◯	◯	◯	◯	◯

Please tell us more:

	During class time	Outside of class time	A mixture of in class time and outside class time	Other
Coursework should be completed:	○	○	○	○

Please tell us more:

6. Your views on the brief for the review of Leaving Certificate Physics, Chemistry and Biology

Please rate your overall level of satisfaction with what is proposed in the **brief for the review of Leaving Certificate Physics, Chemistry and Biology**

Extremely dissatisfied Extremely satisfied

0	1	2	3	4	5	6	7	8	9	10

Please include any comments you wish to make on the brief for the development of revised curricula for Leaving Certificate Physics, Chemistry and Biology:

7. Any other thoughts you have on the draft background paper

Please include any other thoughts you have on the draft background paper:

Thank you

Thank you for taking the time to complete this questionnaire. Please do not forget to press "Finish" to submit your answers to this survey when you will be given the option to download a PDF version of this survey and your answers.
If you have completed a hard copy of this questionnaire, please return it to:

Consultation on the Background Paper for the review of Leaving Certificate Physics, Chemistry and Biology,
NCCA,
James Fintan Lalor Ave,
Portlaoise,
Co Laois.

A summary of the findings will be published on the NCCA website at the end of the consultation.

Appendix 3 – List of organisations who responded to the online questionnaire

The online questionnaire was open to all who wanted to participate. Some responded on behalf of an organisation and gave permission for the organisation to be listed as a respondent. The table below gives the list of such organisations.

TCD Chemistry Education Research Group
Mercy Secondary School Waterford
Dungarvan CBS
St Angela’s college Sligo
University of Limerick
National University of Ireland Galway
Caritas College
St. Peter’s College, Wexford
Gaelcholáiste Charraig Uí Leighin
Professional Development Service for Teachers
University of Limerick
Director CASTeL at Dublin City University
Crescent College Comprehensive S.J.
Royal Society of Chemistry
Chemistry Department - St Brendan's College - Killarney
ISTA
Dunshaughlin Community College
Ratoath College
Kilkenny College
McEgan College Macroom
Coláiste Ghlór na Mara

Appendix 4 - Focus Group Questions

What is your first impression having read the Background Paper?

The Background Paper highlights the importance of having a clear, common purpose for LC Physics, Chemistry, Biology curricula.

What do you think should be the purpose of LC Physics, Chemistry and Biology?

Chapter 5 pages 27-31 discusses issues involved in assessing learning, it draws on findings from the SEC trial of practical assessment and points to commissioned research for an international perspective on coursework and practical assessment in senior secondary science

What do you think are the opportunities presented by the inclusion of a coursework assessment component for LC PCB? What are the challenges?

The brief for the review of LC PCB asks the SDGs to consider a number of areas in developing contemporary LC PCB curricula.

What should contemporary curricula for LC PCB address?

Appendix 5 – Student Voice Consultation

General

- What, to your understanding, is Science?
- How do you see science as relevant to your life?
- What do you think are the most important things you've learned in [JC/J Cert Science/ LC Science subject]?
- Why do you think learning science is important?
- What do you like about science lessons?
- Do you find learning science challenging? Why?/Why not?
- How important is technology for you in learning science?
- What is the best thing you have done in science this year? What did you learn from this?

Junior Cycle Science

- What did you enjoy most? Why?
- What would you change? Why? How?
- If there was something different you'd like to learn in [JC Science or LC Subject] what would it be?

CBAs/Junior Cert Science

- What did you enjoy most? Why?
- What would you change? Why? How?

Leaving Certificate Science

- Are you thinking of studying LC Science subjects? /What do you enjoy most about your LC Science subjects?
- Which subjects? Why?
- What is influencing your decision(s)?
- What should LC science subjects do for you?
- Are you thinking of pursuing science after secondary school?
- Which area/pathway? Why?
- What is influencing your decision(s)?

NCCA

January 2020