The design of Leaving Certificate science syllabi in Ireland: an international comparison

Report prepared by Áine Hyland

(Emeritus Professor of Education, University College Cork)

for the annual conference of the

Irish Science Teachers' Association

12th April 2014

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Executive Summary

The Leaving Certificate syllabi in physics, chemistry and biology are currently being revised by the National Council for Curriculum and Assessment (NCCA). During the course of the revision, concerns about the proposed design and content of the new syllabi were raised by the Irish Science Teachers Association (ISTA). In particular, ISTA is of the view that it is not sufficient to present the draft syllabi only in terms of broad topics and learning outcomes. I was asked by ISTA to undertake research on the design and specification of syllabi, and to identify international best practice in curriculum design and particularly in the design of science syllabi. This report is the outcome of the research.

In benchmarking the format, design and content of the proposed new syllabi against international comparators, this report has focused on centralised (not school-based) systems of assessment and certification. In each of the three systems chosen - Scotland, Victoria (Australia) and the International Baccalaureate Organisation (IBO) – the assessment and certification of pupil performance at senior cycle is centralised. The three systems are also similar to the Irish system in terms of the breadth of the curriculum at senior cycle, i.e. pupils take six or more subjects for award purposes. They are also systems which are regarded as high-stakes, in that their awards are accepted by prestigious third level institutions for the selection of students. And in all three cases, the curriculum and syllabi have either been recently revised or are in the process of revision. The main focus of comparison in the report is on the format, extent and depth of treatment of the topics associated with the examination syllabi.

Comparing senior cycle science syllabi in the three systems chosen with the NCCA draft Leaving Certificate science syllabi, the report notes a significant difference between the three systems and the NCCA draft syllabi. While the NCCA documentation resembles the national curriculum and assessment guidelines of Education Scotland, and of the Australian Curriculum and Assessment Authority, it differs significantly from the detailed examination syllabi provided by the examining and awarding bodies in Scotland (the Scottish Qualifications Authority), in Victoria, Australia (the Victorian Curriculum and Assessment Authority) and the International Baccalaureate Organisation (IBO).

It would appear that for international benchmarking purposes, the NCCA has used the curriculum framework *Curriculum for Excellence* of Education Scotland, and the national curriculum framework for the whole of Australia, set by the Australian Curriculum, Assessment and Reporting Authority (ACARA), rather than the examination syllabi provided by the Scottish Qualifications Authority (SQA) and by the state of Victoria's Curriculum and Assessment Authority (VCAA), which in the view of this researcher are the more relevant benchmarks.

The report concludes that it is not sufficient to describe a high-stakes examination programme in terms merely of topics and learning outcomes, as the NCCA has done in the draft syllabi. More detailed information about the depth of treatment of subjects and the requirements for examination must be provided at national level in Ireland to bring the syllabi into line with international good practice. Such information could be in the form of course and unit support notes (as in Scotland) or study design (as in Victoria) or a comprehensive chemistry interactive syllabus (as in the IBO). The "depth of treatment" approach with which Irish chemistry teachers have been familiar for the past decade would be another option.

In every public examination system identified for this report, the syllabi for the end of senior cycle examinations include considerable detail about depth of treatment, examination specification, practicals and laboratory experiments and other advice for teachers and pupils. While learning outcomes are specified in all the syllabi, they are only one element of the detail provided. This researcher has not come across any centralised or public examination syllabus at this level which provides only a list of topics and learning outcomes.

The report argues that while learning outcomes are a very valuable tool for identifying what learners should know and be able to do at the end of a course or programme, it is not appropriate to use learning outcomes alone to define a syllabus and its assessment. Learning outcomes are statements of essential learning, and as such they are written at minimum acceptable or threshold (pass / fail) standard. If teachers focus only on learning outcomes, there is a real risk that the teaching and learning targets will be at a minimum rather than a maximum level, that the bar will not be set high enough for student learning, and that as a result, standards will fall.

The draft syllabi for physics, chemistry and biology have now been submitted by the NCCA to the Minister for Education and Skills who (under the terms of the 1998 Education (Ireland) Act) is the ultimate decision-maker in relation to curriculum and examinations. It is a matter for the Minister to decide on the next steps. He can accept or decline the advice of the NCCA or he can refer the draft syllabi back to the NCCA for further elaboration on the basis suggested above. Alternatively, he can seek more elaboration on the syllabi elsewhere, e.g. from the inspectorate or the SEC. Whichever approach the Minister decides to take, the full range of syllabus documentation (including teachers' notes, examination specifications etc.) should be officially published at the same time as the syllabus itself, under the logo of the DES as has been the case in the past. This elaborated documentation should be available well before the syllabus is due to be implemented, to enable teachers to become familiar with the new material and to undergo appropriate professional development and up-skilling.

Chapter 1

Historical Background

1.1 Introduction

The Leaving Certificate syllabi in physics, chemistry and biology are currently being revised by the National Council for Curriculum and Assessment (NCCA). During the course of the revision, concerns about the proposed design and content of the new syllabi were raised by the Irish Science Teachers Association (ISTA). The association is particularly concerned that the proposed new syllabi comprise only broad topics and learning outcomes and that they contain no indication of the depth of treatment required. There is also concern about the lack of clarity regarding mandatory experiments and the assessment of practical work. I have been asked by ISTA to undertake research on the design and specification of syllabi, and to identify international best practice in curriculum design and particularly in the design of science syllabi. This report is the outcome of the research.

The focus of the report is the established Leaving Certificate (LC) and specifically the design and content of the proposed new physics, chemistry and biology syllabi[1]. The Leaving Certificate is awarded on the basis of the results of a public examination, set and marked centrally by the State Examinations Commission[2]. It is regarded as a high stakes examination and is accepted by all higher education institutions in Ireland and by many overseas universities for student selection to third level education. It is important that both the syllabi and their assessment continue to be regarded as comparable to other highly-regarded syllabi internationally, hence the focus on international benchmarking in this report.

The research questions addressed in this report are:

- What is the historical context of syllabus development in Ireland?
- What is international good practice in the drafting of syllabi for second-level curricula?
- Is the current reform of Leaving Certificate syllabi in Ireland in line with international good practice?

I have long had an interest in curriculum and assessment. This interest was sparked more than 40 years ago - in the early 1970s - when I was completing my Masters' degree in education in Trinity College Dublin. The curriculum development unit of the City of Dublin VEC was located in the education dept of Trinity College at that time and a number of students, who were practising teachers, undertook curriculum development projects as part of their Masters' studies. In 1971, the new primary school

1 The report does not address the Leaving Certificate Applied nor is it concerned with the junior cycle.

2 The draft specifications for the new Leaving Certificate physics, chemistry and biology syllabi indicate that it is proposed to introduce two assessment components – written examination (70%) and assessment of practical work (30%) - both components will be externally assessed.

curriculum (radically different to what had gone before) had been introduced and during the seventies, there was pressure from a number of sources on the Department of Education to reform the second level curriculum.

In 1984, the interim Curriculum and Examinations Board was set up by government, and I was appointed as a member of that board. During the life of the interim board (four years) I chaired the Joint Committee which recommended revision of the junior cycle curriculum. I was also intimately involved in the discussions about the reform of senior cycle and of assessment and certification. The reports which were issued at the time are as relevant today as they were then[3]. However, very few of the recommendations of the CEB were implemented and many of the lessons learned about curricular reform in Ireland thirty years ago are valuable in the context of this project.

Among the issues which were discussed in the 1980s, the following are relevant to the current project. What should be the remit of a Curriculum **and** Examinations Board? Would it be an advisory board or would it have executive functions? Would it have responsibility for curriculum and assessment (including public examinations)? How would it relate to the Department of Education inspectorate, which up until then had full responsibility for the second level curriculum and for the public examinations system? How would it be constituted – would it be a representative board (i.e. representative of the education partners, including teachers) or would it consist of curriculum experts? How much consultation would the board engage in? What model of curriculum and syllabus design would it adopt? To what extent would it be influenced by international developments and practice?

These and other questions, as well as Posner's framework for curriculum analysis[4], have informed my approach to this research.

1.2 History of the Design of Second-Level Curriculum and Syllabi in Ireland

It is not my intention in this report to provide a detailed history of the design of second level curriculum in Ireland but some aspects of that history are worth mentioning insofar as they have a bearing on the current debate.

The public examinations system in Ireland had its origins in the Intermediate Education Act of 1878. Under that act, there were originally three grades of public examination – Junior, Middle and Senior grades. The Intermediate Board was responsible for deciding the "Programme of Examinations" for each subject and for setting and marking the examination papers at the end of each school year. There was no overall curriculum framework and each individual subject programme was effectively autonomous and unrelated to any other subject. Programmes of examination were presented in terms

3 These reports included *Issues and Structures in Education – a consultative document (September 1984); Assessment and Certification – a consultative document* (January 1985); *In Our Schools: a Framework for Curriculum and Assessment* (March 1986); and *Senior Cycle: Development and Direction – a consultative document* (November 1986).

4 George J. Posner, *Analyzing the Curriculum: Third Edition* (2004). Boston: McGraw Hill.

of content only and each programme took up less than half a page in the Intermediate Board's "Rules and Programme".

The public examination system quickly came to dominate Irish second-level education, since the only public funding available to schools between 1878 and 1922 were the "results fees" – based on students' results in the public examinations. Without the slightest doubt, the examinations were "the tail that wagged the curriculum dog"[5] during the period 1878 to 1921, as even a cursory analysis of text-books, inspection reports and examination papers from that period shows.

After independence in 1921, payment by results was abolished and the structure of the education system changed. The Department of Education was set up in 1922 and the three separate bodies administering Irish education (the National Board; the Intermediate Board and the Technical Instruction Branch of the Department of Agriculture and Technical Instruction) were brought together under the terms of the Ministers and Secretaries Act. The Junior, Middle and Senior grade examinations were replaced by the Intermediate and Leaving Certificates but the programme of examinations continued to be set centrally by the secondary inspectorate of the newly formed Dept. of Education. The programmes were published in terms of content only and examinations continued to dominate the work of secondary schools.

1.3 Report of the Council of Education 1960

In the 1950s a Council of Education was established to report on the primary and secondary school curriculum. Its report on the secondary curriculum was published in 1960[6]. This report referred to the "syllabi" (as opposed to "programmes of examination") for the various subjects and pointed out that there were four separate Science syllabi for Inter Certificate:

- Syllabus A - Physics and Chemistry;
- Syllabus B – Physics, Chemistry, Botany and Hygiene;
- Syllabus D (for girls only); General Physics; Heat; Chemistry; Hygiene.
- Syllabus E – Non-experimental Course.

For the Leaving Certificate at that time there were six distinct science syllabi:

- Physics;
- Chemistry;
- Physics and Chemistry;
- General Science;
- Botany (introduced in 1924);
- Physiology and Hygiene (introduced in 1924).

5 Andy Hargreaves, *Curriculum and Assessment Reform* (1989) Milton Keynes: Open University Press.

6 Department of Education, *Report of the Council of Education on the Curriculum of the Secondary School (1960)* Dublin: Stationery Office.

The Council of Education was not sympathetic to the growing world movement to give greater emphasis to science in second level curricula. It did not support the inclusion of science in junior cycle as a mandatory subject nor did it support the notion of a practical approach to science teaching, stating[7]:

> The aim of science education is cultural rather than practical: the purpose is not to impart specialised knowledge, nor to give manipulative skill, but rather to provide that broad knowledge of the laws of nature which will leave the pupil with an intelligent general understanding of the physical universe in which he lives. …

The report set out the purpose of science teaching at junior and senior cycles as follows:

> The purpose of science studies in the junior secondary curriculum is to give a basic knowledge of science and of what it has achieved in the history of mankind and to make the young person realise the importance of scientific research….. (At senior cycle) the purpose is to lay solid foundations for future specialisation in pure or applied science and for those who do not propose to undertake such specialisation, to extend their general education.

The report of the Council of Education did not have a major influence on Irish education in the subsequent decades as it was regarded as an unduly conservative report in an era where traditional attitudes to education were beginning to change. In the decade following the introduction of free education in 1967, the emphasis in second level education was on meeting the increase in demand for places rather than on curriculum reform. Some changes did however occur in science education. Biology was introduced in 1966 for the first time as a subject for the Intermediate Certificate and in 1969, a new Leaving Certificate programme in Biology was introduced which included zoology, genetics, ecology, and evolution as well as botany and physiology. In 1972, the Intermediate science syllabus was revised, and in 1975 the biology Leaving Certificate syllabus was also revised.

1.4 Curriculum and Examinations Board 1984-8

It was not until the 1980s, a quarter of a century after the publication of the report of the Council of Education, that the issue of curriculum reform was addressed again – this time with the setting up of the interim Curriculum and Examinations Board in 1984. *Inter alia*, the Board was asked to draw up a curriculum framework for junior and senior cycle and ultimately, each syllabus would be revised in the light of the new frameworks. This model of curriculum development was to become the norm and informs curriculum and syllabus design in Ireland and internationally to the present day.

7 *Ibid.* p. 186.

1.5 The National Council for Curriculum and Assessment 1988

It was intended that the CEB would be a statutory body and that it would have responsibility for advising on curriculum and assessment AND would have executive responsibility for the examinations system. However, this did not happen. In 1988, following a change of government, the CEB was abolished and the National Council for Curriculum and Assessment (NCCA), which was an advisory body without executive functions, was set up. The NCCA was not initially a statutory body but in 1998, its proposed structure and functions were set down in Section 38 of the Education Act[8]. The NCCA was established on a statutory basis in 2001 "to advise the Minister on matters relating to (a) the curriculum for early childhood education, primary and post-primary schools and (b) the assessment procedures employed in schools and examinations on subjects which are part of the curriculum".

1.6 The State Examinations Commission 2003

For a number of years after the setting up of the NCCA, the inspectorate of the Department of Education continued to set and administer the public examinations and it was not until March 2003 that the State Examinations Commission (SEC) was established by statutory order. The SEC assumed responsibility for the operation of the state certificate examinations from 2003 onwards. The SEC is described as "a non-departmental public body under the aegis of the Department of Education and Skills. It is responsible for "the development, assessment, accreditation and certification of the second-level examinations of the Irish State – the Junior Certificate and the Leaving Certificate".[9,10]

In relation to second level education, Ireland now has two separate bodies with different roles relating to assessment and examination – the NCCA and the SEC. The NCCA advises on assessment and examinations and the SEC administers the public examination system. Both bodies report to the Minister for Education and Skills who, under the terms of the 1998 Education Act, has ultimate responsibility for curriculum and assessment.

1.7 Curriculum and Syllabus Reform in the 1980s and 1990s

The NCCA is composed of representatives of various education and industry/business partners. Work on individual syllabi is overseen by so-called "development groups" (referred to in the past as syllabus or course committees). The composition of these

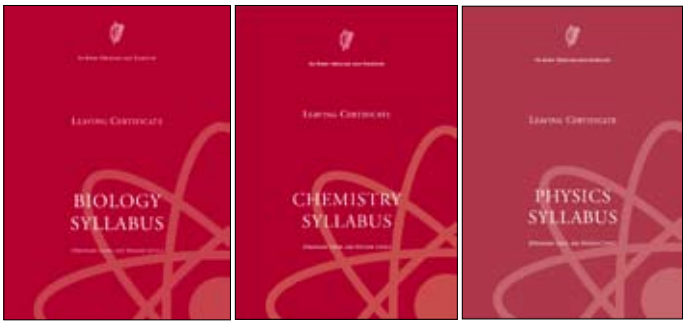
8 Govt. of Ireland, *Education Act (Ireland) 1998*, Section 38.

9 http://www.education.gov.ie; and http://www.examinations.ie.

10 It is of interest to note that, unlike some other countries (e.g. Scotland), the National Qualifications Authority of Ireland (NQAI), set up under the Qualifications (Education and Training) Act 1999 – now subsumed into the Qualifications and Quality Authority - has no role in relation to awards or qualifications at second level. Its role is limited to further and higher (non-university) education.

subject-specific groups has varied slightly from time to time since the 1980s. Currently, each group includes representatives of the teacher unions (ASTI and TUI); management bodies (JMB and IVEA); the university sector (IUA); IBEC; the SEC; the inspectorate of the DES; the relevant subject association and two other members with relevant expertise.

Throughout the late 1980s and early 1990s, the NCCA engaged with the education partners through the members of the council and its course committees / development groups as well as by public consultation, in the review and reform of curriculum and syllabi. A syllabus design framework was agreed and individual subject syllabi were issued from the mid-1990s onwards. Revised syllabi for Leaving Certificate biology, chemistry and physics were implemented between 2000 and 2002 and were first examined in 2004 - 2006[11]. These syllabi were in the format of "Maroon Books" for each subject (between 45 and 75 pages) and were accompanied by Guidelines for Teachers – one for each subject (c.100 pages). Both the syllabi and the Guidelines for Teachers were approved by the Minister for Education and Science and were issued under the logo of the DES[12].



Participants at this conference will be familiar with the so-called "Maroon Books" which became the bible of subject teachers during the past decade or so. The format of the maroon books is consistent and clear across subjects, with a couple of pages setting out the policy context, an introduction outlining the aims (about six bullet points) and structure of the syllabus together with a paragraph on assessment. The syllabi identify a number of key topics (the number varies for different subjects) but is usually in the region of between five and 15 topics. The main body of the maroon book contains a statement of objectives for each subject (distinguishing between ordinary and higher levels) under the headings - knowledge; understanding; skills; competence and attitudes. In the case of senior cycle science subjects, the syllabus is set out in four columns – content; depth of treatment; activities; and social and applied aspects. The syllabus and guidelines are available in hard copy and online (www.curriculumonline.ie). The following page from the current Leaving Certificate chemistry syllabus is an example of the format and layout used:[13]

11 The revised Leaving Certificate chemistry and physics syllabi were introduced in 2000 and the Leaving Certificate biology syllabus was introduced in 2002.

12 www.curriculumonline.ie and hard copies of syllabi published by the Stationery Office under the logo of the Dept. of Education and Science.

13 Examples from the physics and biology syllabi are provided in the appendix.

Extract from current chemistry syllabus

7. ORGANIC CHEMISTRY (CONTINUED)			
Content	Depth of Treatment	Activities	Social and Applied Aspects
7.2 Planar Carbon (continued)	Ketones: structure and nomenclature up to C-4.		
	Physical properties [physical state, solubility (qualitative only) in water and in non-polar solvents].	Solubility of propanone in (i) cyclohexane and (ii) water.	Propanone as a solvent (e.g. in nail varnish remover).
	Carboxylic acids: polar double bond. Structure and nomenclature up to C-4.	Solubility of ethanoic acid in (i) cyclohexane and (ii) water.	Methanoic acid in nettles and ants; ethanoic acid in vinegar. Use of ethanoic acid in the manufacture of cellulose acetate (structure of cellulose acetate not required).
			Use of propanoic acid and benzoic acid and their salts as food preservatives (structure of benzoic acid not required).

The revised physics, chemistry and biology syllabi, introduced between 2000 and 2002 were well received by science teachers. They have stood the test of time well and have now been in use for over a decade. They played a part in halting the decline in the number of students taking chemistry and biology in senior cycle. During the 1990s, the numbers of pupils taking chemistry fell from over 10,000 in 1987 to 6,356 in 2001. Following the introduction of the new syllabi the numbers taking chemistry increased to 8,155 in 2013 and the numbers taking biology increased from 22,000 in 2002 to over 31,000 in 2013. (Details in Appendix).

The formats of the biology and physics syllabi are shown overleaf.

Extracts from current biology and physics syllabi

2.2 CELL METABOLISM (CONTINUED)			
Sub-unit and Topic	Depth of Treatment	Contemporary Issues and Technology	Practical Activities
2.2.5 Respiration	Definition and role of "aerobic respiration". Representation by a balanced equation of the overall sequence of reactions for glucose. A simple treatment of aerobic respiration of glucose by reference to a two-stage process. Stage 1 does not require oxygen and releases a small amount of energy. Stage 2 does require oxygen and releases a large amount of energy. Definition of "anaerobic respiration". Reference to fermentation. Cellular location of the first and second-stage process.	Examine the role of micro-organisms in industrial fermentation, including bioprocessing with immobilised cells: procedure, advantages, and use in bioreactors.	Prepare and show the production of alcohol by yeast.
2.2.6 Movement through Cell Membranes	Selective permeability of membranes surrounding the cells and within the cells. Definition of the terms "diffusion" and "osmosis". Examples of each. Definition of "turgor". Simple explanation of turgidity in plant cells.	Describe the application of high salt or sugar concentration in food preservation.	Conduct any activity to demonstrate osmosis.

VIBRATIONS AND SOUND			
Content	Depth of Treatment	Activities	STS
1. Wave nature of sound	Reflection, refraction, diffraction, interference. Speed of sound in various media.	Demonstration of interference, e.g. two loudspeakers and a signal generator. Demonstration that sound requires a medium.	Acoustics. Reduction of noise using destructive interference. Noise pollution.
2. Characteristics of notes	Amplitude and loudness, frequency and pitch, quality and overtones. Frequency limits of audibility.		Dog whistle.
3. Resonance	Natural frequency. Fundamental frequency. Definition of resonance and examples.	Demonstration using tuning forks *or* other suitable method.	Vocal cords (folds).
4. Vibrations in strings and pipes	Stationary waves in strings and pipes. Relationship between frequency and length.	Use string and wind instruments, e.g. guitar, tin whistle.	String section and woodwind section in orchestras.

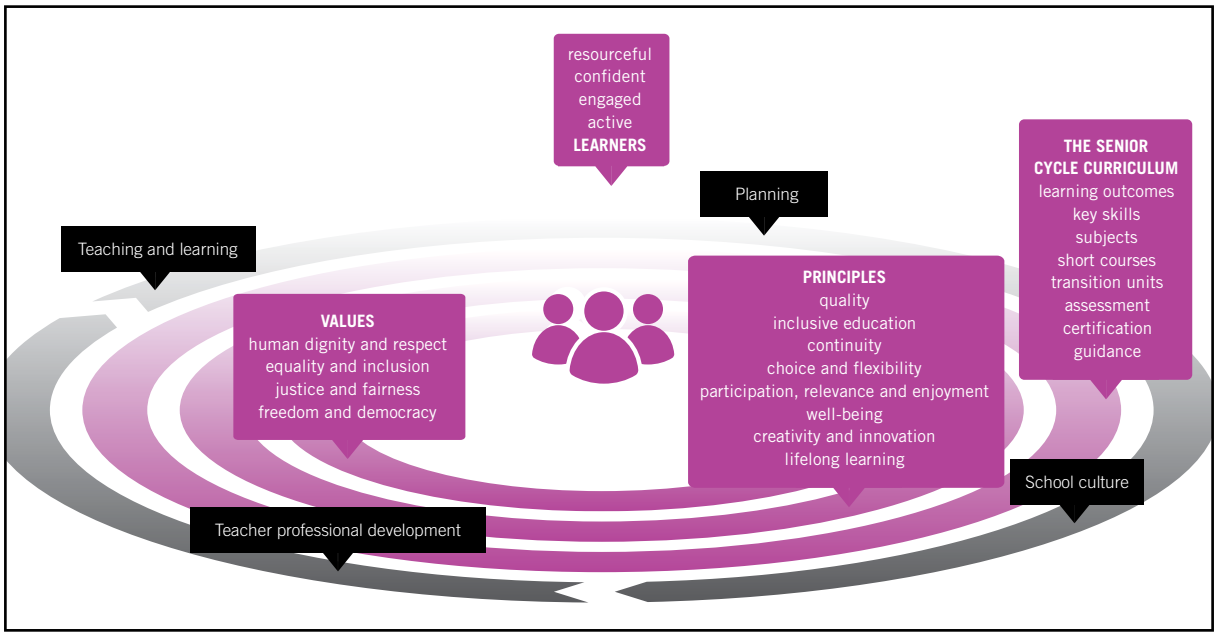
Chapter 2

The Revision of Science Syllabi

2.1 Towards Learning: An Overview of Senior Cycle Education 2009

The print on the revised subject syllabi was hardly dry when the NCCA began to review senior cycle education again. In 2003, the NCCA issued a consultative document *Directions for Development* and began extensive consultations with education stakeholders and the public on the future direction of senior cycle[14]. As well as taking account of the views of the stakeholders, including teachers, students and management, the review was informed by research carried out by the Economic and Social Research Institute (ESRI), by international research and by other national and international developments.

In 2009, the NCCA issued the outcome of its deliberations in a document entitled *Towards Learning: An Overview of Senior Cycle Education*[15]. The following diagram provides an overview of senior cycle as provided in the document:



Influenced by the Lisbon strategy and the National Skills Strategy (2007) the approach to senior cycle curriculum emphasised a skills approach to curriculum development. The five Key Skills of information processing; being personally effective; communicating: critical and creative thinking; and working with others were to be central to the development of the senior cycle curriculum.

14 NCCA (2003) *Developing Senior Cycle Education: Directions for Development* http://www.ncca.ie/uploadedfiles/DirectionsforDevEng.pdf

15 NCCA (2009) *Towards Learning: Listening to Schools* http://www.ncca.ie/en/Curriculum_and_Assessment/Post-Primary_Education/Senior_Cycle/Towards_Learning_an_overview_/Towards_learning_listening_to_schools.pdf

The principles underpinning the curriculum are:

- Quality
- Inclusive education
- Continuity
- Choice and Flexibility
- Participation, relevance and enjoyment
- Well-being
- Creativity and innovation
- Lifelong learning.

With a view to ensuring coherence and consistency across all subjects, each syllabus would follow the following structure:

- Introduction to senior cycle
- The introduction, rationale, aim and objectives for the subject or short course
- A statement about the disposition/capacities, competences/skills, types of understanding/intelligence which are considered important to experiencing and achieving success in the subject
- Related learning
- Syllabus overview
- Statements on key skills, differentiation, teaching and learning and reasonable accommodations
- The syllabus material expressed as topics and learning outcomes
- The assessment arrangements and general assessment criteria that apply for the examination.

The document *Towards Learning* did not indicate the detail which would be provided under the headings "Syllabus Overview" or the heading "The syllabus material expressed as topics and learning outcomes". This will be an issue which will be further explored in this report.

2.2 New Senior Cycle Syllabi

Following the publication of the document *Towards Learning*, the NCCA began to revise the individual subject syllabi. The first syllabus to be developed under the new framework was a syllabus for *Politics and Society* – a proposed new Leaving Certificate subject. Following a lengthy consultation period, this syllabus was approved by the Council in 2011 and was forwarded to the Minister for Education and Skills for approval. That new syllabus has not yet been introduced in schools. To quote from the NCCA website "Opportunities for introducing the new subject to schools are currently being explored".

A new syllabus is also being prepared for **Physical Education**. This will also be a new Leaving Certificate subject. It is significant that the two syllabi developed by NCCA to date using the new framework in *Towards Learning* relate to two subjects which have not previously been examination subjects. Since neither of them has yet been approved by the DES for delivery, there is not yet any on-the-ground experience of the implementation of the syllabus framework at Leaving Certificate level. **The three science syllabi are the first existing LC subjects to be revised under the new framework**. Hence it is particularly important that the proposed design and format of the proposed syllabi be scrutinised and analysed to ensure that the theoretical framework is meaningful and capable of implementation. All education partners share the same vision – Ireland must continue to provide a high quality curriculum for all its young people and in particular the Leaving Certificate must maintain its highly-respected national and international status.

2.3 New Draft Physics, Chemistry and Biology Syllabi 2011

In February 2011, draft revised LC physics, chemistry and biology syllabi were approved by the NCCA Council for consultation. The consultation process had a number of different elements including an online questionnaire and opportunity for written submissions as well as meetings with the subject associations, science teacher networks, third level students, representatives of the STEM industries and third level science departments. The consultation process began in April 2011 and ended in December 2011.

In October 2011, Charles Dolan, IBEC, then President of the ISTA, wrote to the NCCA welcoming the opportunity to comment on the proposed syllabi revision[16]. He emphasised the importance of attracting more students to study science while improving the quality of provision. He made two significant recommendations – (1) that the second mode of assessment be piloted with one of the three senior cycle syllabi before being rolled out in all three subjects, and (2) that the reality of the IT situation be taken into account before assuming that all schools would have adequate broadband access and proper IT facilities for the implementation of the revised syllabi. Detailed recommendations about the proposed content of the syllabi were also made – in the case of chemistry, for example, concerns were expressed about the length of the syllabus and the lack of adequate guidelines on depth of treatment. The lack of availability of laboratory time and resources to enable the practical work to be carried out was also raised. Detailed suggestions were made by the biology sub-committee – they requested more detailed guidelines on depth of treatment of topics and concern was expressed that some of the learning outcomes were too broad and vague. The physics sub-committee also indicated that the depth of treatment of topics was unclear and raised a number of detailed questions about specific aspects of the drafts. The submissions are reproduced in the Appendix.

16 http://www.ncca.ie/en/Consultations/Senior_Cycle_Science/genISTA.pdf

The NCCA *Report on the Consultation* was issued in April 2012[17]. All written submissions made are available online thus making it possible to analyse the extent to which concerns expressed during the consultation process were taken on board. The report admits that while there was broad welcome for the focus of the review, and a general acceptance that learners should engage in inquiry with the attendant change in focus of the practical activities as currently undertaken, the process failed to reach consensus on the issue of reducing the current content of the syllabi. The report stated:

> As learners develop knowledge and understanding of fundamental science concepts and ideas, they will develop key skills and appreciate how science impacts on society. To enable this to happen and to be achievable within the 180-hour time frame, the learning outcomes will have to be limited in number, but rich in content. This is an area where the consultation process failed to reach consensus. ….. There is also new content to be added….

The concerns expressed by the ISTA in their written submission continued to be voiced by some members of the NCCA physics, chemistry and biology development groups as they met during 2012 and 2013 to finalise the revised syllabi. The fact that the format and design of the syllabi had already been pre-determined and that decisions about lay-out and content appear to have been made before the development groups met, led to some members feeling that their role was only one of rubber-stamping, rather than genuine engagement. Some members of the NCCA development groups have indicated that they did not "sign off" on the draft syllabi and some members of the development groups, including ISTA representatives and some university representatives, voiced their disagreement with the draft syllabi throughout the course of the development of the syllabi.

On 6th October 2013, the chairperson of ISTA, Mary Mullaghy, wrote to the NCCA expressing concern about issues which had occurred in all three of the science development groups[18]. As well as drawing attention to concerns that changes were being made to syllabi without proper discussion and consensus among the members of the relevant development groups, she drew attention to the unsatisfactory structure of the proposed syllabi and the lack of clarity in relation to the depth of treatment. She stated:

> The essential problem with the proposed draft syllabi is that they simply contain a list of learning outcomes with no indication re depth of treatment or range of subject knowledge associated with these learning outcomes. We request that this depth of treatment and range of subject knowledge be integrated into the draft syllabi (as is the case with the syllabi currently being taught) before they are finalised by NCCA council. It is vital that this important material is embedded into each of the syllabi and not made available as separate documentation at a later stage. Even highly experienced science teachers at our ISTA Council meeting found problems with interpreting

17 NCCA (2012) *Leaving Certificate Science: Report on the Consultation*. http://www.ista.ie/news/ncca-lc-syllabi-consultation-report

18 Letter dated 6th October 2013 from Mary Mullaghy, Chairperson of ISTA to Dr. Anne Looney, Chief, Executive of the NCCA. This correspondence is reproduced in full in the Appendix.

> many of the learning outcomes. It is clear that there is still a considerable amount of work to be done on the draft syllabi in order to reduce the "fuzziness" of these draft syllabi and thus bring them up to the standard of the current Leaving Certificate Biology, Chemistry and Physics syllabi.

In a further letter to the NCCA on 11th November 2013, Ms. Mullaghy reiterated these concerns. Having assured the NCCA that she was very familiar with international trends of drafting syllabi using learning outcomes, she stated[19]:

> The fundamental problem in Ireland seems to be that the NCCA appears to interpret learning outcomes as replacing all previous methods of syllabus descriptions whereas examination boards in other countries use learning outcomes to enhance syllabus descriptions.

In relation to the lack of depth of treatment in the draft syllabi, she emphasised that the current syllabi are of a high standard, containing, as they do, details of the subject content, details of the depth of treatment, details of teaching activities and details of the social and applied aspects of each syllabus. She explained:

> However, the draft Leaving Certificate syllabi in Biology. Chemistry and Physics as presently constituted contain simply a list of learning outcomes. These draft syllabi (October 2013) are incomplete as they contain no indication of depth of treatment to clarify what is meant by the learning outcomes.

In her letter she also expressed concern about the lack of clarity of mandatory experiments and the lack of clarity on the assessment of practical work[20].

In February 2014, ISTA wrote to each member of the NCCA Council asking them to defer any decision on the ratification of the three Leaving Certificate syllabi until the research undertaken by this researcher has been completed. However, it is understood that the three draft syllabi were ratified by the NCCA Council at its March meeting and that they have now been sent to the Minister for Education and Skills for his approval.

2.4 Draft Syllabi for Leaving Certificate Physics, Chemistry and Biology – February 2014

The draft specifications of the three syllabi are written in accordance with the framework and format set out in the document *Towards Learning.* In the case of Leaving Certificate Chemistry, the total printed documentation comes to less than 50 (double-spaced) pages (more than half of which relates to general introductory sections including the LC curricular framework as well as various associated appendices). The total number of pages dedicated specifically to the draft syllabi is only 12 pages for physics; 18 pages for chemistry and 13 pages for biology.

19 Letter dated 11th November 2013 from Mary Mullaghy to Dr. Anne Looney.
20 The letters from Mrs. Mary Mullaghy to the NCCA are reproduced in full in the appendix.

Each draft document starts with a short section on the "experience of senior cycle" including diagrams on overview and vision. This is followed by a section which introduces the subject and sets out its aims and objectives as well as a section on related learning from early childhood through senior cycle and on to further study. This section also includes an overview of the structure of the syllabus, followed by a sentence on time allocation (180 hours – but no breakdown) and a section on Key Skills; Practical Activities; Teaching and Learning; Technology; and Differentiation. Overall, this introductory material fills approximately 20 pages.

The next section of each draft syllabus outlines the syllabus content. In the case of chemistry, there are five units, each with specified sub-units, headed "*Students Learn About"* (i.e. a topic or sub-topic descriptor). The units and sub-units are simply headings e.g. under *Unit 2. Properties, structures and bonding*, there are six sub-units – *Periodic table and atomic structure; Electronic structure; Bonding; Intermolecular forces; Nanoscience; Oxidation and Reduction.* For each sub-topic, between five and ten learning outcomes are provided, i.e. "*Students should be able to".* Each learning outcomes, as one would expect, consists of one sentence and no further details about issues such as depth of treatment, specific activities, specific assessment criteria or social and applied issues for each topic or sub-topic are provided. This section of the document runs to 18 pages.

The following extract (opposite) from the draft chemistry syllabus indicates the approach taken by the NCCA in setting out the topics and learning outcomes. (The comments in the yellow boxes are inserted by this author to indicate where teachers have suggested that there could be problems of interpretation). Extracts from the draft physics and biology syllabi are provided on p. 22.

This is followed by a short four-page section on Assessment which provides a general description of the two components of assessment – written assessment (70%) and assessment of practical work (30%) both of which will be externally assessed. The information in this section is as follows[21]:

> The written examination will be made up of a range and balance of questions types: short-answer questions, open-ended questions and extended response questions. The questions will require learners to demonstrate understanding, applying, analysing, evaluating and creating appropriate to each level. The key skills are embedded in the learning outcomes and will be assessed in the context of the learning outcomes.

This section also provides broad guidelines (using the language of Bloom's Taxonomy) for the assessment of examination papers. The three final (short) sections of the chemistry syllabus (totalling seven pages), consist of a section on mathematics for chemistry, reasonable accommodations and a glossary of terms.

21 NCCA *Leaving Certificate Chemistry: Draft Specification,* p. 41. (Feb 2014)

Extract from the draft chemistry syllabus

Students learn about	Students should be able to
2.1 Periodic table and atomic structures What is a student expected to do to achieve this Learning Outcome?	• outline /evaluate the historical contributions to the modern understanding of atomic structure including Dalton, experimental work on cathode rays. Thomson's plum pudding model and Rutherford's work, to illustrate how evidence informs scientific theory • evaluate the Bohr model of the atom • outline further contributions to modify Bohr's model, i.e. sublevels, de Broglie, Heisenberg and Shrödinger • distinguish the terms element, compound, mixture, atom, molecule and ion • explain the meaning of the terms atomic number, mass number, isotope, radioactive isotope,relative atomic mass • appreciate the difference between chemical and nuclear reactions

The three draft syllabi (physics, chemistry and biology) are much shorter than the current syllabi as the following table shows:

Comparison of syllabus lengths		
	Current Syllabus	**Draft Syllabus**
Biology	38 pages (p. 7 – 44)	13 pages (p. 21 – 34)
Chemistry	35 pages (p. 37 – 71)	18 pages (p. 23 – 40)
Physics	20 pages (p. 25 – 44)	12 pages (p. 21 – 33)

Extracts from the biology and physics syllabi are shown overleaf.

Before commenting further on these draft syllabi, I now propose to provide an overview of developments in curriculum, syllabus and assessment reform in some other English-speaking countries, and compare what is happening in those countries to the situation in Ireland.

Extract from the draft biology syllabus

3.6 Genetic engineering, DNA sequencing and bioinformatics Very broad statements and impossible to interpret without further details.	• explain the principles and processes involved in genetic engineering • explain the principle and processes of DNA profiling • explain the principle of DNA sequencing and its use in bioinformatics • outline the main type of therapeutic cloning • evaluate the ethical aspects of stem cell therapy and therapeutic cloning in human biology • evaluate the arguments in the debate surrounding genetically modified crops • *use a genome database to search for alleles that are known to cause (or be responsible for) specific genetic diseases • * produce a DNA profile using electrophoresis

Extract from the draft physics syllabus

2.3 Interference	• apply the properties of waves and the principle of superposition to explain wave interference • *investigate and analyse interference patterns for electromagnetic, sound and water waves • examine the conditions necessary to produce a standing wave
2.4 Electromagnetic spectrum Which properties? What atmospheres? Methane, air? Greenhouse effect?	• demonstrate dispersion • discuss the properties of electromagnetic radiation in terms of their wavelength and frequency • analyse colour combination and filtering • discuss the effects of different atmospheres on ultraviolet and infrared radiation • discuss applications of infrared radiation

Chapter 3

Some Perspectives on Curriculum, Syllabus and Assessment Design Internationally

3.1. Introduction

For the purposes of this report, documentation on curriculum, syllabi and assessment in a number of English speaking countries was identified and scrutinised. I would like to express my thanks to Rory Geoghegan who worked with me in identifying appropriate websites and who helped me to categorise and analyse very significant amounts of material in the process.

The curriculum and examination systems we looked at included those in England and Wales; Northern Ireland; Scotland; Australia; New Zealand; Canada and Singapore. The International Baccalaureate Organisation (IBO) was included in our list, since it is recognised internationally as providing a high-quality rigorous senior cycle curriculum and its Diploma is accepted for entrance to universities worldwide.

For the purposes of the analysis, the systems were categorised under three headings:

- Category I – systems comprising two separate entities or bodies – one responsible for providing a framework or guidelines for curriculum (and sometimes assessment) and a separate body with responsibility for assessing, examining and awarding qualifications.
- Category II – systems in federal countries where centrally devised national curriculum and assessment guidelines are provided but where individual states or provinces are responsible for delivering curriculum and assessment.
- Category III – systems where the same entity is responsible for defining the curriculum and for assessing, examining and awarding qualifications.

3.2. Category I: Systems with two separate entities

From the point of view of legal and statutory responsibilities, **Scotland** has two separate bodies – one with responsibility for providing curriculum and assessment guidelines and another for examining and awarding qualifications. Education Scotland, a Scottish Government executive agency (www.educationscotland.gov.uk) provides curriculum and assessment guidelines but responsibility for qualifications and awards lies with the Scottish Qualifications Authority (www.sqa.org.uk). As the national examining and qualifications awarding body, SQA provides detailed syllabi for each subject at senior cycle level, leading to the award of the Higher and Advanced Higher certificates.

In **Singapore**, the Ministry of Education (www.moe.gov.sg) provides a broad curriculum framework and the Singapore Examinations and Assessment Board (www.seab.gov.sg) provides the syllabi for assessment and examinations. The curriculum details on the Ministry website do not include details for individual subject syllabi. This information is provided by the Singapore Examinations and Assessment Board and is available on its website[22].

Similarly in **New Zealand,** the Ministry of Education provides curriculum guidance (www.minedu.govt.nz) but the New Zealand Qualifications Authority (www.nzqa.govt.nz) is the examining and awarding body and detailed syllabi and examinations material is provided by them.

On the face of it, Ireland would appear to fit into this category. However, while Ireland has two separate bodies – the NCCA which advises the Minister on matters relating to curriculum and assessment, and the SEC which is responsible for "the development, assessment, accreditation and certification of the second-level examinations of the Irish State", in practice the SEC is a purely executive body and the NCCA has, until now, undertaken the role of advising the Minister on national curriculum and assessment guidelines **and** has provided details of individual subject syllabi for the public examinations. The Minister is ultimately the decision-maker on issues relating to curriculum, syllabi and assessment, and Ministerial decisions on these matters have to date been issued (both in print and online) under the logo of the Department of Education and Skills.

3.3 Category II: Systems in federal countries

In countries with federal governments, the national government sometimes provides a broad curriculum and assessment framework/guidelines but legal responsibility for providing education invariably lies with the individual states (Australia and the U.S.) or provinces (Canada). In the case of **Australia**, ACARA - the Australian Curriculum, Assessment and Reporting Authority (www.acara.edu.au) - provides a national curriculum and assessment framework but each individual state has its own curriculum and assessment body which is responsible for curriculum, syllabi and assessments in that state, based on the national guidelines.

In **Canada**, there is no federal department of education and no integrated national system of education. Canada's Constitution Act of 1867 states that "for each province, the legislature may exclusively make Laws in relation to Education".

22 The SEAB sets out the A level syllabus and scheme of assessment for each individual subject at Higher Levels 1 2. Each syllabus covers about 50 pages and includes Assessment Objectives (i.e. Learning Outcomes) , Subject Content, Marks Allocated to Assessment Objectives, Structure of Syllabus, Textbooks and References etc.

3.4 Category III: Systems with one entity or body for curriculum, assessment and awards

In **England and Wales**, a statutory National Curriculum for pupils aged 5 to 16 is set down by the Department for Education – Schools (www.education.gov.uk). This curriculum is examined and assessed at five Key Stages up to GCSE level (c.16 years of age). However, the National Curriculum does not apply at senior cycle – pupils at this level follow A-level and/or AS-level syllabi, usually taking three or occasionally four subjects. There are (at least) five different examination board offering GCE A-level syllabi in a wide range of subjects:

AQA (www.aqa.org.uk) (Previously the Assessment and Qualifications Alliance) – AQA is an educational charity, and is a recognised awarding body in England, Wales and N.I.

OCR (Oxford, Cambridge, and RSA Examinations) (www.ocr.org.uk) operates in England, Wales and N.I and over 150 other countries. It is part of the University of Cambridge's Cambridge Assessment.

Edexcel (www.edexcel.com) – Part of Pearson PLC. In 2010, the legal name of Edexcel became Pearson Education Ltd. (Pearson). It operates in England, Wales, N.I and internationally.

WJEC (www.wjec.co.uk) – Welsh Joint Education Committee provides examinations throughout Wales, England and N.I.

CCEA (www.rewardinglearning.org.uk) – Council for the Curriculum, Examinations and Assessment is a curriculum, assessment and examination board in N.I.

In relation to the UK based examination boards, details of the individual subject syllabi are available on the websites of the various boards. While the amount of information varies, in general, the examining boards provide detailed information on the syllabi and they also provide guidelines for teachers. As these boards are private boards which sell their services, they also provide additional services related to teaching for the examinations such as CPD courses for teachers, books and videos etc.

The **International Baccalaureate Organisation (IBO)** is another system which falls into category III. It has four programmes for students aged 3 to 19, including the Diploma Programme for senior cycle pupils. IBO provides detailed syllabus and assessment documentation for each of the four programmes.

For the purposes of delving deeper into the design and format of curriculum and assessment, this researcher chose one example of good practice from each of the above categories. From Category I, we chose Scotland; from Category II, we chose Australia - specifically the state of Victoria; and from Category III, we chose the International Baccalaureate Organisation (IBO). While the status and legal basis of the three systems chosen are different, the approach to the design of curriculum, syllabi and assessment is remarkably similar in all three.

In each of the three chosen systems, the syllabi are centrally defined and assessment and certification is centralised (i.e. not school-based). Pupils/candidates follow a (relatively) broad curriculum (usually about six subjects) rather than specialising in three subjects, as is typically the case in England and Wales. All three are examples of high-stakes systems, whose awards are accepted by universities and other third level institutions nationally and internationally. Therefore, it seems to this researcher that these three systems are relevant comparators for the Irish Leaving Certificate.

3.5 The Design and Format of Curriculum and Syllabi in Scotland

The curriculum in Scotland is non-statutory and is not dictated by government in the same way as in the rest of the U.K. Education Scotland, a Scottish Government executive agency, provides a framework for learning and teaching but responsibility for what is taught rests with the thirty two local authorities as well as with individual schools, taking into account the national guidelines and advice. The Scottish Qualifications Authority (SQA) is the examining and awarding body for all qualifications in Scotland, including second-level qualifications.

A new curriculum framework *Curriculum for Excellence* was developed in Scotland by Education Scotland, and first implemented in schools in 2010/11. It aims "to achieve a transformation in education in Scotland by providing a coherent, more flexible and enriched curriculum from 3 to 18". The curriculum aims to develop four key capacities, helping children to become:

- Successful learners
- Confident individuals
- Responsible citizens
- Effective contributors.

The diagram opposite provides a schematic guide for curriculum planners involved in implementing the framework curriculum for Excellence.

In May 2011, the *Curriculum for Excellence* Management Board published a statement outlining the vision, principles and framework for delivery of the senior phase of Scottish education (for pupils aged 16-18). A Senior Phase Benchmarking Tool is currently being

A curriculum framework to meet the needs of all learners 3 – 18
A schematic guide for curriculum planners

Values
Wisdom, justice, compassion, integrity

The curriculum must be inclusive, be a stimulus for personal achievement and, through the broadening of experience of the world, be an encouragement towards informed and responsible citizenship.

The curriculum: 'the totality of all that is planned for children and young people throughout their education'

- Ethos and life of the school as a community
- Curriculum areas and subjects
- Interdisciplinary learning
- Opportunities for personal achievement

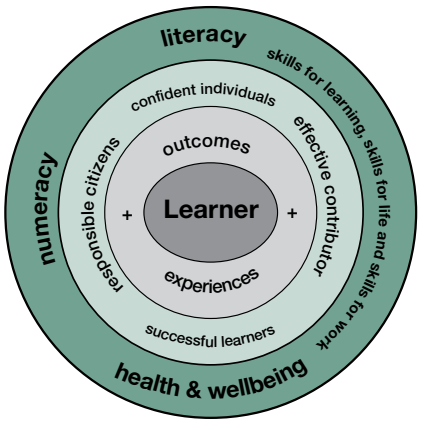
Learning and teaching

- Engaging and active
- Setting challenging goals
- Shared expectations and standards
- Timely, accurage feedback
- Learning intentions, success criteria, personal learning planning
- Collaborative
- Reflecting the ways different learners progress

Experiences and outcomes set out expectations for learning and development in:

- Expressive arts
- Languages and literacy
- Health and wellbeing
- Mathematics and numeracy
- Religious and moral education
- Sciences
- Social studies
- Technologies

Curriculum levels describe progression and development.



All children and young people are entitled to experience

- a coherent curriculum from 3 to 18
- a broad general education, including well planned experiences and outcomes across all the curriculum areas. This should include understanding of the world and Scotland's place in it and understanding of the environment
- a senior phase which provides opportunities for study for qualifications and other planned opportunities for developing the four capacities
- opportunities for developing skills for learning, skills for life and sklls for work
- opportunities to achieve to the highest levels they can through appropriate personal support and challenge
- Opportunities to move into positive and sustained destinations beyond school

Personal Support

- review of learning and planning of next steps
- gaining access to learning activities which will meet their needs
- planning for opportunities for personal achievement
- preparing for changes and choices and support through changes and choices
- pre-school centres and schools working with partners

Principles of curriculum design:

- Challenge and enjoyment
- Breadth
- Progression
- Depth
- Personalisation and choice
- Coherence
- Relevance

Arrangements for

- Assessment
- Qualifications
- Self-evaluation and accountability
- Professional development

support the purposes of learning

prepared "to support local authorities, secondary schools and teachers in analysing the performance of pupils in the senior phase of Curriculum for Excellence[23]". This tool will go live in August 2014.

While curriculum and assessment guidelines and tools are made available by Education Scotland, details of assessment and examination syllabi for certification purposes are provided by the Scottish Qualifications Authority (SQA). Until the end of junior cycle, assessment is school-based. At senior cycle the Higher and Advanced Higher courses are nationally assessed, ***and syllabi for individual subjects are provided by the SQA***[24]. These syllabi are currently in the process of revision to bring them into line with the *Curriculum for Excellence*.

23 http://www.education Scotland.gov.uk/the curriculum/

24 This point is emphasised, as this is where the system in Scotland differs from that in Ireland. The examining and awarding body in Ireland (SEC) does not provide detailed syllabi or programme of examinations. Insofar as detailed information is made available, it has been provided until now by the DES on the advice of the NCCA.

While detailed course specifications are provided at all levels of the curriculum (including those which are assessed at school level) the course specifications (or syllabi) are particularly detailed for subjects which are nationally/centrally examined i.e. for the Scottish Higher and Advanced Higher certificates.

In the case of the Higher Chemistry course for example, which will be examined for the first time in August 2014, the official documentation totals over 200 pages and is available on the SQA website (www.sqa.org.uk/sqa/47913.html) under the following headings[25]:

Mandatory Information:

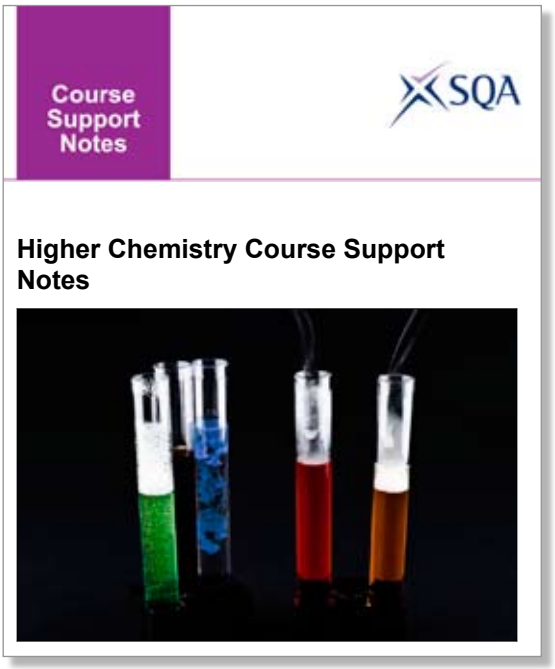
- Course Specification (11 pages)
  (Under this heading the units are set out in terms of Learning Outcomes only)
- Course Assessment Specification (13 pp)
- Unit Specifications (24 pp)

Advice and Guidance

- Course and Unit Support Notes (91 pp)
  (The support notes are set out in three columns, headed Content; Notes and Possible Contexts and Activities).
- Specimen Question Paper and Marking Instructions (56 pp)
- Unit Assessment Support (available to Teachers only).

The Course and Unit Support Notes are particularly relevant to this discussion. Teachers, pupils, syllabus designers and those involved in setting and marking laboratory work, assignments and examinations would find these course and unit notes very useful. A page from these support notes (see following pages) indicates the depth of treatment expected for each topic and also provides invaluable suggestions for busy teachers for possible resources (online and print). Each one of the topics is treated in this way.

The following is an example from the course notes for higher chemistry in Scotland. Examples from the physics and biology course notes are given in the appendix.



25 A screenshot of the relevant overview is provided in the appendix.

Nature's Chemistry		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
Esters, fats and oils Esters — naming, structural formulae and uses. Fats and oils, esters condensation and hydrolysis reactions. Saturated and unsaturated fats and oils. Melting points of oils and fats, through intermolecular bonding.	Ethyl ethanoate is an example of a solvent used to extract caffeine from coffee and tea. Decaffeinated products produced with ethyl ethanoate are often described as 'naturally decaffeinated' because ethyl ethanoate occurs in fruits. Caffeine can be extracted from tea by learners using an aqueous solution of sodium carbonate and ethyl ethanoate and a rough percentage of caffeine in the tea leaves calculated. Esters are also used as solvents for dyes, inks, paints and varnishes. Learners will have encountered ester-type smells from non-food products such as car spray paints, permanent marker pens, whiteboard pens and nail varnish removers. Esters are volatile and this leads to high concentrations in air. Further information on current moves to reduce the use of esters as solvents can be found by searching for 'VOC reduction' or 'low VOC' on the internet. An ester is added to distilled water. After 30 minutes, the pH of the mixture can be tested to demonstrate that an acid is forming. Old bottles of perfume can also be an interesting illustration of ester hydrolysis as the fruity notes in fragrances have frequently hydrolysed leaving the unpleasant stench of	An ester can be identified from the ester group and by the name containing the –'yl-oate' endings. An ester can be named given the names of the parent carboxylic acid and alcohol or from structural formulae. Structural formulae for esters can be drawn given the names of the parent alcohol and carboxylic acid or the names of esters. Esters have characteristic smells and are used as flavourings and fragrances. Esters are also used as industrial solvents. **Making esters** Esters are formed by the condensation reaction between carboxylic acid and an alcohol. The ester link is formed by the reaction of a hydroxyl group and the carboxyl group. In condensation reactions, the molecules join together with the elimination of a small molecule, in this case water. **Hydrolysis of esters** Esters can be hydrolysed to produce a carboxylic acid and alcohol. Given the name of an ester or its structural formula, the hydrolysis products can be named and their structural formulae drawn. The parent carboxylic acid and the parent alcohol can be obtained by hydrolysis of an ester. In a hydrolysis reaction, a molecule reacts with

3.6 The Design and Format of Curriculum and Syllabi in Victoria, Australia

The Australian Curriculum, Assessment and Reporting Authority (ACARA) (www.acara.edu.au) is responsible for providing a national framework for curriculum and assessment for the whole of Australia. ACARA is an independent authority "providing a rigorous, national approach to education through the national curriculum, national assessment program and national data collection and reporting program" ACARA provides guidelines for curriculum and assessment throughout the school system.

In relation to the senior cycle curriculum, fifteen senior secondary subjects across English, mathematics, science, history and geography have been endorsed by the council of federal, state and territory education ministers as the agreed and common base for the development of state and territory senior secondary courses. English, mathematics, science and history subjects were endorsed in December 2012, and geography was endorsed in July 2013. In drawing up the curriculum in the sciences, ACARA pointed out that it reviewed national and international science curricula including those of the UK, Singapore, Ontario and New Zealand, as well as the IB Diploma subjects.

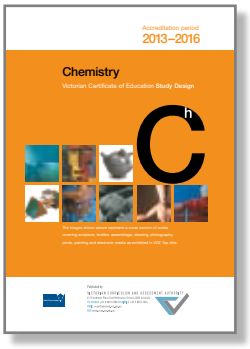
The senior secondary Australian Curriculum for each subject specifies content and achievement standards. The content describes the knowledge, understanding and skills that are to be taught and learned. The achievement standards describe the quality of learning (the depth of understanding, extent of knowledge and sophistication of skill) expected of students who have studied the content for the subject.

However, State and territory curriculum, assessment and certification authorities are responsible for determining how the Australian Curriculum content and achievement standards are to be integrated into their systems. The state and territory authorities also determine assessment and certification specifications for their areas.

In the state of Victoria, for example, the relevant authority is the Victorian Curriculum and Assessment Authority (VCAA) (http://www.vcaa.vic.edu.au/). Drawing on the national guidelines, VCAA sets the syllabus and assessment requirements for each subject at each level from pre-primary to senior secondary, and it awards the Victorian Certificate of Education (VCE) to learners on successful completion of senior cycle studies. The VCE is the accepted certificate for accessing university and other higher education institutions, where the scoring system is based on six subjects taken in the VCE.

The Certificate programme is currently being revised and all documentation is made available online for the accreditation period 2013 – 16. Like Scotland, the material is provided in a series of separate online files. The level of support documentation for Chemistry on the VCAA website is exemplified by the following extract (http://www.vcaa.vic.edu.au/Pages/vce/studies/chemistry/chemindex.aspx) Examples from the physics and biology syllabi are given in the appendix.

Chemistry



Accreditation period: 2013-2016

Curriculum

- **Study Design** (pdf - 1.26mb)
  Details on areas of study, outcomes and assessment for Chemistry Units 1-4: 2013-2016.
- **Study Summary** (doc - 69kb)
  A summary of the VCE Chemistry Study Design for 2013-2016.
- **Resources** (doc - 185kb)
  A list of suitable resources for VCE Chemistry.

Assessment

- **Assessment Handbook** (doc - 283kb)
  Contains assessment advice for both School assessed-Coursework and the examination.
- **Examination Reports**
  Find past exams and sample exams for Chemistry. The data booklet is included with each sample exam.
- **Exam specification and sample exam** (pdf - 515.96kb)
- **Use of Calculators in Exams**
  Information about the use of calculators in Chemistry examinations.

Support Material

- Summary of Changes
  Summary of changes to the VCE Chemistry 2013-2016 Study Design (from the 2006-2012 Chemistry Study Design).
- **Sample Assessment Tasks for Units 1-2** (doc - 121.5kb) (March 2007)
  Examples of the extended experimental investigation, the response to stimulus material and the summary report including annotations of three practical activities.
- **Frequently Asked Questions (doc - 74kb)**
  A set of FAQs for the revised VCE Chemistry Study (accreditation period 2013-2016).
- **Implementation briefing presentation** (ppt - 498.5kb)
- **Nanotechnology** (pdf - 46.47kb)
  Expert paper addressing new content in Unit 1.
- **Green Chemistry** (doc - 78kb)
  Expert paper addressing new content in Unit 2.
- **Biofuels** (doc - 91.5kb)
  Expert paper addressing new content in Unit 3 (and Unit 4).
- **Chemistry - A Pathway to Emerging Sciences in Victoria CD-ROM**
  A resource to support the teaching and learning in VCE Chemistry.

In summary, the chemistry syllabus and supporting material for the VCE totals over 200 pages and is accessible under the following headings:

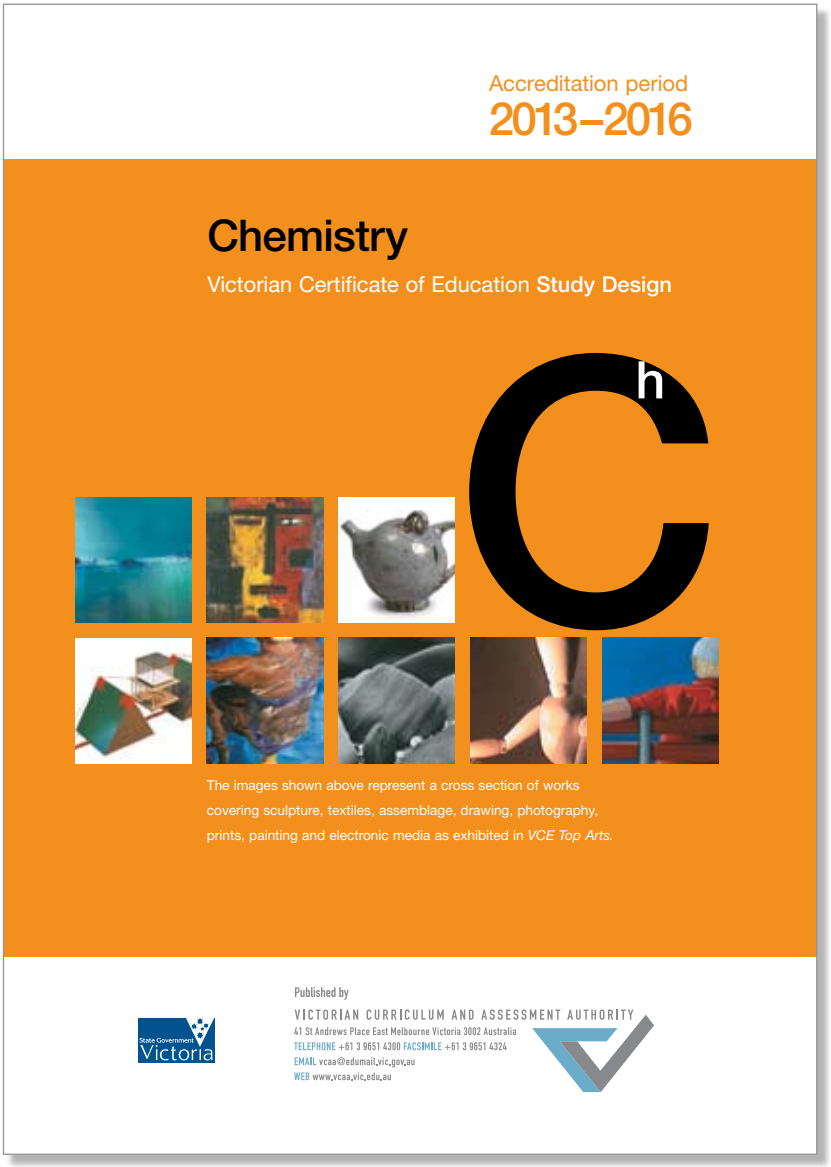
Curriculum:

Study Design (61 pp)
Study Summary (4 pp)
Resources (lists)

Assessment:

Assessment Handbook (40 pp)
Examination Reports (c.100 pp)
Examination specification and sample examinations (40 pp)

The website also contains a wide range of support materials.
The following page from the VCAA website gives an indication of the detail of the material provided.



Unit	Structure and bonding	Reactions	Energy	Skills chemists use
1	Atomic structure Metallic structure Ionic lattice Structure of covalent compounds, molecular structure and covalent lattice structures Structure of alkanes and alkenes Isomers Surface structures Structure of addition polymer	Reactivity trends in the Periodic Table Reactions of metals, ionic and molecular substances Reactions of alkanes and alkenes Surface reactions Addition polymerisation reactions	Ionisation energy Interactions between charged particles Electrostatic nature of chemical bonding Energy from combustion of alkanes Energy and change of state	Collection of experimental data Observation skills Laboratory techniques Data management and interpretation skills Communication skills Calculations Information and communications technology skills Modelling
2	Structure of the water molecule Polar molecules Structure of states of matter Structural changes that accompany change of states	Dissociation and ionisation reactions in water Reaction of solutes in solvents Reactions of acids and bases Redox reactions Reactions in the atmosphere that result from human activity Acid rain, ozone depletion, photochemical smog	Special properties of water; latent and specific heat Kinetic molecular theory Reactions driven by solar energy, e.g. ozone depletion, photochemical smog, greenhouse effect	

In comparing individual subject syllabi (i.e. examination programmes) in Ireland with Australia, the relevant point of comparison is the documentation provided by the State Curriculum and Assessment Authority, not that provided by national government, which from a school's point of view is advisory rather than mandatory. It is the State's curriculum and assessment system that is relevant to the individual school and pupil.

3.7 The Design and Format of Curriculum and Syllabi provided by the International Baccalaureate Organisation (IBO)

The IBO is a non-profit educational foundation, founded in 1968. It has four programmes for students aged 3 to 19, including the Diploma Programme which is a rigorous pre-university course of study designed for students in the 16 to 19 age range. The IBO is regarded internationally as providing a well-balanced and academically rigorous curriculum and examinations system. It aims "to encourage students to be knowledgeable and inquiring, but also caring and compassionate".

The two year Diploma course is presented as six academic areas enclosing a central core. It encourages the concurrent study of a broad range of academic areas. It is a demanding course of study designed to prepare students effectively for university entrance. In each of the academic areas students have flexibility in making their choices, which means that they can choose subjects that particularly interest them and that they may wish to study further at university.

Subjects in the experimental sciences group - chemistry, biology, physics and design technology - are currently being updated, and revised syllabi will be released between March and June 2014 and will be taught from September. The current chemistry syllabus dates from 2007 – first examined in 2009. It is a detailed document (Chemistry Guide) of almost 150 pages, available on line and in print, of which about 100 pages relate to the detail of the syllabus. It contains topics, sub-topics, assessment statements (the equivalent of Learning Outcomes in syllabus documents in other systems). Teachers' notes are also provided. The syllabus is divided into three parts – the Core; Additional Higher Level material (AHL) and Options. There are ten topics in the core and each topic has between two and six sub-topics.

There is a very wide and impressive range of materials available online to support the teaching of this syllabus. For example there is the IB chemistry interactive syllabus (www.ibchem.com/IB/ibsyllabus.htm) where one can click on each theme and sub-theme which brings the reader to a "notes page", which provides further detailed information on the topic.

B Chemistry interactive syllabus 2009

Click on each topic heading to go to the summarised notes page.
See a flash demo of how to use the syllabus

main theme and sub-topics

standard syllabus notes higher syllabus notes

Topic 1: Stoichiometry (sl & hl) - summary

1.1 Mole concept and Avogadro's constant
1.2 Formulas
1.3 Chemical equations
1.4 Moles and gaseous volume relationships in chemical reactions
1.5 Solutions

Topic 2: Atomic theory (sl) - summary

2.1 The atom
2.2 The mass spectrometer
2.3 Electron arrangement

Topic 3: Periodicity (sl) - summary

3.1 The periodic table
3.2 Physical properties
3.3 Chemical properties

Topic 4: Bonding (sl) - summary

4.1 Ionic bonding
4.2 Covalent bonding
4.3 Intermolecular forces
4.4 Metallic bonding
4.5 Physical properties
etc.

Topic 12: Atomic structure (hl) - sum.

12.1 Electron configuration

Topic 13: Periodicity (hl) - summary

13.1 Trends across period 3
13.2 First row "d" block elements

Topic 14: Bonding (hl) - summary

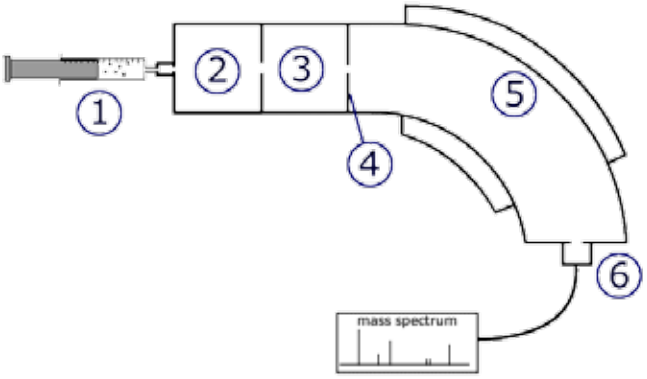
14.1 Shapes of molecules and ions
14.2 Hybridisation
14.3 Delocalisation of electrons

Source: http://ibchem.com/IB/ibsyllabus.htm

The online material contains coloured interactive diagrams as well as text. There are questions related to each topic as well as explanations as to how a student might approach these questions. Previous examination papers are also available. The website includes a list of the resources available to support the learning and teaching of Chemistry – it includes print and online publications, software, ebooks, "Funstuff" (i.e. puzzles, jokes, crosswords) etc. There are also chemistry revision notes (www.ibchem.com/) which use software called *Colourful Solutions* which is interactive chemistry software for students and educators. It includes animations and examples – some of which have Zoom incorporated for classroom use. On website www.ibchemistrysyllabus.blogspot.ie/ one can access the IB 2013 syllabus as well as the Mark Scheme and Notes.

The following diagram from the IBO Chemistry syllabus gives an indication of the detail provided:

1. injection
2. vaporisation
3. ionisation
4. acceleration
5. deflection



1. injection: The sample is injected into the vaporisation chamber
2. vaporisation: It is vaporised and the gas streams into the ionisation chamber
3. ionisation: The electron beam knocks an electron off the vaporised particles makong positive ions
4. acceleration: The positive ions are attracted towards the accelerating plates
5. deflection: The magnetic field deflects the lighter ions more than the heavy ions
6. detection: As the magnetic field is varied by the controller, ions with different masses are detected - these are recorded on the mass spectrum.

http://ibchem.com/IB/ibnotes/02.2.htm

In summarising the three systems chosen for comparison with the Leaving Certificate syllabi in Ireland, we see that the relevant comparator in the case of the two-tier systems, i.e. in Scotland and in Australia, are the Scottish Qualifications Authority and the Victorian Curriculum and Assessment Authority, both of which provide very detailed examination syllabi. While Education Scotland and ACARA (Australia) have some responsibilities similar to those of the NCCA in Ireland, this report argues that they are not the relevant comparator for examination syllabi at the end of senior cycle. In the one-tier system chosen, i.e. the IBO, the organisation also provides detailed syllabi and examination specifications for its Diploma examination.

Chapter 4

Does Over-Specification of Syllabus Design contribute to Rote Learning?

Before coming to any conclusions based on the above documentation, I would like to address an issue that has arisen during this debate. Some curriculum designers in Ireland have expressed concern that over-specificity in syllabus design leads or contributes to rote-learning. It has also been suggested that in a previous report which I presented in September 2011 on *Entry to Higher Education in Ireland in the 21st Century*[26] I may have supported this view.

The following extract from my report at that time makes it clear that this was not the case. In that report, the issue being discussed was whether the Leaving Certificate adequately tests and rewards higher-order thinking, and if not, whether the fault lies with the design of the syllabus or with the design and marking of the public examinations. Having analysed some syllabus documents and related examination papers and marking schemes, I concluded that:

> An analysis of the current curriculum and its individual syllabi suggests that the curriculum itself is not the key problem. The various syllabi are written in such a way as to require students to engage critically with subject content and to apply higher order thinking skills.

Adverting to Bloom's Taxonomy of Educational Objectives and to a 1970 report on the Leaving Certificate, I went on to state:

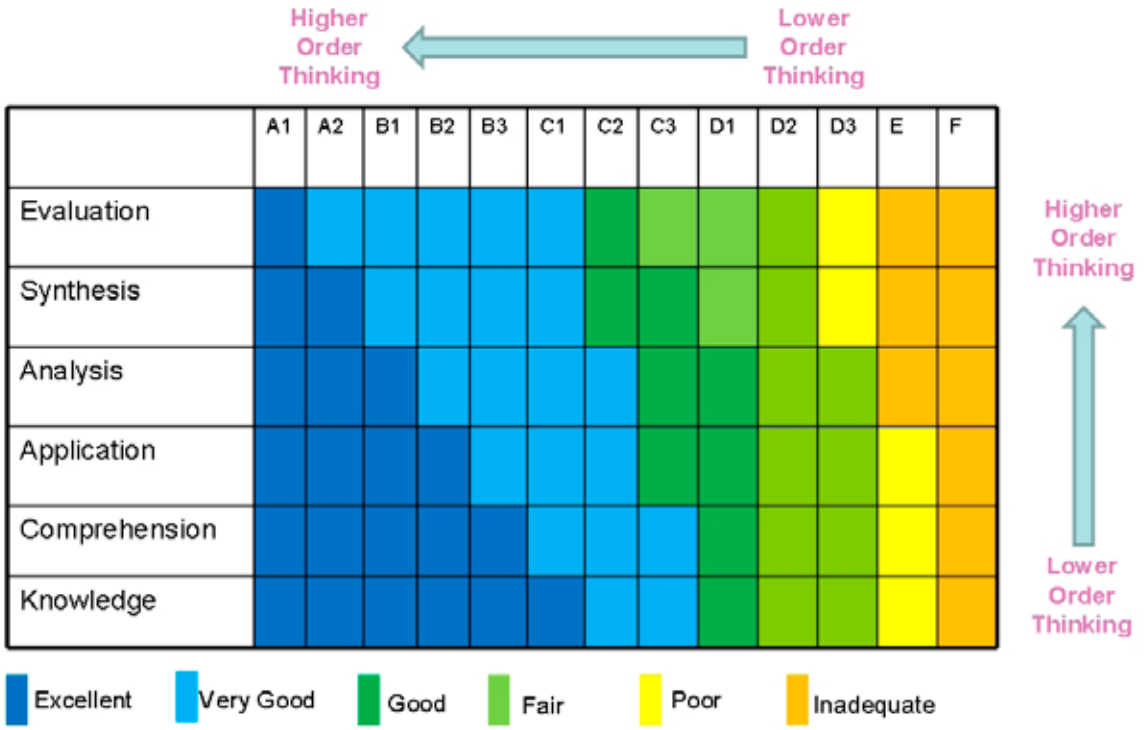
> While the current Leaving Certificate syllabi address knowledge and understanding, higher order thinking such as application, analysis and synthesis are also emphasised. It is not longer true, as it was in 1970, that "the objectives of each subject (are) stated almost exclusively in terms of content" and that one "can only guess at what students (are) expected to do with that content".

I did however express concern about the extent to which Leaving Certificate examinations in Ireland are driving teaching and learning at senior cycle and I pointed out that over-emphasis on lower order skills in setting and marking examination papers would be likely to lead to a culture of rote-learning and memorisation.

In a presentation which I made at a later conference in NUIM in June 2013, I raised this issue again and I presented an outline "assessment grid framework" which I suggested might be considered by the SEC as a template for developing marking schemes for each subject:

26 Áine Hyland, *Entry to Higher Education in Ireland in the 21st Century* http://www.hea.ie/content/discussion-paper-ncca-hea-seminar-be-held-21st-sep-2011-prepared-%C3%A1ine-hyland

Assessment Grid Framework



I am still of the view that the problem of rote-learning and memorisation lies in the type of assessment we have in Ireland – 100% written terminal examination; and inadequate congruence and alignment between the desired learning outcomes of a syllabi, the approach to teaching and learning and the modes and techniques of assessment. In my report in Sep. 2011, I suggested some alternatives:

> Different modes of assessment could include projects, portfolios and other assignments completed in non-examination conditions. Essays and open book questions answered in supervised classroom conditions and externally marked, are other possibilities.[27] Instead of requiring students to sit one written examination at the end of the final year, two or more sittings at different points throughout the two year senior cycle could be an option.[28] Consideration might also be given to assessing some skills, e.g. problem-solving and creativity, in a non-subject related context. New and different forms of assessment could also reduce the current reliance on pen and paper tests and provide for greater use of new technologies, which might include online submission of essays (written under supervision) and computer-marked multiple choice questions. The predictability of the examinations should be reduced and this in turn is likely to reduce the dependence on rote-learning.

27 An open book examination is to be introduced for the assessment of Leaving Certificate Economics.

28 However, some higher education institutions have expressed reservations about assessment in the penultimate year of senior cycle, arguing that such assessment does not measure performance at the completion of senior cycle and therefore lacks validity.

The international comparisons in Section 2 of this report show that it is possible to provide syllabi or examination programmes which include detailed guidelines; teachers' notes; assessment specifications etc. while at the same time devising an approach to assessment which does not reward rote-learning and ensures that higher order skills are recognised and rewarded. To my knowledge, it has never been suggested that the detail provided by the IBO Diploma syllabi or the Scottish Highers or the Victorian Certificate of Education has led to or leads to rote-learning.

Chapter 5: Summary and Conclusions

The current Leaving Certificate physics, chemistry and biology syllabi, which have been implemented since the early 2000s, are highly regarded by teachers and have contributed to a reversal of the decline in the numbers of pupils taking science subjects at senior cycle. It is accepted that like all other syllabi, the science syllabi need to be updated and revised from time to time and new content added. Reform is particularly necessary at the present time, given the advances in science and technology in the past decade and the need for Irish students to be at the receiving end of the most modern and up-to-date syllabi. However, there is a widespread view among teachers that the format and design of the current syllabi[29] have worked well to date and that there is no need to throw the baby out with the bathwater.

In benchmarking the format, design and content of the proposed new physics, chemistry and biology Leaving Certificate syllabi against international comparators, this report has focused on systems where assessment and certification of pupils at senior cycle is centralised (i.e. not school-based). In each of the three systems chosen - Scotland, Victoria (Australia) and the International Baccalaureate Organisation (IBO) – the assessment and certification of pupil performance at senior cycle is centralised. The three systems are also similar to the Irish system in terms of the breadth of the curriculum at senior cycle, i.e. pupils take six or more subjects for award purposes. They are also systems which are regarded as high-stakes, in that their awards are accepted by prestigious third level institutions for the selection of students. And in all three cases, the curriculum and syllabi have either been recently revised or are in the process of revision. The main focus of comparison in this research is on the format, extent and depth of the documentation associated with the examination syllabi[30].

In Scotland, the SQA documentation relating to the Higher Chemistry course, **totals over 200 pages** under the headings

- Course Specification (11 pages)
- Course Assessment Specification (13 pp)
- Unit Specifications (24 pp)
- Course and Unit Support Notes (91pp)
- Specimen Question Paper and Marking Instructions (56pp)

This does not include extended documentation entitled “Unit Assessment Support” which is available to teachers only. Similar documentation is provided for the higher biology and higher physics courses.

In Victoria (Australia), documentation relating to the chemistry syllabus for the Victorian Certificate of Education **totals over** 200 pages under the following headings:

29 As set out in the maroon books and online on www.curriculumonline.ie

30 The senior cycle higher chemistry syllabus is chosen for detailed analysis.

- Study Design (61 pp)
- Study Summary (4 pp)
- Resources (lists)
- Assessment Handbook (40 pp)
- Examination Reports (c.100 pp)
- Examination specification and sample examinations (40 pp)

The relevant website also contains a further wide range of support materials. Similar documentation is provided for the physics and biology syllabi for the VCE.

The IBO Diploma programme for chemistry is provided in a detailed document of **almost 150 pages**. **Extensive teachers' notes are also provided.** In addition, a comprehensive chemistry interactive syllabus is available online, comprising detailed notes and information (including interactive diagrams) on each individual topic (totalling well over a further 100 pages). (http://www.ibchem.com/IB/ibsyllabus.htm). The website also contains chemistry revision notes for students and educators as well as marking schemes and notes. Overall, the documentation available for the IBO diploma in chemistry runs to hundreds of pages, and similar documentation is available for the IBO diploma in biology and physics.

In all of the above systems, the senior cycle chemistry syllabus includes a wide range of explanatory and supporting material provided by the body which examines and awards the qualifications. In all three systems, the extent, depth and richness of the documentation are impressive and run to over 200 pages.

Comparing these three chemistry syllabi with the NCCA draft specification for Leaving Certificate chemistry, one notes a significant difference in approach between the three systems chosen and the approach of the NCCA. While the NCCA document resembles, to some extent, the national curriculum and assessment guidelines of Education Scotland, or the curriculum and assessment guidelines of the Australian Curriculum and Assessment Authority it does not resemble the detailed examination syllabi provided by the examining and awarding bodies in Scotland (the Scottish Qualifications Authority), in Victoria, Australia (the Victorian Curriculum and Assessment Authority) and the International Baccalaureate Organisation (IBO).

It would appear that for international benchmarking purposes, the NCCA has used the curriculum framework *Curriculum for Excellence* of Education Scotland, and the national curriculum framework for the whole of Australia, set by the Australian Curriculum, Assessment and Reporting Authority (ACARA), rather than the examination syllabi provided by the Scottish Qualifications Authority (SQA) and by the Victorian Curriculum and Assessment Authority (VCAA), which in the view of this researcher are the more relevant benchmarks.

The NCCA might well argue that since their terms of reference are "to advise the Minister on matters relating to (a) the curriculum for early childhood education, primary

and post-primary schools and (b) the assessment procedures employed in schools and examinations on subjects which are part of the curriculum" their role is more analogous to that of Education Scotland and ACARA than to that of the Scottish Qualification Authority or the Victorian Curriculum and Assessment Authority. In that event, they might validly argue that it is not their role to produce detailed syllabus and examination guidelines. However, since the setting up of the NCCA in the late 1980s, examination syllabi in Ireland have been provided by the NCCA, and as previously indicated, these syllabi provide the type of detail which is typically provided internationally for public examinations.

While the current NCCA draft specifications may be a valid first step in outlining the syllabi[31], this researcher agrees with the ISTA that it is not sufficient to describe a high-stakes examination programme in terms merely of topics and learning outcomes. More detailed information about the depth of treatment of subjects and the requirements for examination must be provided at national level in Ireland to bring the syllabi into line with international good practice. Such information could be in the form of course and unit support notes (as in Scotland) or study design (as in Victoria) or a comprehensive chemistry interactive syllabus (as in the IBO). The "depth of treatment" approach with which Irish chemistry teachers have been familiar for the past decade would be another option.

In every public examination system identified for this report, the syllabi for the end of senior cycle examinations include considerable detail about depth of treatment, examination specification, practicals and laboratory experiments and other advice for teachers and pupils. While learning outcomes are specified in all the syllabi, they are only one element of the detail provided. This researcher has not come across any centralised or public examination syllabus at this level which provides only a list of topics and learning outcomes.

The following extract from an article by Jenny Moon, one of the best known proponents of the use of learning outcomes in syllabus design in higher education, explains why it is not appropriate to use learning outcomes alone to define a syllabus and its assessment[32]:

> Learning outcomes are **statements of essential learning**, and as essential learning, they are written at minimum acceptable or threshold (pass / fail) standard. The learning described in learning outcomes is the learning that must be attained in order that the learner can pass. In effect, learning outcomes are written at the pass / fail point. …

31 In stating that the draft specification may be a "valid first step" I am not endorsing the Units of Study or the topics or the learning outcomes, as I am not an expert on chemistry and am not therefore competent to make a judgement about the content of a chemistry syllabus.

32 Jenny Moon, *Linking Levels, Learning Outcomes and Assessment Criteria* – paper accessed on http://www.aic.lv/bolona/Bologna/Bol_semin/Edinburgh/J_Moon_backgrP.pdf.

> Grading is a separate operation from passing or failing to pass a learning outcome. The criterion for attaining a learning outcome will match the pass / fail point for the grade assessment criterion (see the material on assessment criteria below). Many people are surprised when they realise that learning outcomes are written at threshold standard, however the use of such a standard is fully justified in terms of creating a clear relationship with assessment and level.

It can be argued that if teachers focus only on learning outcomes, there is a real risk that the teaching and learning target will be a minimum rather than a maximum, that the bar will not be set high enough for student learning, and that as a result, standards will fall.

From 1989 to date, the advice provided by the NCCA to the Minister has included the level of detail that teachers expect and need to enable them to prepare their students for the Leaving Certificate public examinations. That level of detail has also been used and will continue to be required by the SEC to enable them to set and mark the Leaving Certificate examination papers. It is the considered opinion of this researcher, that the issue of depth of treatment and clarity of examination specifications will become an issue for all Leaving Certificate subjects as the revision of Leaving Certificate syllabi proceeds. It is almost inevitable that the concerns raised by ISTA will be echoed by other subject teachers and associations as well as by third level representatives if the matter is not addressed now.

I understand that the draft syllabi for physics, chemistry and biology have now been submitted to the Minister for Education and Skills who (under the terms of the 1998 Education (Ireland) Act) is the ultimate decision-maker in relation to curriculum and examinations. It is a matter for the Minister to decide on the next steps. He can accept or decline the advice of the NCCA or he can refer the draft syllabi back to the NCCA for further elaboration on the basis suggested above. Alternatively, he can seek more elaboration on the syllabi elsewhere, e.g. from the inspectorate or the SEC. Whichever approach the Minister decides to take, it is essential that the full range of syllabus documentation (including teachers' notes, examination specifications etc.) should be officially published at the same time as the syllabus itself, under the logo of the DES as has been the case in the past. It is also essential that the elaborated documentation should be available well before the syllabus is due to be implemented, to enable teachers to become familiar with the new material and to undergo appropriate professional development and up-skilling.

The issue of whether the examination syllabi should be available in hard copy or online also needs to be addressed. The international documentation analysed for this report indicates that where IT facilities and broadband access are reliable and easily accessible, online material has considerable potential. I would argue that if at all possible, the new physics, chemistry and biology syllabi and related resource materials should be made available online. However, given the inadequacy and/or unreliability of broadband access in many parts of Ireland[33], it is still too soon to rely

33 While undertaking research for this report, this author had difficulty on a number of occasions accessing www.curriculumonline.ie. Whether this was a problem with access or an intrinsic

exclusively on online access and in the short to medium-term at least, hard copies of syllabus materials will have to be provided.

The interactive science materials, and links to relevant diagrams, papers, article and books provided in connection with the science syllabi analysed for this report, are indicative of the step-change that has occurred in teaching and learning in recent years. In coming to a decision about the detail to be provided for the Leaving Certificate examination syllabi, consideration might be given by the Minister to collaborating with other bodies, either nationally[34] or internationally to provide appropriate state-of-the art materials thereby avoiding unnecessary and expensive duplication or "re-inventing the wheel". As science subjects are less culturally bound than some other subjects, resources developed for science teaching in one country are likely to be relevant and suitable for teachers and learners in another country. All the documentation accessed for this report is in the public domain, and is accessible for anyone (teacher or pupil or member of the public) who wishes to use it.

The syllabus committees /development groups should continue to be involved in the identification and where relevant, the development of resources to support the new subject syllabi. Members of development groups contribute invaluable expertise and experience, on a pro bono basis, to Irish education. They help to bridge the gap between theory and practice, between the ideal and the possible. Teachers, in particular, have an important role to play as they are at the chalk-face on a daily basis and bring knowledge of the on-the-ground constraints to the discussion[35]. Third level representatives and employers help to ensure that the revised syllabi prepare future pupils appropriately for further learning and for work. The partnership model has served Irish education well in the past and will hopefully continue to do so in the future.

In conclusion, it is the considered view of this researcher that the final versions of the proposed new syllabi for physics, chemistry and biology, should contain at least the same depth of treatment as is available in the current syllabus documents, as well as detailed examination specifications and Teachers' Notes. When approved by the Minister, the full range of documentation in relation to each syllabus should be published online and in hard copy under the logo of the Department of Education and Skills, prior to the implementation of the syllabi.

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problem on the website was not clear. On the same occasions the author had no difficulty accessing the ACARA, IBO or SQA websites.

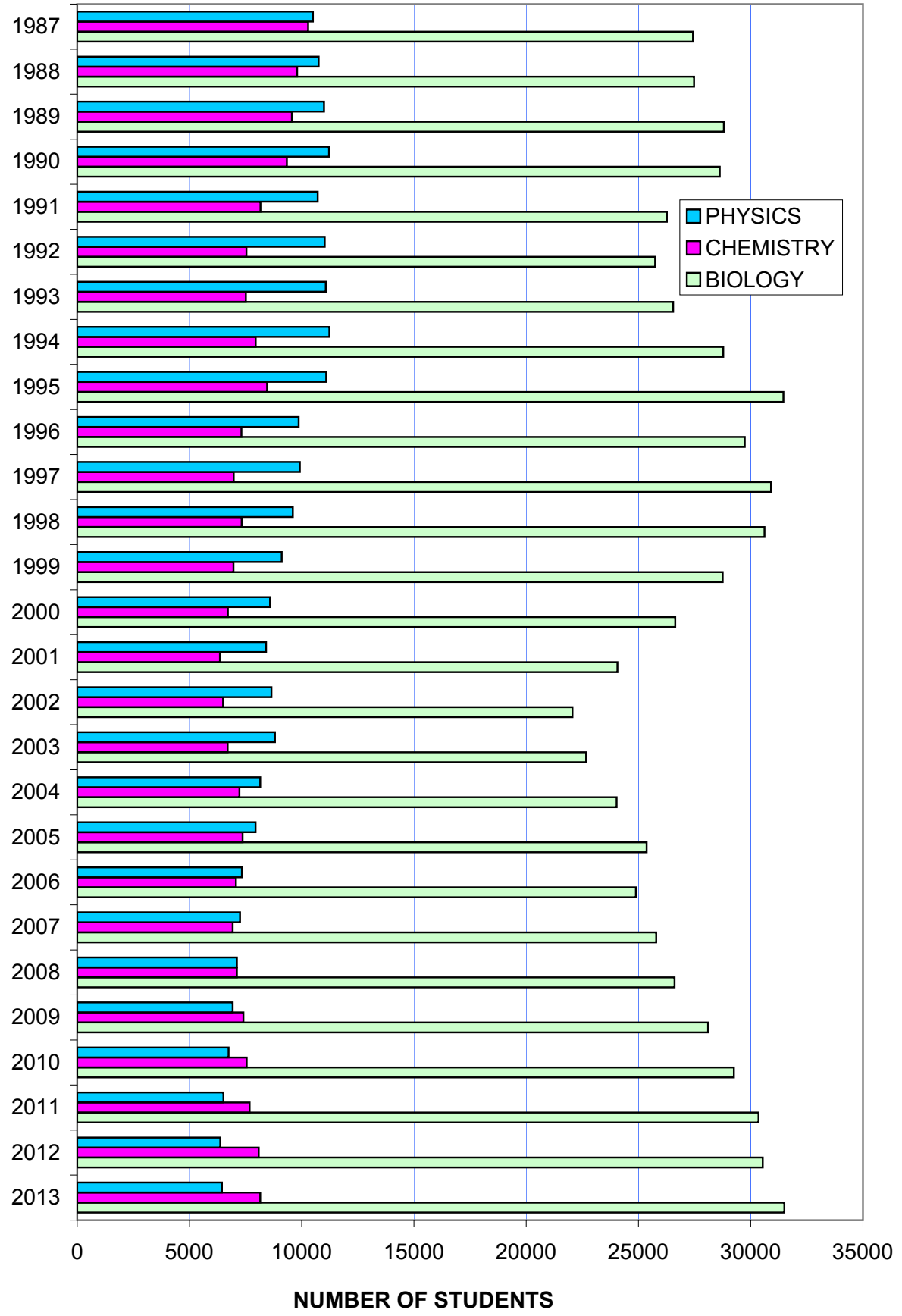
34 For example, Science Foundation Ireland.

35 In an analysis of curriculum reform over a period of 150 years, the findings of which I published 30 years ago in *Irish Educational Studies* Vol. 6 No. 2 (p. 34) I stated: "While additional funds would appear to be a necessary condition for curriculum renewal, it is not a sufficient condition. The above analysis would suggest that the goodwill and support of teachers … is also essential if curriculum reform is to succeed". In the same vein, writing about curriculum reform in 1984, John Coolahan wrote "The lessons of the last 15 years indicate that unless the support and co-operation of the teacher unions are obtained there is little prospect of significant curricular or examination reform". (John Coolahan, *The ASTI and Post-Primary Education in Ireland 1909-1984*).

Appendix A

Numbers of Candidates taking Physics, Chemistry and Biology in the Leaving Certificate Examinations, 1987 – 2013

YEAR	BIOLOGY	CHEMISTRY	PHYSICS
1987	27431	10287	10497
1988	27479	9795	10753
1989	28804	9564	10995
1990	28620	9339	11218
1991	26262	8163	10711
1992	25743	7541	11024
1993	26543	7511	11074
1994	28775	7952	11233
1995	31459	8462	11091
1996	29737	7316	9867
1997	30907	6970	9917
1998	30613	7325	9603
1999	28750	6963	9112
2000	26641	6713	8588
2001	24061	6356	8411
2002	22061	6497	8651
2003	22669	6699	8806
2004	24027	7229	8152
2005	25362	7366	7944
2006	24885	7071	7335
2007	25791	6926	7251
2008	26607	7114	7112
2009	28101	7403	6924
2010	29249	7548	6745
2011	30349	7677	6516
2012	30536	8086	6373
2013	31500	8155	6448


1987
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1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
PHYSICS
CHEMISTRY
BIOLOGY
0
5000
10000
15000
20000
25000
30000
35000
NUMBER OF STUDENTS

Appendix B

ISTA Submission to the NCCA Consultative Process on Senior Science Education, October 2011

Irish Science Teachers' Association
Eol Oidi Na hEireann

Eli Lilly,

Dunderrow,

Kinsale,

Co Cork

23/10/11

Dr. Anne Looney,

Chief Executive Officer NCCA,

24 Merrion Square,

Dublin 2.

Dear Dr. Looney,

I am writing to you in my role as President of the Irish Science Teachers' Association. Given the importance of consultation as part of any change process, the ISTA was delighted to have the opportunity to comment on the revised LC Biology, Chemistry and Physics syllabi with its members throughout the country. These views have been collated by subject matter convenors and the details of their review and its summary are attached by the Chairperson Ms Yvonne Higgins.

It is well recognised that never has the need been greater, to enhance the science subject uptake, in our 2nd level students so that an adequate number of highly scientifically qualified are available to help grow the Irish economy into the future. In the past decade while other sectors have declined, the Pharmachemical / Biotechnology sector has continued to remain in Ireland and increase their early stage development of new products at their facilities here resulting in increased employment opportunities. A very large part of that decision making is based on the quality of graduates available. Unfortunately in the uptake of science subjects, Ireland continues to struggle. Therefore any change in the

syllabus that will potentially attract more students while improving the quality of education is to be welcomed by all involved.

Unfortunately we also find ourselves in a very resource restricted, economic environment and must be pragmatic in our acknowledgment of what can be done in reality. Based on these circumstances I wish to highlight 2 areas that merit serious consideration, as they are crucial, to the success of the implementation of the revision.

The first is a recommendation that suggests that the proposed second mode of assessment be piloted with one of the three senior cycle syllabi before being rolled out in all three subjects. The suggestion that it be piloted with Chemistry or Physics would provide a great opportunity for detailed analysis of the most appropriate form of practical assessment and allow potential issues with availability of resources, access to laboratories, to be resolved. This approach may also help ensure that the necessary funding be put in place in advance of the pilot and ultimately the remaining subject/s.

The issue of IT availability to all students has been highlighted by both industry and education alike. While some inroads have been made in the provision of both hardware and increased broadband access to schools and students, proper IT facilities will be crucial for a successful implementation of this revised syllabus. The feed-back from schools is that IT resources are limited at school level. Part of the National Development strategy is the provision of these resources. Is this an opportunity to convince Government and other partners, that this revision offers a unique opportunity to find these resources and thereby the best outcome for this revision?

I know that the ISTA valued this opportunity to make its input and I have no doubt that the ISTA looks forward to playing its part in improving Science education in Ireland into the future.

.

Yours sincerely,

_____

Charles Dolan

ISTA President

ISTA Convenor Report on L.C. Draft Biology Syllabus for consultation

- Una Moroney

Overview

The ISTA welcomes the reviewing and updating of the Biology syllabus on a regular basis. There is broad recognition of the need to emphasis skills such as information processing and practical work and to include the use of ICT in the learning and teaching of biology. The development of skills that form part of lifelong learning and preparation for the field of work or further studies would be a minimum expectation of a Biology syllabus. However, the changed emphasis has significant implications for Biology teachers and their students. The introduction of the proposed syllabus is implicit on adequate laboratory access, appropriate equipment - both laboratory and ICT - laboratory technicians, I.T. support and professional development. These issues need to be addressed in a fair manner providing equal access in all schools to the resources required to successfully implement the proposed syllabus. The ISTA does not have confidence that the necessary resources will be provided and requests a plan specifying the resources, training and support which will be in place to implement the syllabus.

The introduction of a second mode of assessment is also recognised as a desirable change once it provides the reliability, validity, and transparency required for assessment of such a high stake exam as the Leaving Certificate. The introduction of a second mode of assessment for its own sake which does not provide added value in terms of skills assessed is questionable. A radical overhaul of the terminal exam needs to be undertaken in order to reflect the desired learning outcomes and discourage the practice of rote learning. Without this change it is hard to envisage the desired shift to independent learning with students taking responsibility for their own learning becoming a reality.

In summary to implement the proposed biology syllabus the following must be in place:

- Adequate laboratory access
- Adequate laboratory resources
- Adequate access to ICT
- Laboratory technicians
- I.T. support

1. Length of the proposed Biology syllabus

Clarity is required on the following:

- Depth of treatment required for topics. Suggested time allocation for each topic/sub topic required
- The time requirement for research projects.
- Is the syllabus a stand alone syllabus or is J.C. science a perquisite
- Syllabus too long as new content is time consuming e.g. research projects/debating
- Clarity on meaning of learning outcomes e.g. explain, debate, illustrate

2. Topics that should have been included in the syllabus?

- General dissatisfaction about the reduction of human biology topics particularly the exclusion of the musculoskeletal system and the sensory system. These should be included.
- More lab based practical's which develop manual dexterity and manipulation skills rather than over emphasis on research skills. One third of the proposed practical activities are research based.
- At least one of the present enzyme experiments should be included e.g. effect of temperature/pH on rate of enzyme activity.

3. Topics that should have been omitted from the syllabus?

- Dissect and display the various parts of a flower- too easy for L.C
- Too many research activities
- Too much ecology – unbalanced. A reduction in Ecology content
- Too much molecular biology - unbalanced
- A reduction in the depth of treatment on bacteria - disproportionate

The following modifications are proposed:

Unit 1

Unit 1: not be a separate unit of study. Its learning outcomes to be retained in a preamble and incorporated into the other units of study.

Why? The l.o.'s are repeated throughout syllabus. Appropriate assessment will ensure the learning outcomes are met

Unit 3

3.2 Viruses

The l.o. evaluate the economic and medical importance of viruses … to be modified to … evaluate the economic and medical importance of viruses using two examples of each

Why To tie in with the l.o. on .. industrial and medical importance of bacteria which specifies using two examples of each

3.5. Ecology

1. The learning outcomes:

- Describe the role of organisms in nutrient recycling,
- Describe how the carbon cycle impacts on atmospheric levels of carbon dioxide, Discuss the strategies that can be used to reduce atmospheric levels of carbon dioxide (incl. the use of biofuels and reforestation)
- Use ICT to gather, process and analyse information on the ways humans impact on the environment and suggest how this can be minimised

to be combined into one learning outcome as follows:

Use ICT to gather, process and analyse information on how humans impact on atmospheric levels of carbon dioxide and suggest how this can be minimised

Why? The learning outcomes as they stand are too broad .The present syllabus only deals with pollution as a human impact and with C and N cycle. Analyse ways in which humans impact ... is far too broad.

Describe the role of organisms in nutrient recycling. How many cycles are required in this l.o.? By combining the L.O.'s the carbon cycle could be used as the research activity.

2. Delete the L.O.: Describe two trophic interactions found between two organisms in the ecosystem

Why? Already covered under food chain, food web

3. Delete L.O: Distinguish between qualitative and quantitative studies

Why? Already covered under Conduct an ECOSYSTEM (not habitat) study qualitative and quantitative

4. L.O. Discuss how edaphic factors affect the distribution of organisms to change to outline how some edaphic factors affect the distribution of organisms.

Why? Too broad as stands – how many edaphic factors?

5. Clarification required on L.O. Investigate the relationship between any two parameters for a species ..... Is it referring to primary or secondary data? Is a correlation coefficient required here?

Unit 4

1. L.O. Collect primary data using dataloggers to investigate the effect of any one factor on plant metabolism to change to Collect primary data to investigate the effect of any one factor on plant metabolism

Why? To be left open to the most appropriate method. Sensors often do not collect reliable results. CO_2 and O_2 sensors are very expensive and not reliable for the practical specified. If this is to remain a suitable sensor for this practical needs to be demonstrated.

NOTE: 4.1 Cell structure The cell should read Biomolecules

4.5 Genetics and Heredity

Modifications are proposed for the following learning outcomes:

1. Debate the principal outcomes and some applications of some genome projects and the legal, social and ethical issues that arise from them ..... to be modified to..... Discuss the HGP, some of its potential applications and some of the social and ethical issues that arise from it.

Why? This is the most relevant and advanced of the genome projects. It includes a multitude of topics such as genomes of model organisms, DNA sequencing, gene therapy and bioinformatics. To be expected to include more than one genome project is unreasonable. Legal issues should be deleted as these vary so much from country to country. Just include social and ethical issues.

Debate is not an action verb and is not present in glossary

2. Describe the concept of DNA sequencing

Why? Deleted as included under the Human Genome project

4.10 Genetic engineering

Note; The following learning outcomes have been included under the incorrect headings:

- Isolation of DNA and Electrophoresis should be under 4.6 DNA structure not 4.10 genetic engineering
- Use database to investigate evolutionary relationship ... should be under 4.9. Natural selection and evolution.

1. Modifications are proposed for the following learning outcomes:

- Describe some current applications of gene therapy for an identified disease. ... to be deleted or modified to read ... some potential applications

  Why? Delete as is included under Human Genome project and as there are no current approved gene therapies (except in China which are controversial)
- Debate some of the ethical issues relating to stem cell technology and its therapeutic use .... to be modified to ...Explain some potential applications of stem cells.

  Why? The ethical issues mainly only refer to embryonic stem cells and there is currently no approved therapeutic use of ESC's. The action verb debate already used under HGP and is not an action verb.
- On the basis of information gathered from secondary sources, develop, present and defend a position or course of action related to the use of genetically modified organisms ... to be modified to .... the use of genetically modified foods. Genetic engineering already adequately covered

Why? This is the most relevant and advanced of the genome projects. It includes a multitude of topics such as genomes of model organisms, DNA sequencing, gene therapy and bioinformatics. To be expected to include more than one genome project is unreasonable. Legal issues should be deleted as these vary so much from country to country. Just include social and ethical issues.

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  Why? The ethical issues mainly only refer to embryonic stem cells and there is currently no approved therapeutic use of ESC's. The action verb debate already used under HGP and is not an action verb.
- On the basis of information gathered from secondary sources, develop, present and defend a position or course of action related to the use of genetically modified organisms ... to be modified to .... the use of genetically modified foods. Genetic engineering already adequately covered

Why? This L.O. is too broad. GM foods has the most relevance of the GMO,s. for students

- The l.o. ….Use a database to find organisms whose genomes …… to be modified to …. find a genetic disease.

  Why? Students would find this very interesting and would enjoy the research. This would make a good research project.

5.1 Structure and transport system of the plant

The l..O. . .. dissect and display the various parts of a flower ....is misfiled it should be included under 5.10 Sexual Reproduction in the Flowering Plant

5.2 Structure and transport system of the human

L.O. ... collect data using sensors to relate exercise level to breathing rate or pulse rate in a human.. should be .. collect data to relate exercise level to breathing rate or pulse rate in a human..

Why? The use of heart rate sensors does not produce correct data. Also an important life skill for emergency first aider is to be able to take a pulse by traditional methods. Sensors not usually used in real life situations.

NOTE:

- The use of sensors should be confined to areas where they are effective e.g. field studies .. light intensity, ph etc

- The above modifications deals with the concerns of depth of treatment, lack of clarity on L.O. and the over emphasis on debates and research

5.11 Human Reproduction

L.O. ... **describe in simple terms fertilisation, implantation, placenta formation, and placenta functions** ... is H.L on the draft but O.L. on present syllabus

L.O. ... Describe in simple terms the development of a fertilised egg to a blastocyst, to an embryo and to a foetus .. is on draft as O.L. but on present syllabus as H.L.

These 2 outcomes have obviously been mixed up in the copy and paste

4. Laboratory resources and IT resources required for implementing revised syllabi

The following have been identified as been inadequate in schools

- Lab access for practical work.
- Electrophoresis kits
- Spectrometers
- Lab technicians
- Dataloggers and Sensors
- Computers in labs/access to computer labs.
- Poor internet connections
- Dataprojectors

6. Are there areas included in the revised syllabi in which training is required

- Electrophoresis
- Teaching using key skills
- Training in using debates as a teaching methodology
- Measuring the level of certain constituents in a range of food samples
- BLAST
- Pyramids of biomass
- Bioinformatics
- Research methods and presentations
- Using powerpoint
- Datalogging
- New genetics material
- Practical work and learning needs

7. Any other comments.

Concerns about .....

- Layout of syllabus.. mandatory practicals to be itemised separately
- Rationale for deletions particularly human biology
- Agree with practical exam but concerns about how it will be implemented, validity, reliability, logistics
- Level of equipment in labs
- Access to lab space
- Access to computers
- Human biology for communication with / understanding health care professionals has been sacrificed to satisfy industry's demands
- Concerned about timetabling, and time available to work in groups
- Lack of lab technicians
- Gap between J.C. and L.C.
- Need for revision of J.C
- Sample papers required
- There is too much emphasis on research activities (1/3 of the practical activities). The actual lab skills developed by students have been reduced.
- Worried about assessment of research activities e.g. What is the procedure if a student is absent for a mandatory practical
- No funding to implement this syllabus.

- Importance of all students carrying out the same practical activity.
- Not enough information on the practical assessment which is worth 15%
- Keep existing syllabus with some updates in genetics, reduce ecology, remove IAA – change questioning
- 5% for lab notebooks too much … compromise integrity
- Introduction of all 3 syllabuses at same time too much
- Repetition of Unit 1 learning outcomes throughout the syllabus. Does not need a separate unit
- Learning outcomes and depth of treatment vague as in following examples

✓ .economic medical importance of viruses

✓ how edaphic factors influence distribution of organisms

- ✓ describe the role of organisms in nutrient recycling
- ✓ use ICT to gather, process and analyse information on the ways humans impact on the environment and suggest how this can be minimised
- ✓ the relationship between any two parameters of a species … primary or secondary data… l.o. already examined under 1.2
- ✓ select primary data using dataloggers to investigate the effect of any one factor on plant metabolism … dataloggers often do not collect reliable results. CO2 and O2 sensors v expensive. Should be open.
- ✓ Describe the concept of DNA sequencing .. too vague
- ✓ Genome Projects … should be able to select one… too vague
- ✓ Gene therapy … no currently approved gene therapies
- ✓ GMO's too vague
- ✓ BLAST … issues with internet
- ✓ Dataloggers for pulse/breathing rate …. Not reliable… present method satisfactory
- ✓ Analyse quantitative data on illness … repeated l.o from unit 1
- ✓ Presentation on human disease disorder … already example done under reproduction

Irish Science Teachers' Association Submission on the proposed revision of the Leaving Certificate Chemistry Syllabus

October 5th 2011

Well-attended meetings were organised by the ISTA branch structure throughout the country in September 2011 to discuss the Chemistry Syllabus document, issued for consultation by the NCCA.

Detailed reports from these meetings and from a number of individual submissions have been assembled and collated by the Convenor of the Chemistry Sub-committee of Council, John Daly.

This submission will summarise issues raised under the following headings:-

1. **Length of the syllabus proposed & guidelines as to depth of treatment.**
2. **Views on content added, omitted & deleted.**
3. **Laboratory resources issues.**
4. **Laboratory availability, management issues & IT resources**
5. **In-service requirements**
6. **Second mode of assessment issues.**
7. **Terminal examination issues.**

1. Length of the syllabus proposed & guidelines as to depth of treatment.

Almost all submissions strongly signalled that the syllabus was too long. It was a common view that the exact time required to cover the syllabus was difficult to judge as the document lacked adequate guidelines on depth of treatment. Views were expressed that the excessive length of the course would not allow the "active learners" time to research, debate and present research as is suggested.

2. Views on content added, omitted & deleted.

A cautious welcome was extended to the new material included but any enthusiasm was overshadowed by the issue in point 1 above. It was suggested that "greenchemistry" in industry should be included.

All submissions mentioned that insufficient old material had been deleted from the syllabus to make room for new material and to allow for new emphasis on practical work and the second mode of assessment. Suggested deletions included (a) history of the Periodic Table (b) electrochemistry (c) reduce the number of mandatory experiments to facilitate the open-ended investigations and research projects (d) geometric isomerism (e) calorimetry (f) history of the atom (g) waste management (h) more material from the current 'Options' sections. Concern was expressed that the topic 'organic chemistry' showed little evidence of the need for higher order thinking.

3. Laboratory resources issues.

It was reported that there were huge variations from school to school in the availability of class sets of working, up-to-date, data-logging equipment. The absence of any chemistry syllabus requirement to use data-acquisition software, up to now, has meant that schools with limited budgets have not invested in this area even though encouraged to by the Discovery Science & Engineering initiatives.

4. Laboratory availability, management issues & IT resources

Without exception, teachers were appalled at the additional workload implied by this new approach to carrying out practical work, accountable to the second mode of assessment. The difficulty of gaining access to and managing laboratories without any technical assistance or in the absence of designated hours per week for that part of their job, was a source of anger at every meeting.

The commonly held view was that the NCCA seemed to work in a vacuum as regards implementation issues. There was widespread anger that such an organisation should be so insensitive and remote from the realities of a typical Irish secondary school. I quote from a typical branch report:-

> *I can't stress how concerned teachers were by the huge logistical demands this will impose, without any apparent recognition of an already tough workload, and no proposal included in the draft to work out how all this is actually to be done or funded. The availability of lab time will be a real problem for many. The increased practical work required, not only in Chemistry, but also in Biology and Physics, will lead to impossible demands on lab resources for many schools.*
> *Who is going to provide the extra work needed to organise lab resources, maintain sensors in working order, calibrate pH sensors etc.*
> *Teachers who have perhaps two L.C. science subjects, and Junior Science, already have a huge workload. These new syllabi will clearly add to this.*

IT resources in schools were reported as being very limited and would rarely allow class groups to access the web or school-networked material. Some points raised were:- (a) a trolley of net-books is a rarity (b) time in a functioning computer room is hard to find as this facility has to be shared over the whole school community (c) adequate speed internet access is rare (d) internet access in the classroom is not at all common (e) technology requires constant maintenance and a regular renewal budget.

5. In-service requirements

All reports concluded that a significant amount of CPD was required to properly train chemistry teachers to deliver this syllabus. Particular areas of concern were, (a) nanotechnology, (b) mass spec and IR spectroscopy (c) forensics (d) use and management of sensor technology (e) preparation of pupils for practical assessment (f) management of research projects (g) IT upskilling.

6. Second mode of assessment issues

Many reports asked for clarification on issues related to the above topic. I quote from a typical branch report:-

> *We had serious problems trying to work out how the practical assessment would take place. A number of concerns were raised, some of an entirely practical nature, and some questioned whether it would really just test how good students were at writing up a report? Whoever has to come up with the proposed practical activity, year after year, has a difficult job. We felt that whatever the activity it should be rigorously tested to ensure that it could be done in the allotted time with a high degree of probability of success.*
> *Who will set up labs? One teacher pointed out that she has more students taking the subject then she has work stations in the school. How is this going to be done safely?*

Who will supervise? (This would need qualified people, and not teachers of general subjects).

When will this exam take place? Is this going to take place at much the same time as orals, music practicals, the other science subjects? Depending on subject choices it could prove extremely demanding for some students.

Will all students doing L.C. Chemistry do the same exam at the same time, otherwise it would be unfair as word would get out to those doing it later with the attendant benefit?

Will this lead to even less lab time for students displaced from labs while this is going on?

Will the proposed authentication of lab notebooks by the teacher imposed even further demands on teachers' time?

7. Terminal examination issues

One submission quoted Aine Hyland, who in a recent report on access to Higher Education said, "assessment is the tail that wags the curriculum dog". This submission raised an issue that, it is of little value to change the LC chemistry syllabus if the terminal examination is not radically changed in style so as to measure, to a much greater extent, higher order thinking and to a lesser extent memory skills.

The submission also suggested that the primitive – fit the results to a bell-curve by manipulating the marking scheme- method of correcting the terminal examination paper needs to be changed. This has lead in the past to a rote-learned answer being considered adequate one year and unacceptable the next. This submission concluded that the Examinations Commission and the NCCA should be the one body where the syllabus designers can oversee the production of a terminal examination paper which will properly reflect the aims and objectives of the proposed syllabus.

In conclusion

The Irish Science Teachers' Association expects that these views, sourced from many chemistry teachers, will be given serious, thoughtful and careful consideration.

The ISTA asks the NCCA to recognise the grubby realities of an impoverished Irish education system before introducing syllabus revisions. Money may not be available for classroom and school laboratory infrastructure improvements. The proper and successful implementation of this chemistry syllabus revision depends on and requires a considerable financial commitment. The DES should commit to both or neither.

John Daly
Convenor of the ISTA Chemistry Sub-committee of Council

Irish Science Teachers' Association Submission on the proposed revision of the Leaving Certificate Physics Syllabus

- Sean Finn

1. Opinions on length of the revised syllabi.

- Syllabus is too long considering that most classes are mixed ability.
- Length difficult to determine when depth of treatment of topics is unclear. There is great concern that the learning outcomes are very unclear. Some have many hidden facets which mask the length of the syllabus.
- Some sections that are 'apparently' omitted from the draft will have to be taught in order to achieve learning outcomes and so the draft syllabus is far too long, e.g. to teach x-ray production, thermionic emission will have to be taught but is not included as a learning
- A lot of the 'deleted' material is really required for a full understanding
- It is difficult to know what should be included in light of the ambiguity over whether it is a stand-alone syllabus or is Junior Science a pre-requisite. In the case that junior science is not a pre-requisite many of the fundamentals will have to be included.
- Seismology – it is not particularly relevant to Irish students.

2. Views on content included in the syllabi;

Are there other topics that should have been included in the syllabus?

- There was unanimous agreement that the Doppler effect must be included.
- Boyle's Law
- Conduction, Convection and Radiation are not mentioned in the syllabus, yet there energy efficiency is an important part of the syllabus. Required material should be explicit not implicit.
- Vectors – since they have been removed from the Maths syllabus.
- The structure of a semi-conductor laser.
- Investigation on relationship between angle of incidence and angle of refraction should be re-worded as sine of both angles. Names of Laws and Formulae such as Snells Law should be included.
- It is difficult to know what should be included in light of the ambiguity over whether it is a stand-alone syllabus or is Junior Science a pre-requisite. In the case that junior science is not a pre-requisite many of the fundamentals will have to be included.
- Doppler effect should be considered

- Medical Physics was proposed by a number of branches It should include elements already in the draft as well as additions (ultrasound, medical imaging etc). The rationale was that this is an area of application of physics known to be of great interest to students, to girls as well as boys.
- Particle Physics : a significant number wanted to see some element of this topic retained on the syllabus on the grounds that:
    - It is a topic of interest to many students
    - It is a cutting-edge area of current research
- Frequency vs. 1/ length of a string experiment should also be carried out.
- There is concern that the historical aspects and STS are not specified sufficiently in the draft syllabus.
- Some topics excluded are needed to understand other topics still on. e.g. how can you explain spectroscopy without having knowledge of electron energy levels within the atom, but the Bohr model is gone.

3. Are there any topics that should have been omitted from the syllabus?

- Seismology – it is not particularly relevant to Irish students. Many commented that the it contained too much material or that its inclusion at the expense of Particle Physics or Doppler Effect was regrettable
- Vectors – since they have been removed from the Maths syllabus.
- The structure of a semi-conductor laser

4. Lab. resources required for implementing revised syllabi - are these present in schools?

- Seismology meters
- Sensors for data-logging experiments
- Making a musical instrument – no lab resources currently in schools.
- It was difficult to answer this question as there was no clear list of experiments, if they would be mandatory and how many there would be but the group felt that as long as there wasn't a variation on the previous set of mandatory experiments schools should be equipped to cover the experimental elements of the syllabus. However, issues were raised on whether all equipment would be present in all labs for the practical assessment and lab access.

5. IT resources required for implementing revised syllabi - are these present in schools?

- Laptops needed for teachers
- Software simulations for practicals and investigations need to be organised to a central location
- Internet access is an issue in some schools
- The issue of access to computers/school computer lab was raised. Access in most schools is limited as most subjects are introducing more and more ICT. As with a number of the questions, it was hard to give an accurate response as the depth of treatment required is not stated in the draft syllabus so it is hard to say if the resources are in place.
- Using computer room to prepare presentations is not a runner

6. Are there areas included in the revised syllabi in which you would wish to receive extra training?

- A teachers' guide/manual will be required.
- More clarification on 'optical appliances'
- Seismology
- Designing and making a musical instrument
- Use of sensors
- Software simulations
- Anything new, e.g. green energy
- Space
- Some mentioned poster presentations as an area requiring training.
- A substantial number suggested that a larger proportion than 20 percent should be allocated to the practical assessment component.
- Marks to be given for the Research Activity
- External examiners to observe students during the practical exam and award marks for their actions as well as for the written proforma
- Practical work could be assessed earlier in the term as is done for Agricultural Science

7. Any other comments.

- A teachers guide will be needed to give clarity to depth of treatment

- In other countries where practical assessment takes place lab technicians are in school labs. In light of the computer content of the course their assistance will be needed on maintaining the ICT stock as well as running the lab.
- A list clarifying the content changes between the current syllabus and the draft was requested (“what is new” and “what is gone”).External examiners to observe students during the practical exam and award marks for their actions as well as for the written proforma
- Practical work could be assessed earlier in the term as is done for Agricultural Science
- Some aspects of the syllabus appear to be in because they are "trendy", not because they are fundamental to an understanding of the subject
- Some of the titles of the units are ridiculous e.g. "Surfing the Physics Wave", "Physics Matters", "At Home with Physics"
- Greater clarification needed on second mode of assessment – who will set up the laboratory? when will the exam take place? how many students will be examined at the same time etc.
- Outrage over many of the basic concepts that have been omitted from the draft syllabus, including: F=ma, Boyles Law, Doppler Effect, Coulombs Law, 4 fundamental forces.
- Many teachers felt that it is not possible to teach the topics proposed on the draft without teaching the above omitted items.
- Many of the practicals begin with the word ‘Investigate’ but in fact they are not investigations as we already know the outcome.
- Further clarification required on many topics including: ‘radiation dose’, ‘diffraction grating experiment’, ‘nanoscale’.
- Clarification needed on the presentations
- Queries over the timing of the second mode of assessment – when will it be conducted?
- Will practical assessment have a kit?
- Will all practical exams be on the same day?
- If so how will schools with large physics numbers manage?
- If not will early candidates are at a disadvantage?
- Will there be just one set practical exam, or will there be a choice?
- How many students in a lab at the one time for the practical exam? (The video on ncca.ie shows six)
- Will there be an external examiner/supervisor for the practical, or is it the class teacher?
- There are misgivings around the credibility and integrity of the practical exam: is it fair, what is it purporting to access, is it valid?
- Practical assessment seems great in theory but fair implementation will be very difficult
- It is not practical to supervise one's own students during practical exam - some teachers will help them
- The practical exam is marking a write-up, not the actual practical skills

- The practical exam should be done at the same time on the same day in every school
- Very serious issues with the whole integrity of the practical work
- Is the 15% really for a written or a practical exam?
- The use of terms like surfing the physics wave etc in the title of the sections is trying to be fashionable and is silly and trivialises the subject, this does not seem to have happened with chemistry and biology.
- Introducing the changes to physics biology and chemistry should not take place. Please pilot one subject first.
- A rolling review of the subject should take place after the first cycle.

Appendix C

Correspondence between Ms Mary Mullaghy, Chairperson of ISTA and the NCCA – October and November 2013

Irish Science Teachers' Association
Eagraíocht Eolaithe na hÉireann

26 Bailis Manor,
Athlumney,
Navan,
Co. Meath.

Dr Anne Looney, Chief Executive,
National Council for Curriculum and Assessment,
35 Fitzwilliam Square,
Dublin 2.

6/10/'13

Dear Dr Looney,

I write to you in my role as Chairperson of the Irish Science Teachers' Association. At our Council meeting held on 5th October 2013, the ISTA representatives on the NCCA Leaving Certificate Biology, Chemistry and Physics development groups reported to ISTA Council on the latest drafts of these syllabi. It is a matter of grave concern that changes are made to syllabi without proper discussion and consensus among the members of the relevant syllabus committee / development group. It is unacceptable that significant insertions or deletions are made to syllabi without any prior agreement. It is also unacceptable that minority opinions are accorded more weight than those of the majority. Great concern was also expressed that, as currently constituted, the drafts of these syllabi would be submitted to NCCA Council in the near future.

We wish to remind you that when the present Junior Certificate Science syllabus was introduced in 2003, the syllabus that was circulated to schools contained simply a list of learning outcomes without any indication of depth of treatment or the range of subject knowledge required. To make matters worse, there were numerous examples of learning outcomes that were incorrectly written and this resulted in a corrected version of the syllabus having to be subsequently sent to schools by the Department of Education. The ISTA spent three years (2003 – 2006) attempting to get clarification on depth of treatment of the syllabus and eventually thirty one pages of clarifications were issued to the ISTA by the NCCA. We hope that there will not be a repeat of this situation with the proposed new syllabi in Biology, Chemistry and Physics.

In terms of structure and clarity of depth of treatment, the Leaving Certificate syllabi in Biology, Chemistry and Physics currently being taught in schools are far superior to the proposed draft syllabi recently circulated. The essential problem with the proposed draft syllabi is that they simply contain a list of learning outcomes with no indication re depth of treatment or range of subject knowledge associated with these learning outcomes. **We request that this depth of treatment and range of subject knowledge be integrated into the draft syllabi (as is the case with the syllabi currently being taught) before they are finalised by NCCA Council.** It is vital that this important material is embedded into each of the syllabi and not made available as separate documentation at a later stage. Even highly experienced science teachers at our ISTA Council meeting found problems with interpreting many of the learning outcomes. It is clear that there is still a considerable amount of work to be done on the draft syllabi in order to reduce the "fuzziness" of these draft syllabi and thus bring them up to the standard of the current Leaving Certificate Biology, Chemistry and Physics syllabi.

Concern was also expressed about the mode of assessment of practical work associated with the draft syllabi. **We request that a pilot project conducted by professionals in science education research be carried out prior to the introduction of the new syllabi in order to test the reliability and validity of the proposed mode of assessment of practical work.** The carrying out of this pilot project will enable time to be given to bringing the draft syllabi up to standard so that we can all work in partnership and thus enable science teachers to have ownership of the new syllabi in order to ensure their successful implementation in the classroom.

I hope that you and your colleagues in NCCA will give our concerns your serious consideration.

Yours sincerely,

_____
Mary Mullaghy (Hon Chairperson)

25th October 2013

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

Ms. Mary Mullaghy
26 Bailis Manor
Athlumney
Navan
Co. Meath

Dear Ms. Mullaghy

Thank you for your recent correspondence on senior cycle science and your request for the inclusion *of depth of treatment and range of subject knowledge required* in each case.

In deciding to move to a learning outcomes approach to all primary and post-primary specifications in the future, the Council drew on research in teaching, learning and assessment and on international practice in the articulation of national curricula.

Our work with teachers in various networks has shown that teachers value the direction given by outcomes, the opportunities they afford to focus on the learning, the support they offer for formative and summative assessment, and the flexibility they offer in the planning and sequencing of pedagogy. In the decade since the 2003 Junior Certificate Science syllabus, teachers have become more practiced in the use and interpretation of learning outcomes, and the NCCA has worked to improve how it crafts and connects them. We don't intend to include 'depth of treatment' and/or 'range of subject knowledge' in the new specifications for the sciences or for other subjects in senior cycle. However, as was discussed at a recent round of development group meetings, we will be including some examples of teaching, learning and assessment approaches that will support teachers in classroom planning.

Work on the assessment is ongoing and is informed by extensive work which has already taken place with classroom teachers, as well as input from science education research. I am confident that the appropriate validity/reliability balance will be achieved in the final model proposed.

Yours sincerely

Anne Looney
Chief Executive

Irish Science Teachers' Association
Eol-Oiúl na hÉireann

26 Bailis Manor,
Athlumney,
Navan,
Co. Meath.

Dr Anne Looney, Chief Executive,
National Council for Curriculum and Assessment,
35 Fitzwilliam Square,
Dublin 2.

11/11/13

Dear Dr Looney,

Thank you for your letter dated 25th October 2013 in relation to senior cycle science. Having recently attended the World Conference on Science Education in Borneo, I am very familiar with the international trends of drafting syllabi using learning outcomes. The fundamental problem in Ireland seems to be that the NCCA appears to interpret learning outcomes as **replacing** all previous methods of syllabus descriptions whereas examination boards in other countries use learning outcomes to **enhance** syllabus descriptions. We will be referring this matter to our colleagues in the university sector who have expertise in the area of learning outcomes and will revert to you when we have received their professional opinion on this matter.

In your letter you state that "in the decade since the 2003 Junior Certificate Science syllabus, teachers have become more practiced in the use and interpretation of learning outcomes…". I would be very grateful if you could forward me the evidence for this statement since, as practising teachers, this is not our experience. In fact it took three years for the ISTA to get clarification from the NCCA on a whole range of learning outcomes in the Junior Certificate syllabus, e.g. *"Separate mixtures using a variety of techniques: filtration, evaporation, distillation and paper chromatography".* No amount of practice in the use and interpretation of learning outcomes will inform teachers on whether they are expected to teach simple distillation or fractional distillation.

The ISTA recognises that there is still a significant amount of work to be done in order to bring the draft syllabi in Leaving Certificate Biology, Chemistry and Physics up to an acceptable standard. We are concerned that the mistakes made in the Junior Certificate Science syllabus will be repeated in these syllabi. Our concerns may be summarised as follows:

- **Lack of depth of treatment**. The Leaving Certificate syllabi that are being taught in our schools at present are of a high standard. The syllabi contain details of the subject content, details of the depth of treatment, details of teaching activities and details of the social and applied aspects of each syllabus. These syllabi compare favourably with syllabi in other countries where the above details as well as learning outcomes are included. However, the draft Leaving Certificate syllabi in Biology, Chemistry and Physics as presently constituted contain simply a list of learning outcomes. These draft syllabi (October 2013) are incomplete as they contain no indication of depth of treatment to clarify what is meant by the learning outcomes. The problem may be easily highlighted by comparing the number of pages in the Higher Level syllabi being currently taught to those in the draft syllabi. (Introductory material is excluded from the page count).

	Current syllabus	Draft syllabus
Biology	37 pages (p.7 – 44)	11 pages (p. 19 – 30)
Chemistry	34 pages (p. 37 – 71)	17 pages (p.20 – 37)
Physics	19 pages (p. 25 - 44)	12 pages (p. 17 – 29)

We do not wish to see the situation repeated as occurred in the draft Junior Cert Science syllabus where a syllabus document of only 19 pages of Learning Outcomes was sent to schools and teachers were expected to teach the entire Junior Certificate programme based on this very unsatisfactory document. As outlined in our submission to the NCCA on 6th October 2013, it took the ISTA three years (2003 – 2006) to obtain clarification on the depth of treatment of the learning outcomes. It subsequently transpired that this clarification had little relevance or official standing as the clarification documentation was not embedded in the syllabus. It is not acceptable to the ISTA that depth of treatment should be covered in Teachers' Guidelines – it must be an integral part of the syllabus.

- **Lack of clarity of Mandatory Experiments**. This is a still lack of clarity on the list of Mandatory Experiments in the syllabus, e.g. at the most recent meeting of the Leaving Cert chemistry development, there was still confusion about what experiments were simple test-tube demonstration experiments and what were full Mandatory Experiments. No list of Mandatory Experiments has been made available for any of the three Leaving Certificate Biology, Chemistry or Physics syllabi.

- **Lack of clarity on Assessment of Practical Work**. We are deeply concerned at the lack of detail of the proposed Assessment of Practical Work. Not only is there a lack of detail on the proposed mode of assessment, but, there appears to be a lack of communication between the NCCA and the SEC as evidenced by the fact that recent draft syllabi stated that *"the tasks are set and the electronic submission is marked by the State Examinations Commission".* The SEC representatives on the NCCA development groups did not appear to know anything about the electronic submission proposal. We reiterate our request made in our submission of the 6th October that a pilot project conducted by professionals in science education research be carried out with a broad spectrum of randomly selected schools prior to the introduction of the new syllabi, in order to test the reliability and validity of the proposed mode of assessment of practical work.

In view of the concerns outlined above, we request the NCCA to avoid rushing to complete the Leaving Certificate syllabi in Biology, Chemistry and Physics within the next few weeks and to allow time for the draft syllabi to be brought up to the standard of the current syllabi. This would also allow a pilot project to be carried out on the Assessment of Practical Work.

We look forward to working in partnership with you and your colleagues in the NCCA so that the teachers in the classroom can have a sense of ownership of the new syllabi in order to ensure their successful implementation in the classroom.

Yours sincerely,

_____

Mary Mullaghy.
(ISTA Hon Chairperson)

Appendix D

Extracts from the Scottish Qualifications Authority Higher Chemistry Syllabus

SQA

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- Delivery Processes
- News and Events
- CfE Vacancies
- FAQs and Feedback

Higher Chemistry

This Course is valid from August 2014.

The Higher Chemistry Course develops learners' curiosity, interest and enthusiasm for chemistry in a range of contexts. The skills of scientific inquiry and investigation are developed throughout the Course, and the relevance of chemistry is highlighted by the study of the applications of chemistry in everyday contexts.

Chemistry homepage

Qualification content and delivery tools

The documents on this page are for teachers and lecturers.

Learners studying this qualification may also find the documents useful.

The 'Related information' panel on this page contains information that applies to all new National Qualifications in this subject.

Use the tabs below to open each section individually. Alternatively you can view all the sections.

Contact Information

- Candidate and General Enquiries
- 0345 279 1000

Related Information

- N3 - N5 Chemistry: Quality Assurance - external verification
- N3 - N5 Chemistry Course Comparisons
- Higher Chemistry Course Comparison
- New NQs - notification of changes to documents

External Web Links

- BBC resources for National 4 Chemistry
- BBC resources for National 5 Chemistry

SQA

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Assessment and Exams
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Principles and Guidelines
CfE Policy Information
Delivery Processes
News and Events
CfE Vacancies
FAQs and Feedback
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Chemistry homepage

Qualification content and delivery tools

The documents on this page are for teachers and lecturers.

Learners studying this qualification may also find the documents useful.

The 'Related information' panel on this page contains information that applies to all new National Qualifications in this subject.

Use the tabs below to open each section individually. Alternatively you can view all the sections.

Mandatory information

- Course Specification
- Course Assessment Specification
- Unit Specifications

Advice and guidance

- Course and Unit Support Notes

Assessment support

- Assessment overview
- Specimen Question Paper and Marking Instructions
- Unit Assessment Support

- Data Booklet

Higher Chemistry Course Comparison
New NQs - notification of changes to documents

External Web Links

BBC resources for National 4 Chemistry
BBC resources for National 5 Chemistry

- SCHOLAR Scotland online revision materials
- Education Scotland - advice and support for Chemistry National Qualifications

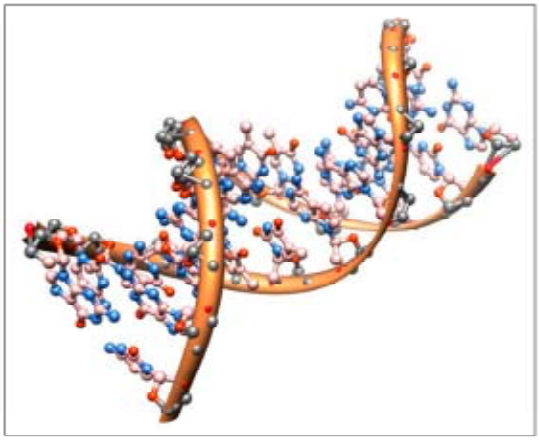
Appendix E

Extracts from the Scottish Qualifications Authority syllabi for Physics and Biology

Course Support Notes

SQA

Higher Biology Course Support Notes

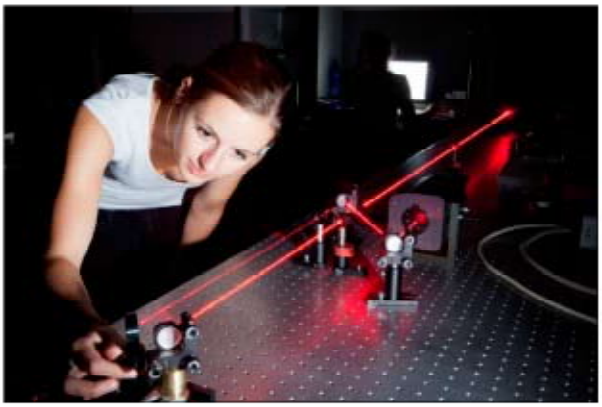


Mandatory Course key areas	Suggested learning activities	Exemplification of key areas
1 The structure and replication of DNA		
(a) Structure of DNA —nucleotides (deoxyribose sugar, phosphate and base), sugar–phosphate backbone, base pairing (adenine, thymine and guanine, cytosine), by hydrogen bonds and double stranded antiparallel structure, with deoxyribose and phosphate at 3' and 5' ends of each strand.	Case study examining the experimental evidence of the bacterial transformation experiments of Griffiths and identification of DNA as the transforming principle by Avery *et al.*, phage experiments of Hershey and Chase, Chargaff's base ratios and the X-ray crystallography of Wilkins and Franklin.	All cells store their genetic information in the base sequence of DNA. The genotype is determined by the sequence of bases.
(i) Organisation of DNA — circular chromosomal DNA and plasmids in prokaryotes. Circular plasmids in yeast. Circular chromosome in mitochondria and chloroplasts of eukaryotes. Linear chromosomes in the nucleus of eukaryotes.	Watson and Crick's double-helix model as an evidence-based conclusion. Case study on Meselson and Stahl experiments on DNA replication. DNA gel electrophoresis. Comparison of DNA extraction from peas and kiwi fruit (false positive result in latter as DNA is obscured by pectin).	The DNA found in the linear chromosomes of the nucleus of eukaryotes is tightly coiled and packaged with associated proteins.

Course Support Notes

SQA

Higher Physics Course Support Notes



Physics: Our Dynamic Universe (Higher)		
Mandatory Course key areas	**Suggested learning activities**	**Exemplification of key areas**
Motion — equations and graphs Equations of motion for objects moving with constant acceleration in a straight line. Motion-time graphs for motion with constant acceleration in a straight line. Displacement, velocity and acceleration-time graphs and their interrelationship. Graphs for bouncing objects and objects thrown vertically upwards. All graphs restricted to constant acceleration in one dimension, inclusive of change of direction.	Practical experiments to verify the relationships shown in the equations. Light gates, motion sensors and software/hardware to measure displacement, velocity and acceleration. Using software to analyse videos of motion. Motion sensors (including wireless sensors) to enable graphical representation of motion. Displacement-time graphs. Gradient is velocity. Velocity-time graphs. Area under graph is displacement. Gradient is acceleration. Acceleration-time graphs. Investigate the variation of acceleration on a slope with the angle of the slope. Motion of athletes and equipment used in sports. Investigate the initial acceleration of an object projected vertically upwards (eg popper toy). Objects in free-fall and the movement of objects on slopes should be investigated.	$s = vt$ $v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ $s = \frac{1}{2}(u + v)t$

Appendix F

Extracts from the Physics and Biology Syllabi of the Victorian Curriculum and Assessment Authority

HOME > Biology Index

Biology

- Accreditation period - Units 1-4: 2013-2016
- Curriculum
- Assessment
- Support Material

Accreditation period - Units 1-4: 2013-2016

Note: This Biology study design (accreditation period 2013-2016) was revised during 2012 and replaces the previous Biology study design (accreditation period 2006-2014). VCE study designs are no longer available in hard copy format.

Curriculum

- **Study Design** (pdf - 1.25mb)
  Details of areas of study, outcomes and assessment for Biology Units 1-4: 2013-2016.
- **Resources** (doc - 113.5kb)
  A list of suitable resources for VCE Biology.
- **Study Summary** (doc - 79kb)
  A summary of the VCE Biology Study Design for 2013-2016.

Assessment

Back to Top

- **Assessment Handbook** (doc - 241kb)
  Contains assessment advice for both School assessed-Coursework and the examination.
- **Examinations Reports**
  Find past exams and sample exams for Biology.
- **Exam specification and sample exam** (pdf - 783.6kb)

Support Material

Back to Top

- **Summary of Changes (pdf - 615.68kb)**
  Summary of changes to the VCE Biology 2013-2016 Study Design (from the 2006-2012 Biology Study Design). For the full lists of key knowledge, teachers must refer to the study design.
- **Expert Papers addressing new content in Units 3 and 4**
  - **Signal transduction** (doc - 97kb)
  - **Recent developments and advances in evolutionary theory** (doc - 83.5kb)
  - **Molecular Biology** (pdf - 53.21kb)
  - **Proteomes, Genes and Junk DNA** (pdf - 210.28kb)
- **Frequently Asked Questions** (doc - 84.5kb)

VICTORIAN CURRICULUM AND ASSESSMENT AUTHORITY

State Government Victoria

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Early Years
- VEYLDF 0-8 (Victorian Early Years Learning and Development Framework)

Foundation to 10
- AusVELS
- Literacy and Numeracy Testing

Senior Secondary
- VCE (Victorian Certificate of Education)
- VET (Vocational Education and Training)
- VCAL (Victorian Certificate of Applied Learning)

HOME > Physics Index

Physics

- Accreditation period - Units 1-4: 2013-2016
- Curriculum
- Assessment
- Support Material

Accreditation period - Units 1-4: 2013-2016

Note: The Physics study design (accreditation period 2013-2016) was revised during 2012 and replaces the previous Physics study design (accreditation period 2009-2014). VCE study designs are no longer available in hard copy format.

Curriculum

- Study Design (pdf - 1.37mb) (PDF - 1.8MB)
  Details on areas of study, outcomes and assessment for Physics Units 1-4: 2013-2016.
- Study Summary (doc - 70kb) (DOC - 56KB)
  A summary of the VCE Physics Study Design for 2013-2016.
- Resources (doc - 199kb) (DOC - 183KB)
  A list of suitable resources for VCE Physics.

Assessment

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- Assessment Handbook (doc - 379kb) (DOC - 363KB)
  Contains assessment advice for both School assessed-Coursework and the examination.
- Examination Reports
  Find past exams and sample exams for Physics.
- School-assessed Coursework Reports
  Find School-assessed Coursework Reports for VCE Physics.
- Exam specifications and sample exam (pdf - 832.61kb) (PDF - 832KB)
- Use of Calculators in Exams
  Information about the use of calculators in Physics examinations.

Support Material

Back to Top

- Summary of Changes (PDF - 615KB)
  Summary of changes to the VCE Physics 2013-2016 Study Design (from the 2006-2012 Physics Study Design). For the full lists of key knowledge, teachers must refer to the study design.
- Frequently Asked Questions (doc - 75kb) (DOC - 58KB)
  A set of FAQs for the revised VCE Physics Study Design (accreditation period 2013-2016).
- Implementation briefing presentation (ppt - 504.5kb) (PDF - 486KB)
- **Table of Electronic Symbols**
  Table of commonly used electronic symbols for VCE Physics and VCE Systems Engineering.
  - Table of Electronic Symbols (doc - 339.5kb) (March 2007, DOC - 353KB)
  - Table of Electronic Symbols (pdf - 221.89kb) (March 2007, PDF - 128KB)