AUSTRALIAN CURRICULUM, ASSESSMENT AND REPORTING AUTHORITY

# Consultation Report

# Draft Senior Secondary Australian Curriculum: Science

November 2012

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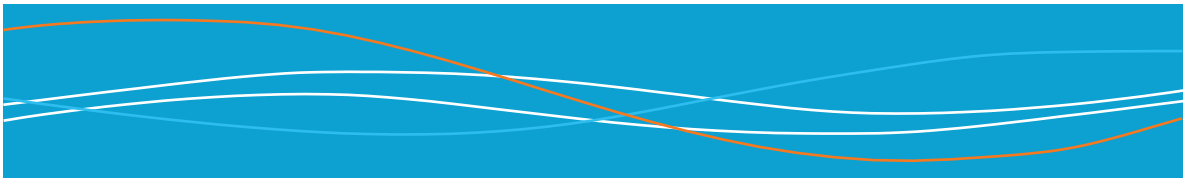


# Contents

# Executive summary

## Background

The Australian Curriculum, Assessment and Reporting Authority (ACARA) is responsible for a national curriculum from Foundation to Year 12 in specified learning areas.

In December 2010, ACARA published the Foundation to Year 10 Australian Curriculum for English, History, Mathematics and Science. During 2010, draft curriculum content was also developed for 14 senior secondary subjects (four in each of English, Mathematics and Science, and two in History) and released for public consultation. From mid-2010 to December 2012, an iterative process of curriculum writing, consultation, feedback analysis, revision and refinement was conducted. The process included selected curriculum writers and advisers, and ongoing engagement with key stakeholder groups including state and territory education authorities, ACACA Australasian Curriculum, Assessment and Certification Authorities, professional associations and academics,

Chapter 1 of this report provides more detail on the context for the development of the senior secondary Australian Curriculum and explains the development process over the two-year period.

The draft Senior Secondary Australian Curriculum: Science was released as four subjects:

- Biology
- Chemistry
- Earth and Environmental Science
- Physics

## Methodology

The draft senior secondary Australian Curriculum was made available for nationwide consultation from 10 May to 20 July 2012.

There were two main avenues for formal consultation feedback: an online questionnaire on the consultation portal of the Australian Curriculum website, and written submissions sent directly to ACARA.

Feedback was directly sought on rationales and aims, structural coherence, coverage and clarity of content, clarity and coherence of achievement standards, and representation of general capabilities and cross-curriculum priorities.

Chapter 2 of this report provides more detail about the consultation methodology.

## Consultation demographics

Across all 14 senior secondary subjects (English, History, Mathematics, Science), 373 responses were received to the online questionnaire, including 110 for Science. In addition to the questionnaire responses, 162 written submissions were received. Numerous written submissions addressed each of the four learning areas and the subjects therein.

Note that single responses often incorporated the views of many respondents.

The breakdown of online questionnaires for each subject is presented in Appendix 1.

All states and territories provided feedback on the draft curriculum either through the online questionnaire or via detailed written submissions.

Feedback was submitted by key stakeholders throughout Australia including:

- state and territory curriculum and school authorities
- peak bodies (such as teacher professional associations, government agencies and non-government organisations)
- schools
- individuals (teachers, academics, parents, members of the community).

Organisations that made written submissions are listed in Appendix 2.

## Key findings

The consultation feedback identified strengths common to all four Science subjects:

- The subject rationale and aims are clear, comprehensive and appropriate.
- There is a clear link between the subjects and the F–10 Australian Curriculum: Science.
- The three strand structure is appropriate and valued, particularly the inclusion of *Science as a Human Endeavour (SHE).*
- The *Science Inquiry Skills (SIS)* based on a generic set and elaborated in each subject/unit are appropriate and useful.
- The two dimensions of the achievement standards are appropriate.
- The emphasis on the cross-curriculum priority of *Sustainability* across the Science subjects is appropriate.

Specific areas for improvement across all four science subjects were also identified:

- The subjects contain too much content to be taught through an inquiry or contextualised approach.
- Mandated contexts in *Science as a Human Endeavour* limit flexibility and create too much additional content.
- Unit learning outcomes need to be more strongly aligned with the achievement standards.
- Mathematical expectations in relation to data analysis (error and uncertainty) are unclear – greater detail requested.
- There is insufficient indication of the opportunities to develop general capabilities and cross-curriculum priorities in the subjects.
- In relation to the achievement standards, there are issues with regard to clarity, indication of increased cognitive/skill demand across the two pairs of units, and differentiation of performance between levels.

These broad concerns became the focus of review and refinement, as did concerns specific to each of the four Science subjects.

The strengths as well as areas for improvement identified in the consultation feedback as being specific to Biology, Chemistry, Earth and Environmental Science and Physics are described in Chapters 4 to 7 respectively of this report.

# 1. Background information

## 1.1 Context for senior secondary curriculum development

The draft curriculum was developed according to a set of design specifications that were approved by the ACARA Board following consultation with state and territory curriculum, assessment and certification authorities. These are published in ACARA's *Curriculum Design Paper* (v3.0) (2012) (see www.acara.edu.au/curriculum/development_of_the_australian_curriculum.html)

The design specifications build on:

a) the *Senior Secondary Years Position Paper* that was subject to national consultation in 2009
b) discussion of senior secondary curriculum in the *Shape of the Australian Curriculum* (v3.0) which included reference to overall characteristics of the senior secondary Australian Curriculum.

The senior secondary Australian Curriculum specifies content and achievement standards for 14 senior secondary subjects across English, History, Mathematics and Science. Content refers to the knowledge, understanding and skills to be taught and learned in each subject. Achievement standards refer to descriptions of 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.

The senior secondary Australian Curriculum for each subject has been organised into four units. In each subject, Units 3 and 4 are designed to be developmentally more challenging than Units 1 and 2. Each unit is designed to be taught in approximately half a school year (approximately 50–60 hours' duration, including assessment and examinations). This design enables flexibility in the delivery of the four senior secondary units so that they may be studied singly in half a year, as two units over one year, or as four units over two years.

Each subject is clearly organised with a rationale, aims and learning outcomes to which the content and achievement standards are written.

The rationale for each subject:

- describes the nature of the subject in general terms and outlines how learning in the subject relates to the contemporary world and current practice
- explains the place and purpose of the subject, how learning in the subject is valuable, and how it contributes to meeting the national goals of schooling
- is consistent with the Foundation – Year 10 learning area rationale.

The aims for each subject present high-level statements of the major purpose of the subject and the intended developments in student learning.

The learning outcomes for each subject broadly describe what a student is expected to have learned as a result of studying the specified content. They describe the major dimensions of content, namely the knowledge, understanding and skills required by the subject.

Together with the content and achievement standards, the learning outcomes for each subject provide sufficient detail for:

a) teachers and students to know what is expected to be taught and learned
b) state and territory authorities to set assessment and certification requirements.

## 1.2 Key stages in the development process

The key stages, development criteria and roles/responsibilities are outlined in ACARA's *Curriculum Development Process* (v6.0) which has been published on the authority's website. The process is summarised in the following timeline.

February–March 2011

- Review of final report from the 2010 consultation on senior years' curriculum content along with key stakeholder (authorities, professional associations and universities) submissions to identify the major issues in relation to the curriculum content
- Preparation of conceptual models for senior secondary achievement standards and an options paper for consideration by an achievement standards reference group

April 2011

- Consideration of senior secondary curriculum design and structural elements
- Discussion of a preferred option for development of senior secondary achievement standards
- Analysis of relevant state and territory documents regarding achievement standards, subject-specific 'grade' or equivalent-level descriptors, and related policy expectations

May 2011

- Drafting of senior secondary Australian Curriculum (particularly rationale, aims, units, content descriptions) by writers and advisory groups
- Advice from ACACA regarding plans to develop achievement standards and proposals for redrafting the curriculum and the draft senior secondary curriculum design paper

June–July 2011

- Draft curriculum materials presented to national panels for feedback

August–October 2011

- Analysis of national panel feedback
- Revision of the draft curriculum in response to feedback and in light of concurrent work to develop the achievement standards
- Circulation of the draft curriculum to state and territory authorities for reviewing prior to the next round of national panels

November–December 2011

- Further round of national panel meetings to inform ongoing review of the curriculum

August–December 2011

- Research into current standards in equivalent subjects in states and territories
- Development of possible model/s for achievement standards and subsequent drafting of achievement standards for each subject
- Advice from Achievement Standards Reference Group, ACARA's F–12 Curriculum Reference Group, and ACACAs

January–February 2012

- Continuing review of the curriculum with assistance of critical reviewers, content experts and advisory groups

March–April 2012

- Preparation of the next draft of the curriculum for a further round of national panel review
- Bilateral meetings with each state and territory curriculum authority
- Subsequent revision in consultation with advisers and writers to prepare consultation draft for approval for national consultation

May–July 2012

- Release of draft curriculum for national consultation on the Australian Curriculum consultation website from 10 May to 20 July
- Continuing engagement with expert groups, advisory groups and national panels
- Review of national and international information on achievement standards

July–August 2012

- Comparisons of the draft curriculum with comparable curriculum offerings in selected international jurisdictions

August–October 2012

- Finalisation of senior secondary consultation feedback reports
- Concurrent analysis of significant concerns and suggested areas for improvement drawn from the initial feedback analysis, with particular attention given to state/territory authority submissions
- Reviews by international experts and a desktop mapping analysis of similarities and differences between the Australian Curriculum and international curricula
- A further round of national panel meetings (6 to11 September 2012) to assist advisory groups and writers to further revise and refine the curriculum
- Consultation data analysed and appropriate revisions made to the curriculum
- Senior secondary Australian Curriculum forwarded to the ACARA Board for approval

November–December 2012

- Curriculum submitted to AEEYSOC (Australian Education, Early Childhood Development and Youth Affairs Senior Officials Committee) for consideration in November
- Endorsement at SCSEEC (Standing Council on School Education and Early Childhood) meeting of 7 December for publication

# 2. Methodology

## 2.1 Consultation processes

The draft senior secondary Australian Curriculum was made available for nationwide consultation from 10 May to 20 July.

There were two main avenues for formal consultation feedback:

- an online survey on the consultation portal of the Australian Curriculum website, where respondents completed a rating scale for each question and were able to write a comment
- written submissions sent directly to ACARA.

The online survey comprised a mixture of rating-scale questions (four-point Likert scale) and space for comments that focus on suggestions for improvement. Feedback was sought on the:

- rationale, aims and coherence of the unit structure for each subject
- coverage and clarity of curriculum content
- clarity and coherence of the achievement standards
- representation of general capabilities and cross-curriculum priorities.

All online survey questions are included in Appendix 1.

Written submissions were received from state /territory education authorities, professional associations and other stakeholders. These typically offered more detailed feedback than was possible via the online survey. Respondents were requested to complete a cover sheet that contained space to record basic demographic information to assist in the collation and analysis of responses.

Opportunities to provide feedback either via the online survey or by written submission were promoted on the ACARA website and through education authorities, professional associations, and academics in the field of education. Reminders were regularly provided to subscribers to through the online newsletter *ACARA Update*.

## 2.2 Feedback: gathering, analysis and reporting

**Quantitative data**, from the online surveys, are presented in charts and tables throughout this report and in the appendices. All quantitative data were collated and analysed in spreadsheets, from which charts and tables were produced. The methodology for the collection and analysis of the data is outlined below.

For rating-scale questions, the frequency of responses for each rating (strongly agree, agree, disagree and strongly disagree) was assigned a numeric value (for example, strongly agree – 4, agree – 3). Values were totalled, and a percentage was calculated for each category and displayed as a column graph.

Data analysis included breakdowns by state and territory for each question.

**Qualitative data** were outsourced to experts in research and data analysis. The data were gathered both from the comments in the online survey and from the written submissions, and

were analysed using NVivo software. From responses to each question in the online survey, comments were categorised as ‘concerns’, ‘strengths’ and ‘suggestions’, with specific topic nodes developed within these three categories. Comments were analysed for recurring themes and general trends.

An identical coding procedure was used for the written submissions.

ACARA senior project officers also read and reviewed all the consultation feedback (quantitative and qualitative). They supplemented the qualitative analysis with reference to emphases and trends evident in the data, from their own critical analysis of the feedback.

For reporting purposes, the analysed data were organised according to the broad organisers for the survey- Rationale and Aims, Organisation, Content, and Achievement Standards. Findings are reported against these headings in terms of strengths, areas of contention, and areas for improvement.

Analysis of specific elements of consultation feedback highlighted the usefulness of grouping issues raised in the feedback into several categories for response by ACARA, namely:

| **Category** | **Response** |
|---|---|
| **1.** Broad and strong agreement and consistent with design brief and subject rationale | Addressed through revision of the documents |
| **2.** Identifies errors in content | Addressed through revision of the documents |
| **3.** Conflicting views about the issue and/or how to resolve it | Decision to be made by ACARA with advisors about how to address |
| **4.** Inconsistent with design brief and would require a change in design specifications | Noted, not addressed |
| **5.** Related to nature of integration and implementation | Best resolved by the state/territory during the process of integration |

## 2.3 Quality assurance

Qualitative data were analysed externally by data analysis consultants to ensure greater objectivity. ACARA officers met with the researchers to discuss the results of the data and ways to make its presentation clear to the reader.

Findings from the data analysis were checked against submissions of major stakeholders such as curriculum, assessment and certification authorities whose input typically represented the views of a large number of respondents. This was to ensure no significant concerns were left unrecognised in the findings.

All consultation feedback, including written responses and online surveys, was archived to TRIM, ACARA's information management system. Data integrity checks were carried out to ensure that data were both accurate and relevant. All online data from the surveys were checked and duplicates were removed.

# 3. Consultation findings: across the Science learning area

This section summarises the key strengths and areas for improvement that were identified in the consultation. There was also much commentary around implementation issues, although these were not the prime focus of consultation.

## 3.1 Consultation demographics: Science

### *3.1.1 Online questionnaire responses*

A total of 110 questionnaires were received across the four senior secondary science subjects of Biology, Chemistry, Earth and Environment Science and Physics, representing 651 individual respondents.

Table 1: National representation of respondents by state across the Learning Area – online questionnaire

| State/Territory | Number of questionnaires | Respondent group size |
|---|---|---|
| Australian Capital Territory | 2 | 5 |
| New South Wales | 31 | 146 |
| Northern Territory | nil | |
| Queensland | 21 | 188 |
| South Australia | 7 | 22 |
| Tasmania | 3 | 22 |
| Victoria | 34 | 57 |
| Western Australia | 12 | 211 |
| **TOTAL** | **110** | **651** |

A breakdown of the quantitative data generated by the online questionnaire is available in Appendix 1.

### 3.1.2 Written submissions

A total of 85 written submissions were received, again representing a number of respondents. As many of the submissions did not reference the number of participants, the respondent group size is unclear.

Table 2: National representation of written submissions across the Learning Area.

| State/Territory | Number of written submissions |
|---|---|
| National | 8 |
| Australian Capital Territory | 4 |
| New South Wales | 16 |
| Northern Territory | 1 |
| Queensland | 22 |
| South Australia | 6 |
| Tasmania | 6 |
| Victoria | 13 |
| Western Australia | 9 |
| **TOTAL** | **85** |

The list of contributing groups and organisations can be found in Appendix 2.

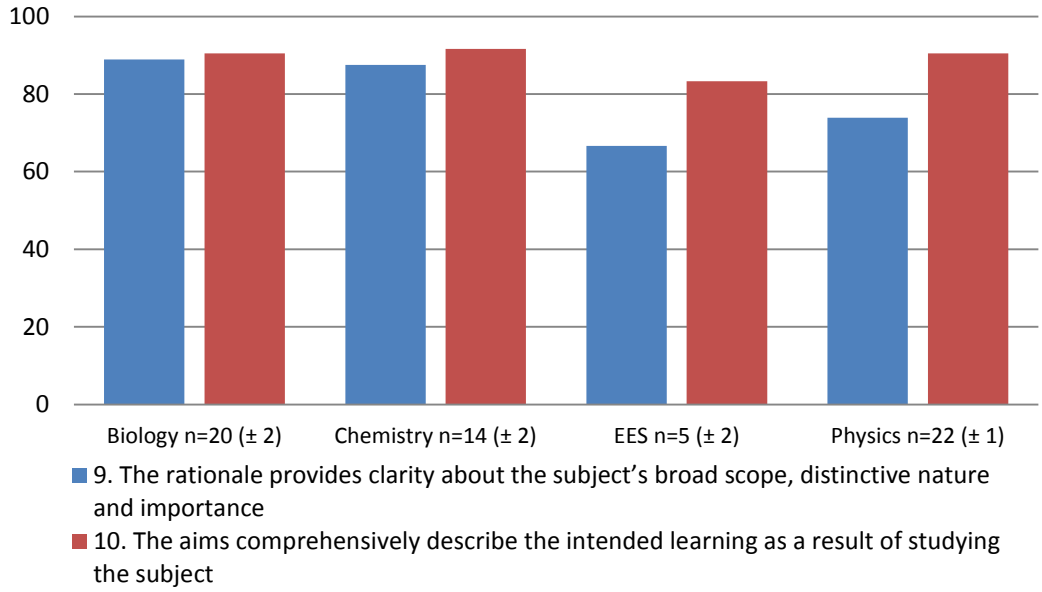
## 3.2 Strengths

### 3.2.1 Rationale and aims

Across the four subjects, there was a high level of agreement or strong agreement with the statements that 'the rationale provides clarity about the subject's broad scope, distinctive nature and importance' and 'the aims comprehensively describe the intended learning as a result of studying the subject'.

> *The Rationale clearly outlines the nature of the curriculum, inclusive of the major concepts, theories and models expected in a national Biology course. It provides clear links to the strands and the four units. (SCSA WA)*

Figure 1: Responses to Questions 9 and 10. Rationale and aims (% strongly agree and agree)




### *3.2.2 Structure*

The majority of respondents felt that there was a strong connection between the senior secondary Science subject content and the F–10 Science curriculum (particularly with regard to the continued three strand structure), and that Units 3 and 4 were more cognitively demanding than Units 1 and 2.

Figure 2: Responses to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum (% strongly agree and agree)

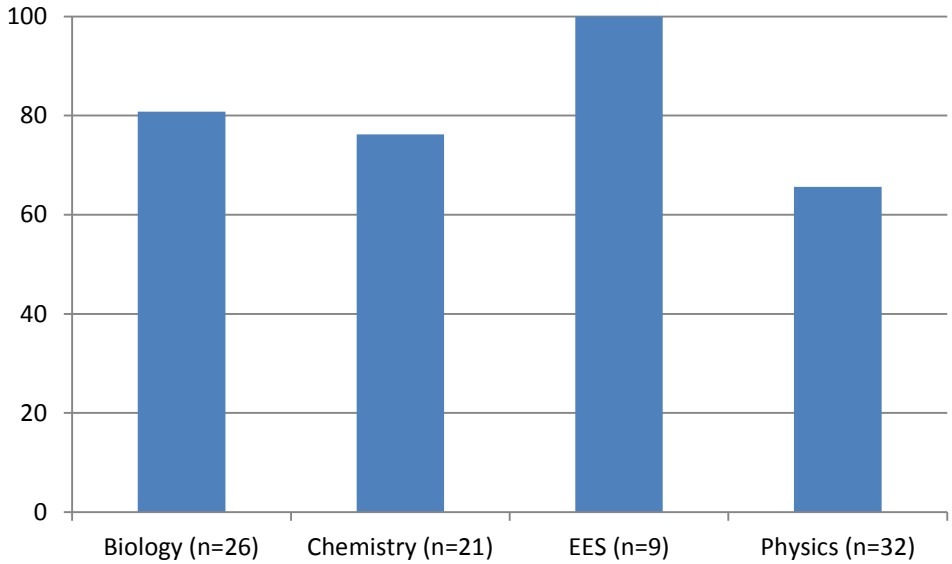
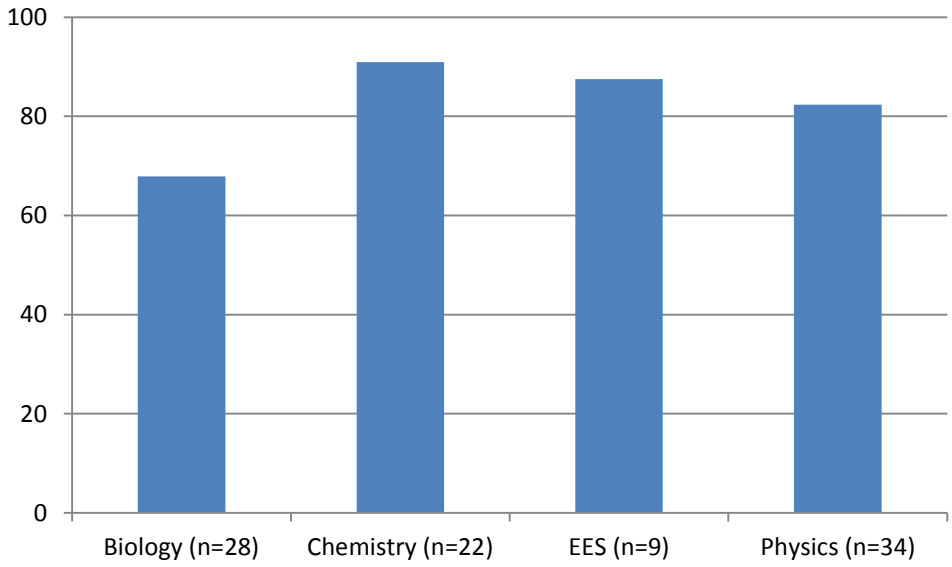


Figure 3: Responses to Question 12. Units 3 and 4 are more cognitively demanding than Units 1 and 2 (% strongly agree and agree)




A number of respondents noted that the use of the three strands of *Science Understanding*, *Science as a Human Endeavour* and *Science Inquiry Skills* as the basis for integrated programming and teaching was a strength of the curriculum design, and that the inclusion of the *Science as a Human Endeavour* strand was to be applauded.

> *Teaching students about Science as a Human Endeavour is an integral part of a modern science education. There are some excellent examples to be found in the [Physics] curriculum … (Astronomical Society of Australia)*

> *The inclusion of Science as a Human Endeavour, with good examples, will promote the inclusion of this strand in classroom teaching. (NT BOS)*

> *We highly commend the inclusion of Science as a Human Endeavour into the core content of science courses. (Department of Environment and Conservation, WA)*

### *3.2.3 Content*

The presentation of the *Science Inquiry Skills* as a set of generic skills similar across subjects and elaborated in each unit was well received by the majority of respondents.

> *Science Inquiry Skills are written for an entire unit based on the generic science inquiry skills. The generic Science Inquiry Skills and the subject specific descriptions work well. (QSA)*

A number of respondents also valued the capacity for states or territories, schools or individual teachers to select and integrate local contexts when developing teaching programs.

> *All subjects now offer opportunity for the inclusion of local contexts. (NT BOS)*

### 3.2.4 Achievement standards

Although a number of significant issues were raised with regard to the achievement standards, the two dimensions of *Concepts, Models and Applications* and *Inquiry Skills* were broadly supported by respondents.

> *The dimensions, Concepts, Models and Applications, and Inquiry Skills are supported. It is appropriate and logical; linking to the strands Science Understanding, Science as a Human Endeavour and Science Inquiry Skills. (QSA)*

### 3.2.5 General capabilities and cross-curriculum priorities

A number of respondents commented specifically on the description of and explicit content relating to the cross-curriculum priority of *Sustainability* across the four subjects.

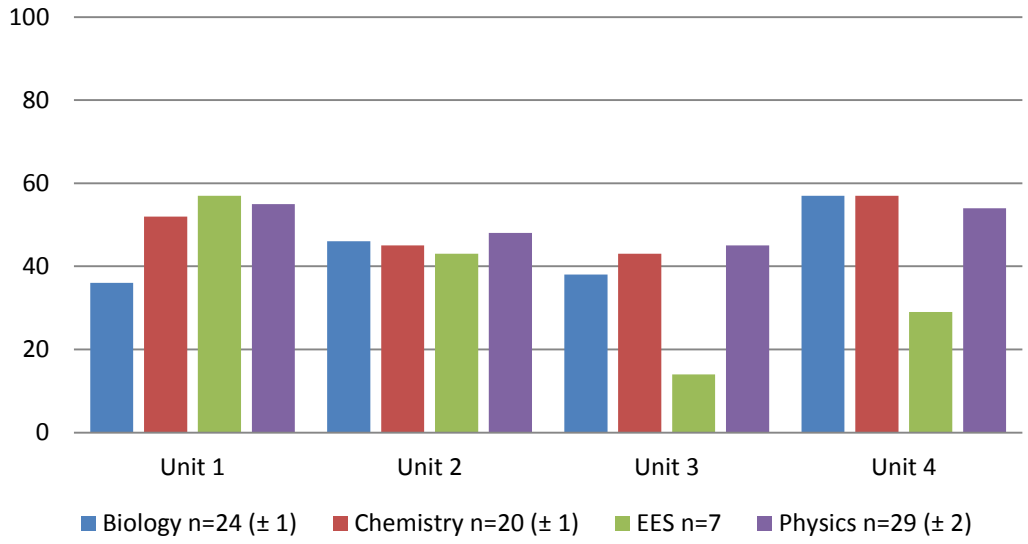
> *Science descriptions of Sustainability in the Cross-curriculum Priorities are good and are mostly followed through into the content. (Department of Environment and Conservation, WA)*

## 3.3 Areas for improvement

### 3.3.1 Content

Although there was variation in the responses across units within subjects, there was generally strong concern that the subjects included too much mandated content to enable inquiry approaches, deep learning and exploration of local, topical or engaging contexts. Figure 4 shows that across the subjects, the strongest concerns were typically raised in relation to the amount of content in Unit 1 and Unit 4. However, a large number of respondents also identified content that they considered should be added to the subjects.

Figure 4: Responses to Questions. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (% disagree and strongly disagree)



While respondents frequently expressed their support for the *Science as a Human Endeavour* strand, many noted that the content descriptions in this strand often included too much contextual information, were too focused on historical events, and should focus on concepts rather than context. Others commented that the statements were too broad and that the use of examples created confusion for teachers with regard to assessment.

> *The Science as a Human Endeavour sections are too prescriptive on content and would be limiting for some schools. (ISQ)*
>
> *The inclusion of the Science as Human Endeavour strand is supported. However, the treatment is too biased towards the history of famous scientists, and not focused on the ideas, concepts, and contemporary applications of science. (SACE Board)*
>
> *Science as a Human Endeavour statements could be written to allow more choice as they currently mandate additional content rather than allowing extension of already included concepts. (ASTA)*

A number of respondents commented that the unit learning outcomes were not sufficiently aligned to the unit content and/or the achievement standards.

The level of mathematical demand was raised across a number of subjects, with respondents requesting greater clarity regarding the level of mathematics required for statistical and data analysis.

Although a number of respondents identified the lack of context in the curriculum documents as enabling flexibility and choice at the state or school level (see comments in 3.2.3 above), other respondents argued that this lack of context was a serious flaw in the curriculum, which would result in traditional, highly theoretical teaching which would not engage students.

### *3.3.2 General capabilities and cross-curriculum priorities*

Respondents identified a range of areas where the description of the opportunities for integrating the cross-curriculum priorities and general capabilities in the Organisation section should be strengthened or broadened. In addition, specific groups highlighted a need for explicit content related to *Ethical behaviour* (especially in relation to animal welfare), *Aboriginal and Torres Strait Islander histories and cultures*, and *Asia and Australia's engagement with Asia* within the senior secondary science subjects.

### *3.3.3 Achievement standards*

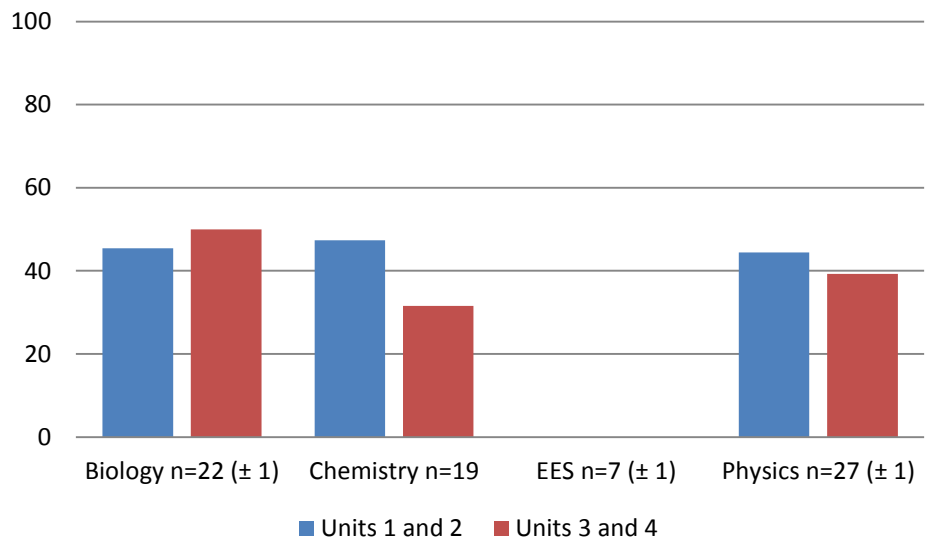
Although the majority of respondents could see the connection between the content and the achievement standards, a significant number of issues were raised across all the subjects regarding the level descriptions.

A large number of respondents felt that the achievement standards lacked clarity and were insufficiently comprehensive, were not pitched appropriately (responses varied with regard to whether they were too demanding or insufficiently demanding), and did not represent sufficient increasing cognitive demand across the levels of achievement or between pairs of achievement standards.

*A general comment is that some of the standards are too wordy, and will be much more likely to be used effectively if their length is reduced and their language reviewed so that wherever possible the plain sense is clear to both the teacher and the senior student. (STAT)*

A number of respondents commented specifically on the lack of 'quality words' to differentiate achievement at different levels.

Figure 5: Responses to Questions 26 and 40. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (% disagree and strongly disagree)




## 3.4 Other issues

### *3.4.1 Structure*

While a number of respondents variously called for a more 'spiral curriculum' approach, others requested a more developmental approach in which content was not repeated across units. These statements were frequently linked to local arrangements regarding student entry to the subject at different points.

*The introduction of a fundamental concept, such as 'cells', in only one unit (Unit 2 in this case), and not reintroducing the concept in other units, is not supported. This is a fundamental flaw in the selection of topics, as it compartmentalises them and mitigates against students understanding the connections in their study. This approach means that students study this concept once and do not revisit and further develop understanding in greater depth at a later stage. (SACE Board)*

### 3.4.2 Content

A number of respondents indicated that they were unclear about the intent of the terms 'including' and 'for example'. Some respondents expressed a preference that no examples be included as this made examination difficult.

A number of respondents interpreted each content description to represent equal teaching time and emphasis within the curriculum. It should be noted that this is not the case. Similarly, some respondents interpreted the unit sections to represent equal portions of the teaching time and emphasis within a unit. This is also not the case.

Several respondents indicated they were disappointed that an extended scientific investigation would not be mandated via the Australian Curriculum but would depend on state/territory decisions.

> *It is a regrettable that Extended Experimental Investigations have been progressively diminished through the drafts, only to disappear at the end… these activities are the ones that physics students and teachers alike remember and treasure. (AIP, Victoria)*

### 3.4.3 Achievement standards

Many respondents interpreted the achievement standards as replacements for existing assessment and reporting structures at a state or territory level; their feedback regarding the usefulness and appropriateness of the achievement standards reflected this assumption.

### 3.4.4 Implementation

Many respondents expressed concerns regarding teacher support for implementing the new curriculum, and provided feedback on the type of advice that states and territories should provide when integrating the Australian Curriculum into their local materials.

### 3.4.5 Additional subjects to be developed by ACARA

Various respondents suggested that additional science subjects be developed by ACARA. These included psychology, marine science, environmental science (as a stand-alone subject not related to Earth science), computer science, and general science.

# 4. Consultation findings: Biology

## 4.1 Consultation demographics

This section provides a brief overview of the number and spread of responses through the two consultation forms – the questionnaire and written submissions – in relation to Biology.

### *4.1.1 Online questionnaire*

Thirty-three questionnaires were received for Biology, representing 195 respondents.

Table 3: National representation of respondents by state – online questionnaire Biology

| State/Territory | Number of questionnaires | Respondent group size |
|---|---|---|
| Australian Capital Territory | 1 | 4 |
| New South Wales | 6 | 40 |
| Northern Territory | nil | |
| Queensland | 6 | 48 |
| South Australia | 3 | 2 |
| Tasmania | 2 | 21 |
| Victoria | 13 | 18 |
| Western Australia | 2 | 62 |
| **Total** | **33** | **195** |

A summary of the quantitative data generated by the online questionnaire is available in Appendix 1.

### 4.1.2 Written submissions

A total of 34 written submissions were received, representing a number of respondents. As many of the submissions did not reference the number of participants, the respondent group size is unclear.

Table 4: National representation of respondents by state – Biology written submissions

| State/Territory | Respondent group size |
|---|---|
| Australian Capital Territory | 4 |
| New South Wales | 40 |
| Northern Territory | |
| Queensland | 48 |
| South Australia | 2 |
| Tasmania | 21 |
| Victoria | 18 |
| Western Australia | 62 |
| National | **195** |
| **TOTAL** | |

The list of contributing groups and organisations can be found in Appendix 2.

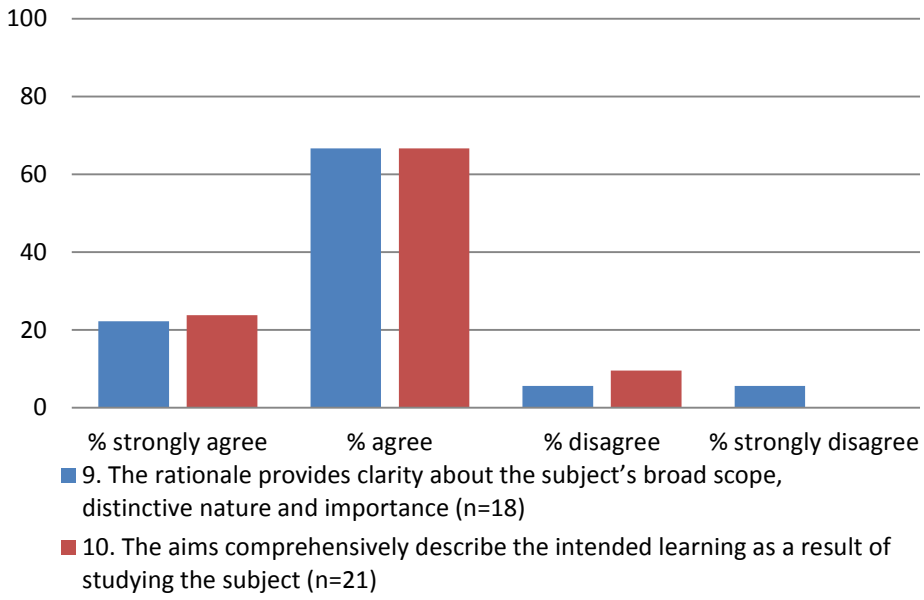
## 4.2 Strengths

### 4.2.1 Rationale and aims

There was a high level of agreement with the statements that 'the rationale provides clarity about the subject's broad scope, distinctive nature and importance' and 'the aims comprehensively describe the intended learning as a result of studying the subject'.

> *The Biology curriculum appears to be moving to more holistic understandings and incorporates challenge. (Department of Environment and Conservation, WA)*

Figure 6: Responses to Questions 9 and 10. Biology rationale and aims

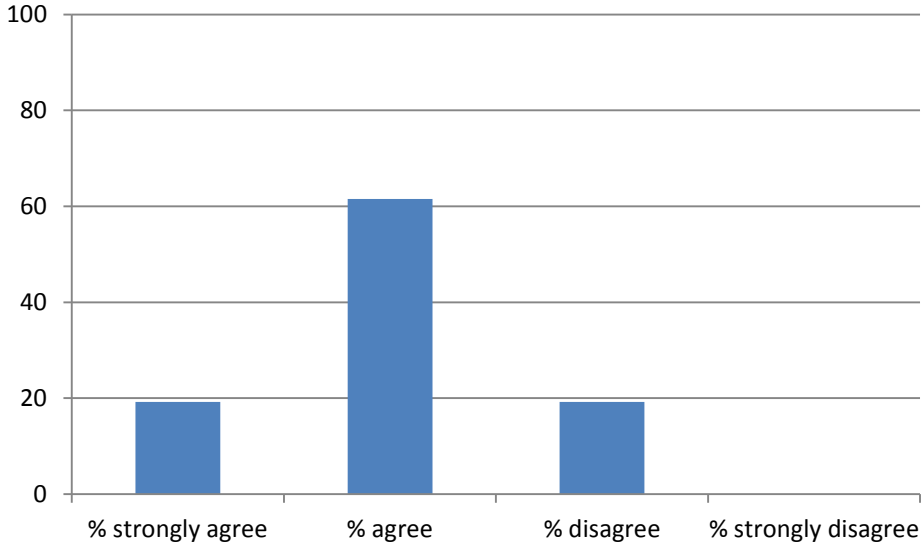



### *4.2.2 Structure*

The majority of respondents agreed that there is a clear link between the Biology curriculum and the F–10 Australian Curriculum: Science.

> *[The link to F–10] … is considered one of the strengths of the course and evidence of the significant consideration given to the continuity across the F–12 curriculum. (Brisbane Catholic Education)*

Figure 7: Responses to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum – Biology (n=26)

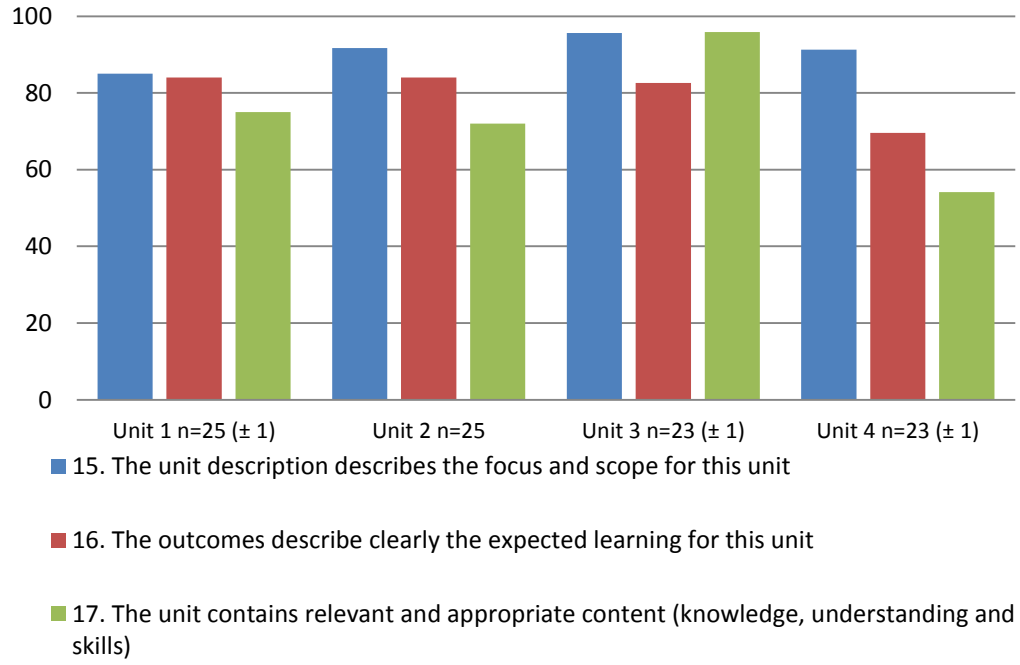


### 4.2.3 Content

The majority of respondents strongly agreed that the unit descriptions clearly described the focus and scope for the units and that the unit learning outcomes provided a clear description of the expected learning for the units. For all units (with the exception of Unit 4), the majority of respondents agreed that relevant and appropriate content had been selected.

> *In terms of the level of difficulty with the suggested changes it is thought the course is well balanced and is pitched at the right level for preparation for further study at university and also for students wanting to study the course for other reasons. (ASTA)*
>
> *Overall, this reads very well. It is coherent and, if well taught, should engage learners. There is an excellent balance between established and contemporary topics within biology. (International reviewer)*
>
> *There is coherence across the units, with Unit 3 being particularly well written. (AISWA)*

Figure 8: Responses to Questions 15, 16 and 17. Biology content (% strongly agree and agree)




### 4.2.4 General capabilities and cross-curriculum priorities

A number of stakeholders commented favourably on evidence of strong integration of the cross-curriculum priority of *Sustainability* across the units.

## 4.3 Areas for improvement

### *4.3.1 Structure*

A number of respondents commented that Unit 4, in particular, was less cognitively demanding than Unit 3.

A number of respondents felt that the units were disjointed and did not develop topics in an appropriate sequence. This was particularly commented on for Unit 4, where respondents felt the unit was 'disjointed' and repetitive of Unit 1 ecology content, resulting in an imbalance towards ecology in the subject.

> *There are areas of content that seem to be overly represented (ecology) and other areas such as human physiology/biology that could be included to provide a more interesting course that will be attractive to students. (ASTA)*

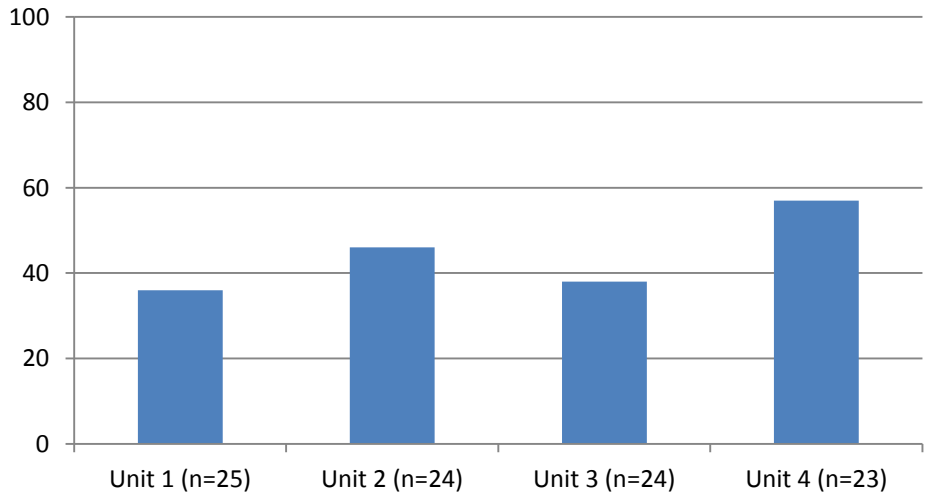
Several respondents provided revised topic sequences that they felt would be more appropriate. It should be noted that there was little alignment between these sequences beyond that which aligned with the Australian Curriculum sequencing.

### *4.3.2 Content*

A number of respondents commented on the amount of content across the four units, in particular identifying Unit 2 and Unit 4 as requiring a significant reduction in content. A number of respondents also commented that Unit 1 seemed to have significantly less content in comparison with the other units.

> *Given the emphasis on field and research investigations (Unit I), and field, laboratory and research investigations (Unit 4) there is too much content. These investigations are extremely valuable but they take up a lot of class time. (NT BOS)*

Figure 9: Responses to Questions 18, 23, 32 and 37. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours – Biology (% disagree and strongly disagree)



A number of respondents identified issues related to cognitive demand, arguing broadly that the entire subject was pitched at too high a level for the target student cohort. Specific areas that drew commentary were the inclusion of immunology and ecosystem dynamics models in Unit 4.

While some respondents felt that the immunology content in Unit 4 was beyond the cognitive capacity of senior secondary students, many more commented that there was too little emphasis on physiology and disease, particularly human physiology, and that this section needed to be developed further.

> *Some topics are inappropriate for study at Year 11 and 12. Unit 4 contains immunology. University experts have advised that this should be removed due to the complexity of the processes and the changing understanding that scientists have of this area. (SACE Board)*
>
> *More detail is required on the dot points relating to nervous and endocrine systems, so depth of content to be taught can be determined. (AISWA)*

Some groups requested that additional content be added, beyond the current scope of the subject. This included an increased focus on food security, biochemistry, human evolution, and animal ethics.

> *Animal ethics, or how humans ought to treat animals, involves consideration of universal ethical frameworks such as deontological, utilitarian, and virtue ethics and principles such as respect, justice and integrity to guide our attitudes and treatment of animals across all areas, for example research and teaching, farming, recreation, wildlife and companion animal management . (AEERG)*
>
> *It is imperative that higher-level primary industry science themes are taught across a broader range of disciplines because the future of primary industries at present is under threat … (Primary Industries Education Foundation)*
>
> *Further content inclusions expected of a contemporary biology curriculum include: a study of disease; microbiology; a significantly greater in-depth treatment of cell biology, molecular genetics, immunology and biochemistry than is seen in the current draft; biomarkers; rational drug design; bioinformatics; a stronger link between current research and the curriculum strands; and opportunities for investigating current local and global biology-related issues in society. (VCAA)*

# 5. Consultation findings: Chemistry

## 5.1 Consultation demographics

This section provides a brief overview of the number and spread of responses through the two consultation forms – the questionnaire and written submissions – in relation to Chemistry.

### *5.1.1 Online questionnaire*

Twenty-six questionnaires were received for Chemistry, representing 182 respondents.

Table 3: National representation of respondents by state – Chemistry online questionnaire

| State/Territory | Number of questionnaires | Respondent group size |
|---|---|---|
| Australian Capital Territory | Nil | |
| New South Wales | 8 | 47 |
| Northern Territory | Nil | |
| Queensland | 7 | 52 |
| South Australia | 2 | 12 |
| Tasmania | Nil | |
| Victoria | 4 | 10 |
| Western Australia | 5 | 61 |
| **Total** | **26** | **182** |

A summary of the quantitative data generated by the online questionnaire is available in Appendix 1.

### *5.1.2 Written submissions*

A total of 29 written submissions were received, representing a number of respondents. As many of the submissions did not reference the number of participants, the respondent group size is unclear.

Table 6: National representation of respondents by state – Chemistry written submissions

| State/Territory | Number of written submissions |
|---|---|
| Australian Capital Territory | 2 |
| New South Wales | 5 |
| Northern Territory | 1 |
| Queensland | 5 |
| South Australia | 3 |
| Tasmania | 2 |
| Victoria | 3 |
| Western Australia | 3 |
| National | 5 |
| **TOTAL** | **29** |

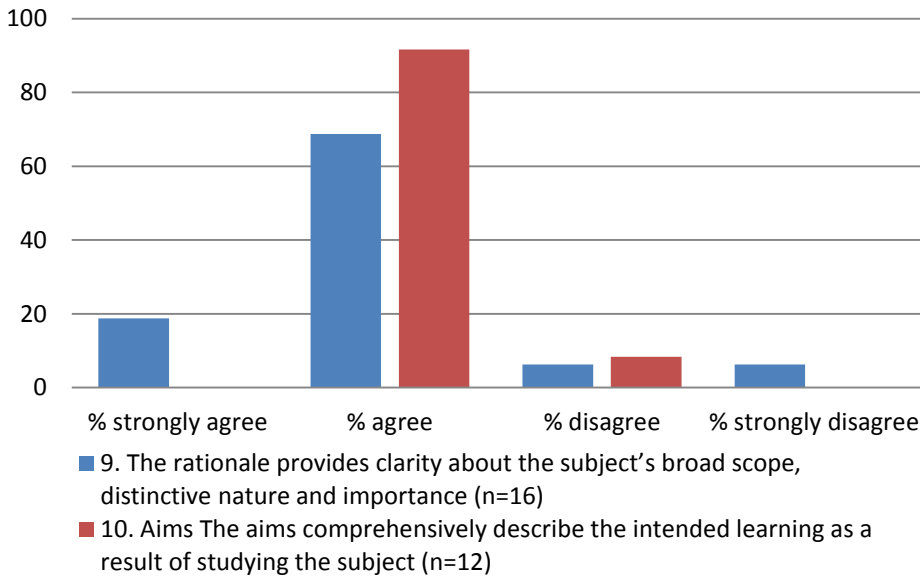
The list of contributing groups and organisations can be found in Appendix 2.

## 5.2 Strengths

### *5.2.1 Rationale and aims*

There was a high level of agreement with the statements that 'the rationale provides clarity about the subject's broad scope, distinctive nature and importance' and 'the aims comprehensively describe the intended learning as a result of studying the subject'.

Figure 10: Responses to Questions 9 and 10. Chemistry rationale and aims

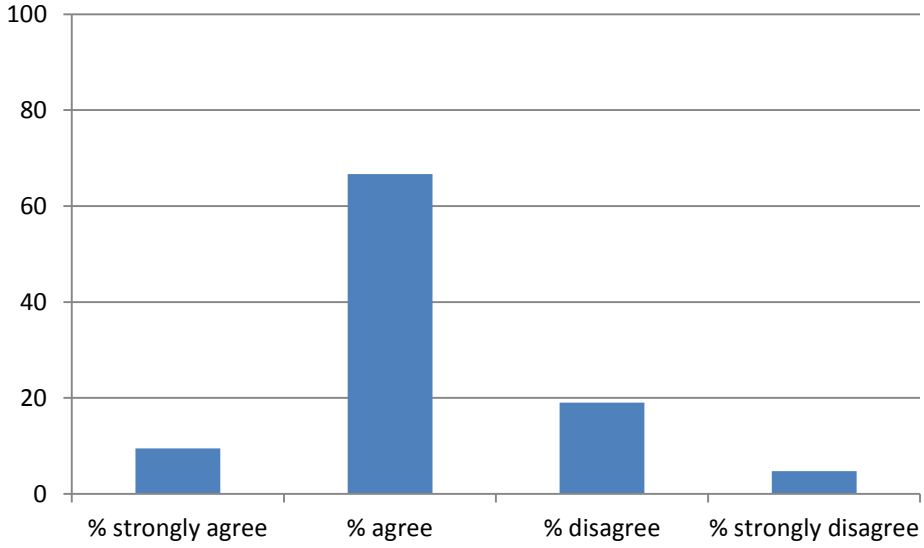



### *5.2.2 Structure*

The majority of respondents noted that there was strong continuity in the development of concepts from the F–10 Science curriculum, and increased cognitive demand from Units 1 and 2 to Units 3 and 4. The four units were generally seen as a logical progression.

> *The sequence of units is logical…The "for examples" are very helpful…There are ample opportunities for local contexts. (NT BOS)*

Figure 11: Responses to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum – Chemistry (n=21)



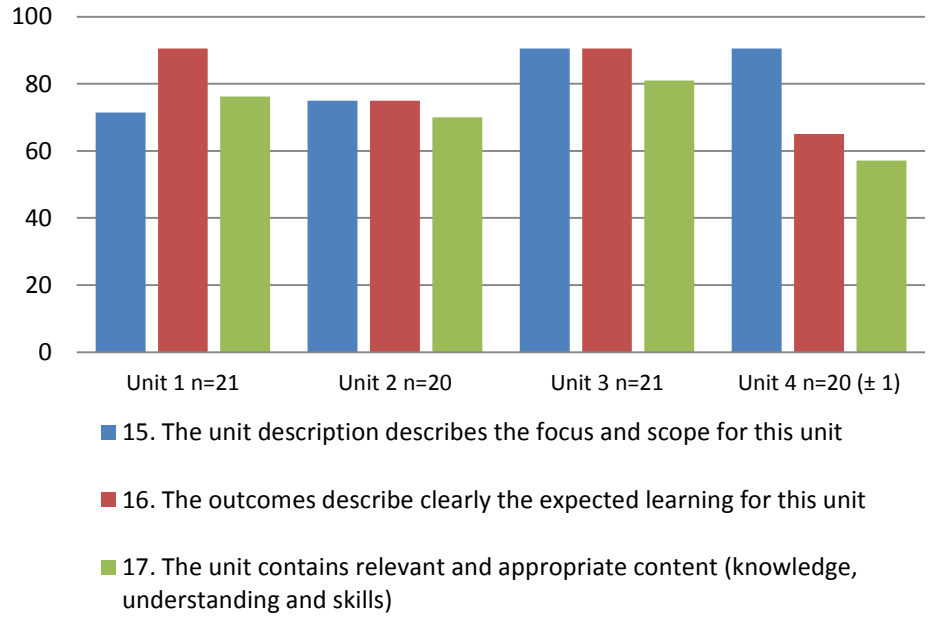
### *5.2.3 Content*

The majority of respondents agreed that the unit descriptions clearly described the focus and scope of the units, and that the unit outcomes clearly described the expected learning for the units.

A number of respondents commented specifically on the selection of relevant and appropriate content (knowledge, understanding and skills) for the units. This was reflected in the questionnaire findings, although the response was less positive with regard to the content in Unit 4.

> *ACARA is to be commended for their effort to include relevant and engaging modern content such as green chemistry, nanotechnology, issues concerning sustainability and applications of polymer science alongside the more familiar 'traditional' content expected in a senior secondary chemistry curriculum. (WA SCSA)*
>
> *[The curriculum] covers most of the major sections of chemistry well…Concepts are clear and present a range of chemical phenomena (AAS National Committee for Chemistry)*
>
> *…pleased to see synthesis at last taken its rightful place in school chemistry as a key activity in chemistry (ASERA)*
>
> *This strand (Science Inquiry Skills) of the curriculum is well thought out and suits current Chemistry teaching techniques. (CEA)*

Figure 12: Responses to Questions 15, 16 and 17. Chemistry content (% strongly agree and agree)



## 5.3 Areas for improvement

### *5.3.1 Content*

A number of respondents expressed concern that the subject could exclude a number of students because of the theoretical emphasis and the cognitive demand of the content, particularly in Unit 1.

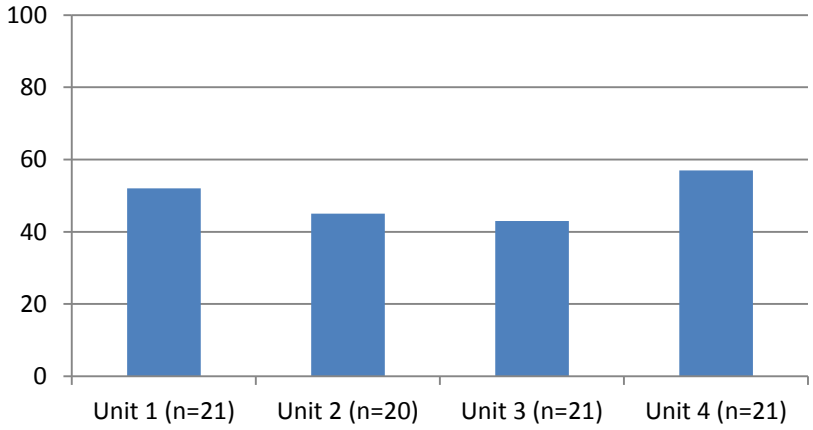
> *The introduction to Chemistry is too theoretical. The topics in Unit 1 emphasise the knowledge and understanding of models and theories, particularly in the Science as a Human Endeavour sections. (SACE Board)*

> *The cognitive demand, given the amount of content, was considered to be generally too high with the draft curriculum appearing to be elitist, as on reading it appears only to be accessible to the brightest students in each of the states and territories. (ASTA)*

While there were a number of comments regarding the amount of content across the subject, Units 1 and 4 were particularly identified in the questionnaire responses as being content heavy, with some respondents also articulating concerns regarding Unit 3.

> *Unit 3 is far too big with too much content expected to be covered. Redox and equilibrium as well as teaching in context and linking to Science as a Human Endeavour will require a lot more time than what is available. There will be no time to do any Extended Experimental Investigations in Unit 3. (ISQ)*

Figure 13: Responses to Questions. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours – Chemistry (% disagree and strongly disagree)




A number of respondents expressed significant concerns regarding the analytical techniques section of Unit 4. This content was seen as problematic for a number of reasons. Some respondents felt the content descriptions were insufficiently specific, others felt the content required equipment that not all schools could access, and there was concern that analytical techniques should not only be covered in Unit 4 but developed across the subject as the evidence base for chemistry knowledge and understanding.

*There are lots of techniques included that secondary schools do not have access to. For example, analytical techniques, gas chromatography. Analysis that can be done in secondary school should be focused on gravimetric, volumetric and empirical formula and need to have the stoichiometry to support this. (AISWA)*

*The study of analytical chemistry needs to be in context not in a separate unit. It really ought to be embedded in relevant parts of Units 1, 2 & 3. (QSA)*

Some respondents also found the synthesis section of Unit 4 limited in its focus. Respondents variously requested greater detail on organic synthesis, a greater focus on nanotechnology, and the inclusion of inorganic synthesis.

*It is a pity… that the curriculum seems to limit [synthesis] to organic examples since so many of the technologies of modern society in the last 25 years owe their existence to the synthesis of new inorganic materials. (ASERA)*

*The inclusion of a more extensive range of functional groups, such as haloalkanes that would enhance possibilities for organic reactions, such as substitution and oxidation reactions. The inclusion of amides, but not amines seems incongruous. The importance of primary, secondary and tertiary structures has little importance if the reactions that differentiate between these structures are not included (e.g substitution reactions of haloalkanes and oxidation of alcohols). The inclusion of aldehydes and ketones would add depth to the later study of analytical techniques. (CEA)*

A number of areas were identified as needing to be developed across the subject, rather than introduced in a particular unit. These areas included green chemistry principles, nanotechnology and nanomaterials, analysis techniques and organic chemistry.

*…disappointing that organic chemistry does not appear until Units 3 and 4 and the lack of biochemistry anywhere is a significant omission. Biochemistry supports many Science as a Human Endeavour concepts. (NT BOS)*

*…the four general classes of nanomaterials and their properties should be investigated, namely carbon-based materials (including fullerenes and nanotubes), metal-based nanocrystallinematerials (quantum dots, nanogold, nanosilver, metal oxides), dendrimers (organic, branched nanoparticles) and nanocomposites (multi-layer structures and inorganic/organic composites). (VCAA)*

# 6. Consultation findings: Earth and Environmental Science

## 6.1 Consultation demographics

This section provides a brief overview of the number and spread of responses through the two consultation forms – the questionnaire and written submissions – in relation to Earth and Environmental Science.

It should be noted that the small sample size for this subject means there are fewer consensus strengths or issues, and respondent views tend to be more polarised.

### *6.1.1 Online questionnaire*

Eleven questionnaires were received for Earth and Environmental Science, representing 87 respondents.

Table 7: National representation of respondents by state – Earth and Environmental Science online questionnaire

| State/Territory | Number of questionnaires | Respondent group size |
|---|---|---|
| Australian Capital Territory | Nil | |
| New South Wales | 3 | 3 |
| Northern Territory | Nil | |
| Queensland | 1 | 40 |
| South Australia | Nil | |
| Tasmania | Nil | |
| Victoria | 4 | 4 |
| Western Australia | 3 | 40 |
| **Total** | **11** | **87** |

A summary of the quantitative data generated by the online questionnaire is available in Appendix 1.

### *6.1.2 Written submissions*

A total of 36 written submissions were received, representing a number of respondents. As many of the submissions did not reference the number of participants, the respondent group size is unclear.

Table 8: National representation of respondents by state – Earth and Environmental Science written submissions

| State/Territory | Number of written submissions |
|---|---|
| Australian Capital Territory | 5 |
| New South Wales | 5 |
| Northern Territory | 1 |
| Queensland | 7 |
| South Australia | 1 |
| Tasmania | 1 |
| Victoria | 6 |
| Western Australia | 6 |
| National | 4 |
| **TOTAL** | **36** |

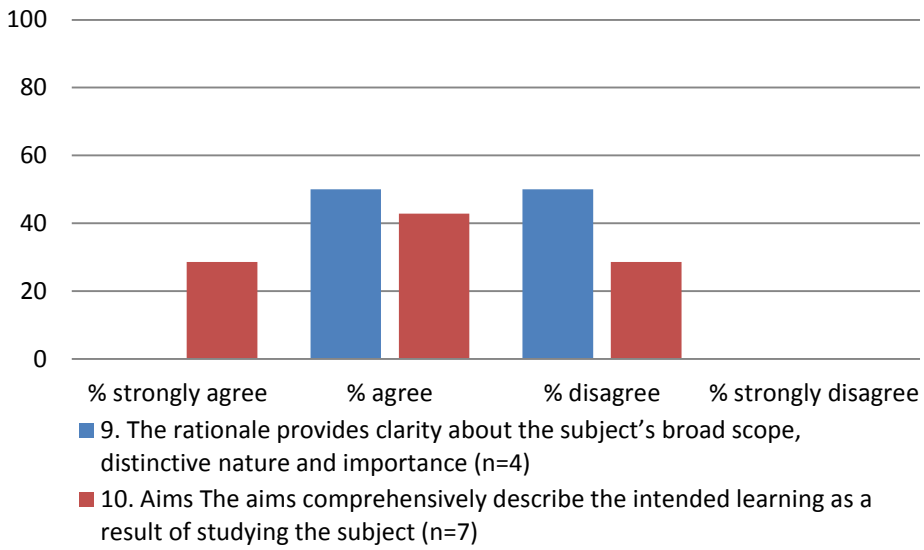
The list of contributing groups and organisations can be found in Appendix 2.

## 6.2 Strengths

### *6.2.1 Rationale and aims*

There was a high level of agreement with the statements that 'the rationale provides clarity about the subject's broad scope, distinctive nature and importance' and 'the aims comprehensively describe the intended learning as a result of studying the subject'.

Figure 14: Responses to Questions 9 and 10. Earth and Environmental Science rationale and aims




### *6.2.2 Structure*

The majority of respondents agreed that there was good continuity in the development of concepts from the F–10 Science curriculum and that there was internal logic and coherence in the four unit structure.

> *The use of the four spheres as a unified system approach generally gives the course a good level of coherence. (ASTA)*
>
> *The four units show a coherent development of earth science and environmental science knowledge and skills across the four units. (WA SCSA)*
>
> *We are very pleased with the Earth Systems approach to the subject and the overall content and feel the over balance within the content is appropriate. The result of all the hard work ACARA has put in is a sound and logical structure for teachers to follow that will result in students developing a great appreciation of Earth Systems Science and solid understanding of the total subject. (TESEP)*

Figure 15: Responses to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum – Earth and Environmental Science (n=9)

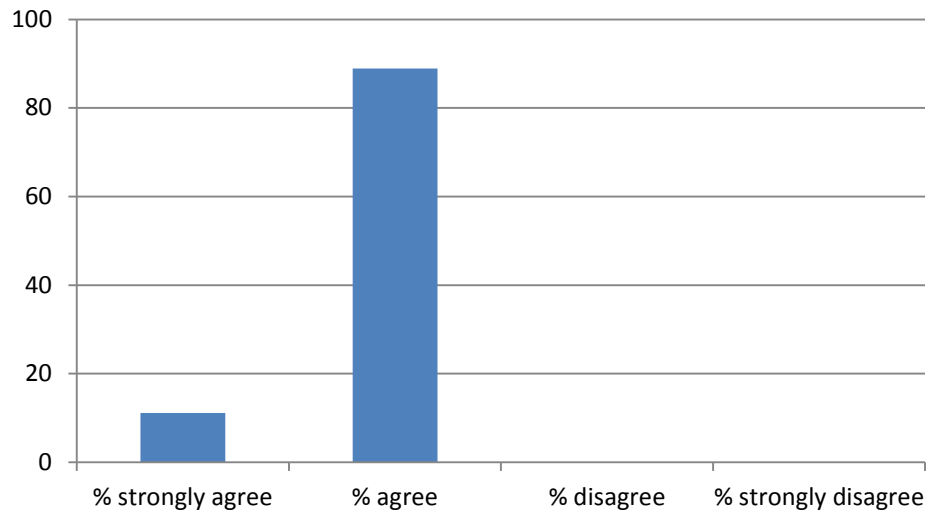
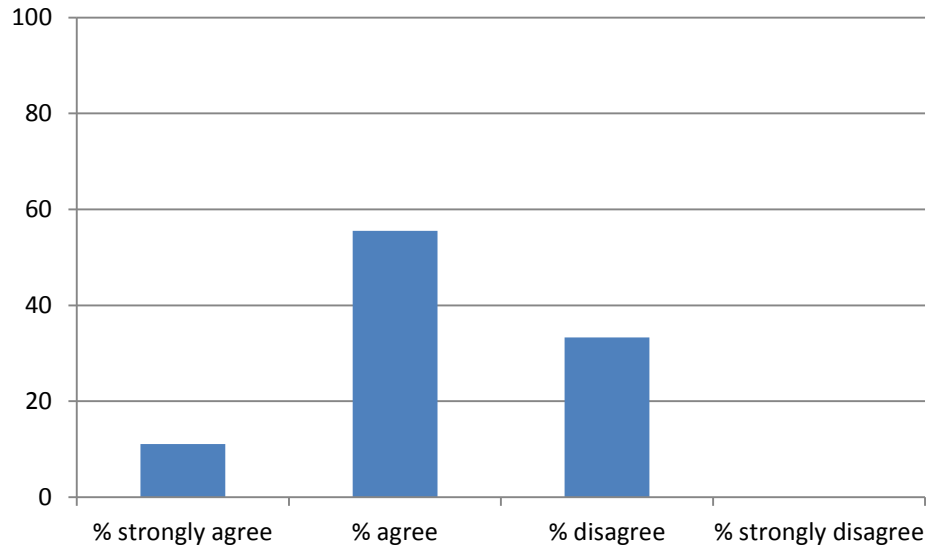



Figure 16: Responses to Question 11. The four-unit structure has internal logic and coherence – Earth and Environmental Science (n=9)



### 6.2.3 Content

Units 2, 3 and 4 were seen as representing appropriate content; Units 3 and 4 were seen as particularly engaging for students. A number of respondents also remarked that the subject enables incorporation of local contexts and issues.

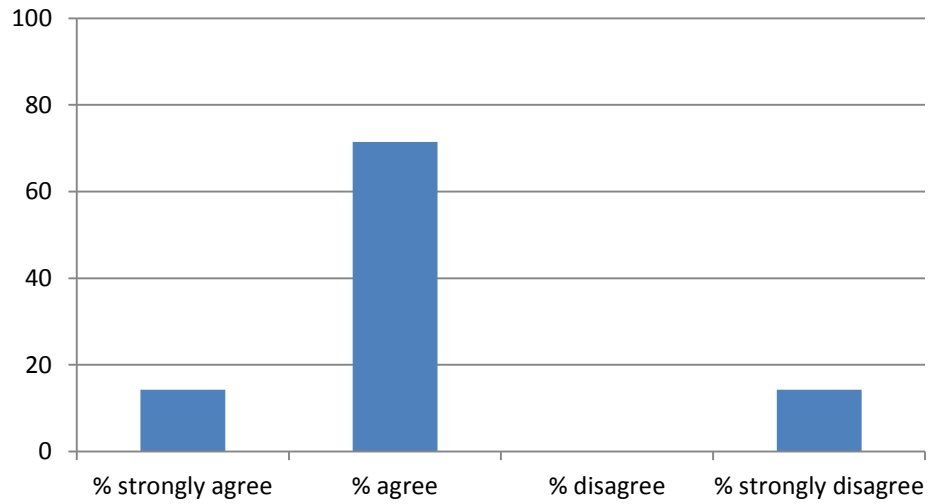
> *EES appears aligned to Sustainability, seems robust, engaging and dynamic and reflects a progression to university. It was felt that the ideas were good and covered contemporary issues. Communities, Aboriginal and social responses and field work are all included. It covered most major environmental concerns in a predominantly Earth Science course. (Department of Environment and Conservation, WA)*

> *[In Unit 4]…the balance and treatment of environmental issues is now right. The focus is on the science and provides a good opportunity to teach about pre-conceptions, critical reflection, and evidence-based decision making. A great unit to be taught in context. (QSA)*

### 6.2.4 General capabilities and cross-curriculum priorities

The majority of respondents commented that the cross-curriculum priority of *Sustainability* was strongly evident in the subject and that the cross-curriculum priorities that naturally fit with this subject were appropriately represented.

Figure 17: Responses to Question 44. The cross-curriculum priorities that naturally fit with this subject are appropriately represented – Earth and Environmental Science (n=7)



## 6.3 Areas for improvement

### *6.3.1 Content*

A number of respondents expressed concern that the depth of treatment required in Unit 1 was not clear; consequently there was too much content to cover in this unit.

> *Teachers are concerned that some parts of the course lack specificity, and this prevents them from confidently identifying the depth at which content must be taught. (SCSA WA)*

Some respondents felt that the content relating to the biosphere was not presented with the same degree of specificity as the other (geological) content, especially in Unit 3, where explicit content on ecosystem services could be added.

> *It was felt that there was a place in this curriculum for ecosystem services and an understanding of the five major categories. We suggest that ideas relating to valuing and costing ecosystem services or the consequences of their use as a free resource be discussed here. Environmental choices have been made on the basis of value (or lack of value) and an idea of the "environmental commons" could also inform this discussion. (Department of Environment and Conservation, WA)*

Different stakeholders had different perceptions of the appropriate balance between Earth science and environmental science. Most state and territory summary responses felt that the balance was generally appropriate; other respondents variously requested removal of the Earth or the environmental science content. One respondent felt that the two aspects of the subject could not be combined without detrimental effects.

> *There were concerns from Victorian teachers that there is an imbalance between the Earth Science and the Environmental components with too much emphasis being placed on the Earth Science. Others indicated they thought there was an appropriate balance given the description of the course. (ASTA)*

> *…Earth science and environmental science each has its own sets of knowledge and skills, and there was concern that, although the combination was justifiable, the practicalities of a combination would result in a dilution of discipline integrity. (VCAA)*

Different respondents perceived the content to be either supportive of or overlapping the Biology subject. Concerns were also expressed with regard to overlap of the Geology subject.

Some respondents noted that pedosphere and soil science were critical to Earth and environmental science in Australia but were not represented in the draft content.

> *Science students… need to learn what resources are used, and about the sustainable land and water management Australian farmers undertake. A basic understanding of the integral role played by the soil in the health of ecosystems and human populations is also important. This will assist future generations to make informed decisions about Australian sustainable food and fibre production and the links these have to World Food Security. (Ag Institute of Australia)*

> *The terms pedosphere (and lithosphere) need to be introduced in Unit 1. The whole course seems to ignore the pedosphere that develops as a result of the dynamic interaction between the atmosphere, lithosphere, biosphere and the hydrosphere. As it happens, the pedosphere is also one of humanity's most essential and non-substitutable resources, at the base of all terrestrial ecosystems. (Individual response, Qld)*

# 7. Consultation findings: Physics

## 7.1 Consultation demographics

This section provides a brief overview of the number and spread of responses through the two consultation forms – the questionnaire and submissions – in relation to Physics.

### *7.1.1 Online questionnaire*

Forty questionnaires were received for Physics, representing 186 respondents.

Table 9: National representation of respondents by state – Physics online questionnaire

| State/Territory | Number of questionnaires | Respondent group size |
|---|---|---|
| Australian Capital Territory | 1 | 1 |
| New South Wales | 14 | 56 |
| Northern Territory | Nil | |
| Queensland | 7 | 48 |
| South Australia | 2 | 7 |
| Tasmania | 1 | 1 |
| Victoria | 13 | 25 |
| Western Australia | 2 | 48 |
| **Total** | **40** | **186** |

A summary of the quantitative data generated by the online questionnaire is available in Appendix 1.

### *7.1.2 Written submissions*

A further 31 written submissions were received, representing a number of respondents. As many of the submissions did not reference the number of participants, the respondent group size is unclear.

Table 10: National representation of respondents by state – Physics written submissions

| State/Territory | Number of written submissions |
|---|---|
| Australian Capital Territory | 2 |
| New South Wales | 6 |
| Northern Territory | 1 |
| Queensland | 5 |
| South Australia | 2 |
| Tasmania | 1 |
| Victoria | 5 |
| Western Australia | 5 |
| National | 4 |
| **TOTAL** | **31** |

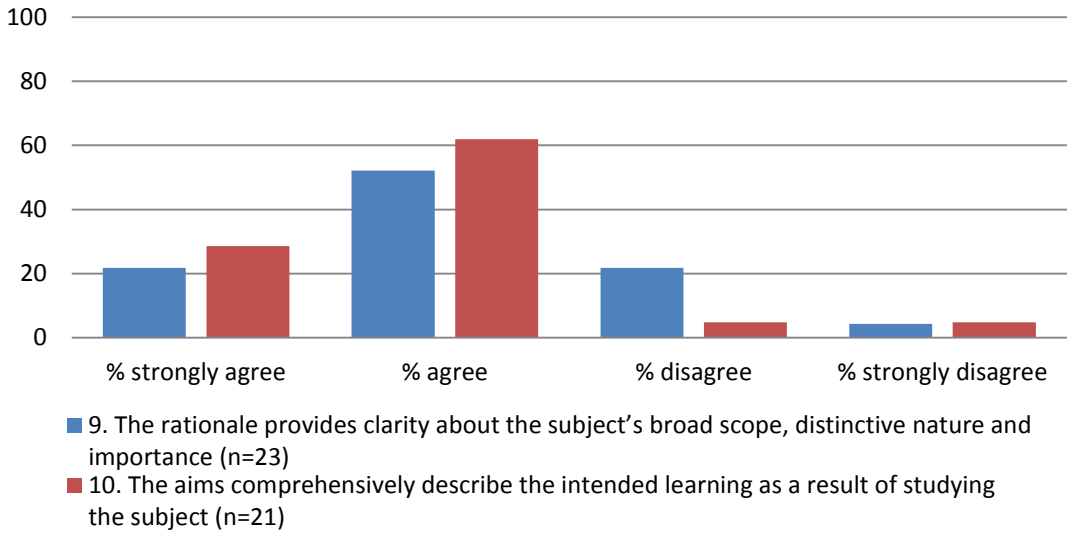
The list of contributing groups and organisations can be found in Appendix 2.

## 7.2 Strengths

### *7.2.1 Rationale and aims*

There was a high level of agreement with the statements that 'the rationale provides clarity about the subject's broad scope, distinctive nature and importance' and 'the aims comprehensively describe the intended learning as a result of studying the subject'.

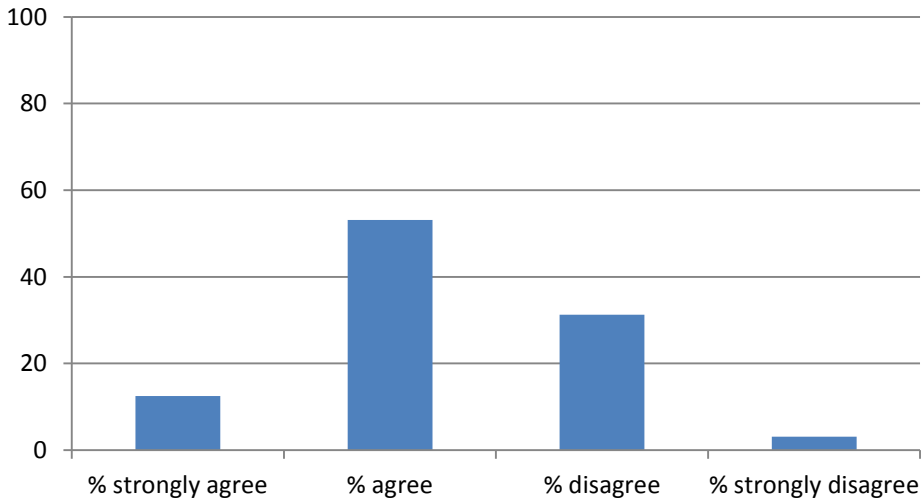
Figure 18: Responses to Questions 9 and 10. Physics rationale and aims




### *7.2.2 Structure*

The majority of respondents agreed that there is a clear link between the Physics curriculum and the F–10 Australian Curriculum: Science.

Figure 19: Responses to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum – Physics (n=32)

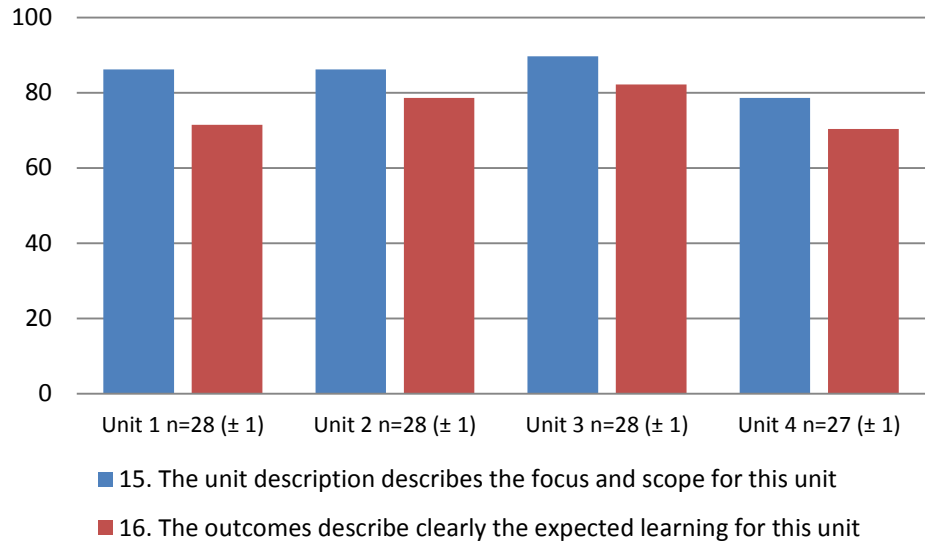


### 7.2.3 Content

The majority of respondents agreed that the unit descriptions clearly described the focus and scope of the units, and that the unit outcomes clearly described the expected learning for the units.

> *In general the content is appropriately challenging, logical and the units cohesive (WA SCSA)*

Figure 20: Responses to Questions 15 and 16. Physics content (% strongly agree and agree)




A number of respondents identified the inclusion of mathematical representations within the *Science Inquiry Skills* strand as a strength of the curriculum.

> *The mathematical representations are strongly supported. (QSA)*

> *The mathematical representations are clear; they help define what is needed. (NT BOS)*

## 7.4 Areas for improvement

### 7.4.1 Content

A number of respondents saw the subject as excluding a number of students because of the theoretical emphasis implied by the unit titles, unit descriptions and section titles.

> *The subject seems to be aimed at the 'elite', mathematically minded students and will exclude those who might have an interest, but are less able. (NT BOS)*

A number of respondents, while agreeing that models were an important aspect of physics, objected to the use of models as a conceptual frame, and recommended that the emphasis of, and references to, models be significantly reduced.

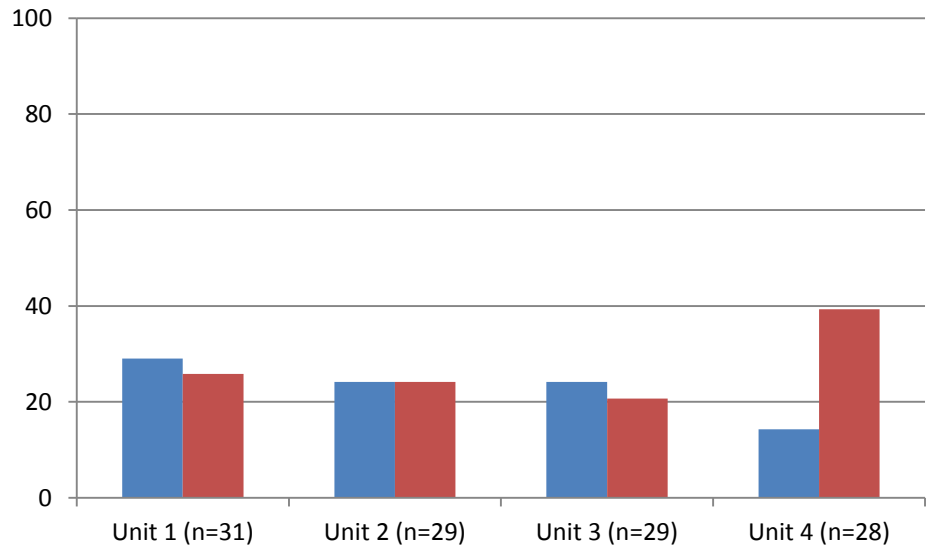
*The use of models as a conceptual framework is not sufficiently explained… The importance of models in physics is not in dispute. However, as an overarching framework the "force fit" of some of the topics and content descriptions seems artificial. Models are only one of the constructs that scientists use to explain the world… Models should arise from student engagement with concepts rather than the other way around. Models have a role, but are not viewed as the priority. (QSA)*

*Ultimately the 'model' approach puts the cart before the horse. Science begins with the phenomena, explanations are sought, then usually with models. (AIP Victoria)*

A number of respondents raised concerns that the curriculum included too much content for the *Science Inquiry Skills* and *Science as a Human Endeavour* strands to be taught appropriately. Some identified Unit 3 as being particularly content heavy; however, a number of other respondents also felt that a considerable amount of content needed to be added to Unit 3.

*The majority of respondents expressed the view that too much content was included in the current draft. This is exacerbated by the fact that the Science as a Human Endeavour strand frequently contains content that requires conceptual understandings not identified in the Science Understanding strand. (VCAA)*

Figure 21: Responses to Question 18. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours – Physics (% disagree and strongly disagree)



While some respondents praised the contemporary nature of the content in Unit 4, a number of respondents expressed concerns that the content was too demanding (particularly the mathematical representations) and would not enable practical work.

> *There are significant issues with Unit 4. Teachers feel it would be difficult to both engage the students and to develop the listed Science Inquiry Skills. It is seen as having a very academic approach. (SACE Board)*

> *Also equations such as De Broglie and Heisenberg's make this an unnecessarily mathematical unit that will put off many students. Similarly, the excessive mathematical analysis of black body radiation seems to be unnecessary. (ASTA)*

> *… the topic of The Theory of Relativity has no school based experiments, similarly with The Standard Model. Only the Quantum Model allows for practical activities … (AIP Victoria)*

Some respondents felt that there was insufficient focus on contemporary applications in the curriculum. Views on whether applications should be part of *Science Understanding* content or introduced as examples via the *Science as a Human Endeavour* strand varied between respondents.

> *Most traditional physics topics have been included in the draft, but there is minimal content (apart from the standard model and relativity) that links to developments in physics that have occurred over the last 50 years … Significant contemporary omissions include: semiconductor physics; photonics; medical physics; nuclear reactor design and the use of thorium as a nuclear fuel; astronomy and cosmology; sustainable energy; and new materials and light structures. (VCAA)*

> *There are some applications named, but there does not seem teaching and learning time to delve into them. The historical makeup of the models seem to be a bigger focus than contemporary physics-based devices, like the cyclotron, Blu-ray players, 3D glasses, MRI scanners, PET scanners, radiotherapy, X-rays, photocopiers, electrostatic precipitators, and loudspeakers. (SACE Board)*

# 8. Key findings and actions taken

## 8.1 Across the Science learning area

### *8.1. Strengths*

- The subject's rationale and aims are clear, comprehensive and appropriate
- There is a clear link between the subjects and the F–10 Australian Curriculum: Science
- The three-strand structure is appropriate and valued, particularly the inclusion of *Science as a Human Endeavour (SHE)*
- The *Science Inquiry Skills (SIS)* based on a generic set and elaborated in each subject/unit are appropriate and useful
- The two dimensions of the achievement standards are seen as appropriate
- The emphasis on the cross-curriculum priority of *Sustainability* across the Science subjects is seen as appropriate

### *8.1.2 Areas for improvement and actions taken*

| **Areas for improvement** | | **Action taken (revisions made)** |
|---|---|---|
| **Broad area** | **Specific issue** | |
| Content | The subjects contain too much content to be taught through an inquiry or contextualised approach. | The *Science Understanding (SU)* content was selectively reduced across the subjects based on specific feedback; this accounted for an approximately 5–10% reduction in content per unit. Some *SU* content descriptions were also further explicated (in some instances through division into more specific statements, in others through use of 'including' or provision of further detail) based on specific feedback to clarify the depth of content required.<br><br>The amount of *SHE* content was reduced by removing contexts from the curriculum content (see next point below); this accounted for an approximately 20% reduction in content per unit.<br><br>In the *SIS* strand, specific investigation types were deleted, and the number/range of mandated investigation processes and equipment were reduced; this accounted for an approximately 5% reduction in content per unit.<br><br>The approximate percentage content reduction varied across subjects and units, but fell within the range of 20–30%. |

| | | |
|---|---|---|
| | Mandated contexts in *Science as a Human Endeavour* limit flexibility and provide too much additional content. | Based on the consultation drafts, a set of *SHE* content descriptions was developed to build on the F–10 progression in each aspect of *SHE* (nature and development of science; use and influence of science). The content descriptions are concept-based and context-free to enable local flexibility; they were developed based on current national and international research and practice.<br><br>A set of seven content descriptions was developed for Units 1 and 2 across all subjects, and another set of seven content descriptions for Units 3 and 4 across all subjects. The sustainability-specific content description is repeated in each set, given the centrality of this concept to all Science subjects.<br><br>This approach reduces content in each unit by approximately 20%, as it reduces the number of *SHE* concepts to be taught and enables jurisdiction or teacher selection of appropriate contexts, rather than mandating context.<br><br>In order to exemplify the possible contexts for the *SHE* concepts, and to indicate the link to the *SU* content, ACARA will develop 'examples in context' for each sub-unit. These will be developed with states and territories and will be available for inclusion in the final online curriculum. |
| | Unit learning outcomes need to be more strongly aligned to the achievement standards. | The unit learning outcomes were revised to align to the subject aims and achievement standards; they now follow a similar sequence, use similar language and enable a clearer line of sight. |
| | Mathematical expectations in relation to data analysis (error and uncertainty) are unclear – greater detail requested. | Further detail was provided with regard to mathematical treatment of error and uncertainty through the *SIS* content descriptions. The level of demand was increased in Units 3 and 4 compared to Units 1 and 2 across all subjects; the level of demand in Physics and Chemistry was higher than in Biology and EES given the nature of these subjects and the nature of the data generated.<br><br>Glossary definitions of terms related to error and |

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| | | uncertainty were added. |
| General capabilities and cross-curriculum priorities | There is insufficient indication of the opportunities to develop general capabilities and cross-curriculum priorities in the subjects. | The description of each cross-curriculum priority and general capability provided in the Organisation section was revised to ensure a richer indication of the opportunities for including these within each subject. |
| Achievement standards | There were issues with regard to clarity, indication of increased cognitive/skill demand across the two pairs of units, and differentiation of performance between levels. | The achievement standards were revised to ensure a clear development in a single concept/skill across the grade levels, and the use of clear and consistent language. Where previously some descriptions had 'dropped off' or been combined at the D or E level, each grade level now contains a description.<br><br>An agreed syntax was used to structure each statement, including an underpinning assumption of quality (that is, that performance described at a given level was what a student can do independently, consistently and competently); and a verb and subject that together indicate cognitive demand.<br><br>The pitch of the descriptions at each grade level was reviewed with reference to current state and territory documents and adjusted to lower demand at the A and E levels in particular.<br><br>State and territory documents were reviewed to ascertain the possibility of differentiating the Inquiry Skills dimension across the two sets of achievement standards; however, this is currently only accomplished through learning outcomes (or equivalent), where it is differentiated at all. On this basis, the Inquiry Skills dimension will not be differentiated across the two sets until validation evidence is collated that indicates this would be more appropriate. |

## 8.2 Biology

### *8.2.1 Strengths*

- The subject's rationale and aims are clear, comprehensive and appropriate
- There is a clear link between the subject and the F–10 Australian Curriculum: Science
- The unit descriptions clearly describe the focus and scope of the units
- The unit learning outcomes provide a clear description of the relevant learning
- Relevant and appropriate content is provided in Units 1–3

### *8.2.2 Areas for improvement and actions taken*

| **Areas for improvement** | | **Action taken (revisions made)** |
|---|---|---|
| **Broad area** | **Specific issue** | |
| Structure | Unit 4 is less cognitively demanding than Unit 3. | Unit 4 was revised to remove the dynamic biosphere section and replace it with an infectious disease section, including a deeper treatment of the immune and endocrine systems. The treatment of homeostasis was also further elaborated to make the cognitive demand clear.<br>Where appropriate (in terms of focus and cognitive demand), the ecology content was relocated to Unit 1 so that Unit 1 was increased slightly in cognitive demand and the ecology content of the subject was not overly reduced (see the next point, below). |
| Content | Unit 4 is disjointed, and ecology seen to be too repetitive of Unit 1 content. | |
| | Unit 1 is less cognitively demanding than other units. | Unit 1 was revised to strengthen the biodiversity section by including more content on relationships within and between biotic and abiotic components; the ecosystems section was strengthened by adding some aspects of Unit 4 ecology so students develop an understanding of the complex dynamics of ecosystems and the ways ecosystems are modelled. |
| | Unit 2 is seen as particularly content heavy. | In addition to reductions in *SHE* and *SIS*, *SU* content was selectively reduced; content that had been covered in F–10 was deleted; some aspects of content descriptions were removed to narrow the focus (for example, structure of enzymes); and some content descriptions were |

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| | | further refined to make depth of treatment clear (for example, body systems' structure and function; photosynthesis and respiration). |
| | There is too little emphasis on physiology and disease. | Unit 4 was revised to have a greater emphasis on physiology and disease through the inclusion of an infectious disease section. |
| | Animal ethics is seen as underemphasised in the subject. | A reference to animal ethics was added to the *SIS* as an inclusion in the research ethics section and a more comprehensive glossary definition was provided. |

## 8.3 Chemistry

### *8.3.1 Strengths*

- The subject's rationale and aims are clear, comprehensive and appropriate
- There is a clear link between the subject and the F–10 Australian Curriculum: Science
- The unit descriptions clearly describe the focus and scope of the units
- The unit learning outcomes provide a clear description of the relevant learning
- Relevant and appropriate content is provided in Units 1–3

### *8.3.2 Areas for improvement and action taken*

| **Areas for improvement** | | **Action taken (revisions made)** |
|---|---|---|
| **Broad area** | **Specific issue** | |
| Content | The curriculum is seen as excluding a number of students because of the theoretical emphasis. | Unit names were revised to emphasise phenomena rather than models; each *SU* section was restructured to begin with a focus on observable phenomena before introducing the explanation and the theory/models. |
| | The cognitive demand of Unit 1 is too high. | Content has been selectively removed from Unit 1 to decrease the cognitive demand (see the next point for details). |
| | There is too much content in Unit 1; specific feedback indicated that sub-levels, orbitals and nuclear forces in the atom could be removed; and rates of reaction could be moved to Unit 2. | In addition to reductions in *SHE* and *SIS*, content has been removed from Unit 1 *SU*: sub-levels, orbitals and nuclear forces within the atom were removed from the atomic structure content description/s on the basis that students would not be able to apply this content at this stage of their learning.<br>Rates of reaction and activation energy were moved to Unit 2 (space was made in Unit 2 to accommodate this through the removal of the context-based atmospheric chemistry and selective removal of content). |
| | There is too much content in Unit 3. | In addition to reductions in *SHE* and *SIS*, content has been removed from Unit 3 *SU*: quantitative expectations regarding equilibrium constants have been removed, as this was not seen as core student learning; the types of electrochemical cells to be taught have been further explicated; greater clarity has been provided regarding the scope of the oxidation |

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| | | and reduction section. |
| | There is too much content in Unit 4. | In addition to reductions in *SHE* and *SIS*, content has been removed from Unit 4 *SU* by redistributing the analytical techniques content and providing greater detail regarding the treatment of organic compounds and synthesis. (See the next two points for further detail.) |
| | Unit 4 Analytical techniques – there were concerns regarding equipment and that analysis should be developed across the subject. | Analytical techniques content descriptions were redistributed across the units as 'how we know what we know'. The content descriptions were revised to focus on the data generated by the techniques and how this could be used (that is, rather than focusing on students having access to expensive equipment). This approach enabled each technique to be taught in the context of the science understanding to which it has contributed evidence. |
| | Unit 4 Synthesis processes sub-unit was considered too limited in its focus. | The Analytical techniques section was removed from Unit 4 and replaced with *SU* content to strengthen the organic chemistry section and to develop concepts of chemical synthesis and design. This will enable opportunities for students to investigate contemporary applications of nanotechnology, biochemistry, drug synthesis. |
| | Green chemistry principles and nanotechnology should be infused across the subject. | Green chemistry principles have been referenced where appropriate across the units. A definition of green chemistry that lists the principles has been included in the glossary. Nanotechnology and nanomaterials have been included across the units. While this has added some additional content, this has been offset by the reductions in content listed above. |

## 8.4 Earth and Environmental Science

### *8.4.1 Strengths*

- The subject's rationale and aims are clear, comprehensive and appropriate
- There is a clear link between the subject and the F–10 Australian Curriculum: Science
- The subject demonstrates internal logic and coherence in the four-unit structure
- The unit descriptions clearly describe the focus and scope of the units
- The unit learning outcomes provide a clear description of the relevant learning
- Relevant and appropriate content is provided in Units 2–4

### *8.4.2 Areas for improvement and action taken*

| **Areas for improvement** | | **Action taken (revisions made** |
|---|---|---|
| **Broad area** | **Specific issue** | |
| Content | There is too much content in Unit 1, and the depth of treatment required is unclear. | The *SU* content descriptions were revised to indicate depth by specifying the aspect of the system/sphere/process to be studied and providing greater explication of concepts.<br>The content description relating to natural selection was removed as this was covered in Year 10 and is revisited in greater depth in Biology. |
| | The pedosphere is not sufficiently referenced; however, it is a resource of vital importance. | References to the pedosphere are made in the unit descriptions for Unit 1 and Unit 3; explicit *SU* content on soil formation has been added in Unit 1; examples of soil as a renewable resource have been added to Unit 4. |
| | The biosphere content is not presented with the same degree of specificity as the other content, especially in Unit 3. | Content relating to the biosphere has been revised to provide greater specificity, including greater explication of the theory of the origin of life in Unit 1, and inclusion of specific content relating to ecosystem services in Unit 3. |

## 8.5 Physics

### *8.5.1 Strengths*

- The subject's rationale and aims are clear, comprehensive and appropriate
- There is a clear link between the subject and the F–10 Australian Curriculum: Science
- The unit descriptions clearly describe the focus and scope of the units
- The unit learning outcomes provide a clear description of the relevant learning
- The inclusion of mathematical representations in *SIS* provides clarity as to their place in the curriculum

### *8.5.2 Areas for improvement and action taken*

| **Areas for improvement** | | **Action taken (revisions made** |
|---|---|---|
| **Broad area** | **Specific issue** | |
| Content | The curriculum was seen as excluding a number of students because of the theoretical emphasis. | Across the subject, references to models were reduced and references to phenomena were strengthened, to reduce the theoretical emphasis.<br>Each *SU* section was restructured to begin with a focus on observable phenomena before introducing the explanation and the theory/model.<br>*SHE* was restructured and a paragraph referencing possible contexts added to the unit description to enable greater opportunity for selection of rich contexts, such as particular technologies or applications of physics, to engage the range of students. |
| | Overemphasis of models was seen as inappropriate and providing the wrong message about the nature and structure of physics. | Units were renamed to focus on phenomena rather than models, in order to send the message that physics is about explaining and predicting phenomena through *use* of models and theories.<br>Where referenced, models and theories were called by their common names, rather than seeking to specify each of them as a model; this is a more familiar treatment and understanding of 'models' in physics. |
| | There is too much content in Unit 3. | In addition to reductions in *SHE* and *SIS*, content has been removed from Unit 3 *SU* that was not seen as core, including: variation in acceleration due to gravity across the surface of Earth; use of the rotational motion of Earth to minimise the energy required to place satellites in orbit; escape velocity and |

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| | | GPE calculation; torque; and use of ferromagnetic materials to improve efficiency of electromagnetic devices.<br><br>Content was further specified to clearly indicate inclusions; for example, uniform circular motion on a horizontal plane and around a banked track. |
| | Unit 4 is too cognitively demanding. | The mathematical demand of the unit has been reduced through removal of equations.<br><br>The content descriptions have been revised to ensure they provide sufficient indication of the concept to be taught, the depth of treatment, and some indication of the way in which students could work with the concept. This has been specifically done in relation to the Standard Model, which, while still theoretical, has been revised in line with international curriculums. |
| | There is insufficient focus on contemporary technologies. | The curriculum has been written to be context-free in order to provide flexibility for jurisdictions and/or teachers to select contexts that are appropriate for the interests and learning needs of their students. However, the following actions will flag potential contemporary technologies:<br><br>• A paragraph referencing possible contexts has been added to each unit description<br><br>• Where appropriate, examples have been added to reference contemporary applications<br><br>• 'Examples in context' will be written as support for *SHE* content that will reference contemporary technologies and applications; for example, the SKA, the synchrotron |

## Appendix 1: Online questionnaire responses

This appendix presents graphs of the responses to the online questionnaires for Biology, Chemistry, Earth and Environmental Science, and Physics.

## Biology

Figure 1: Response to Question 9. The rationale provides clarity about the subject's broad scope, distinctive nature and importance (n=18)

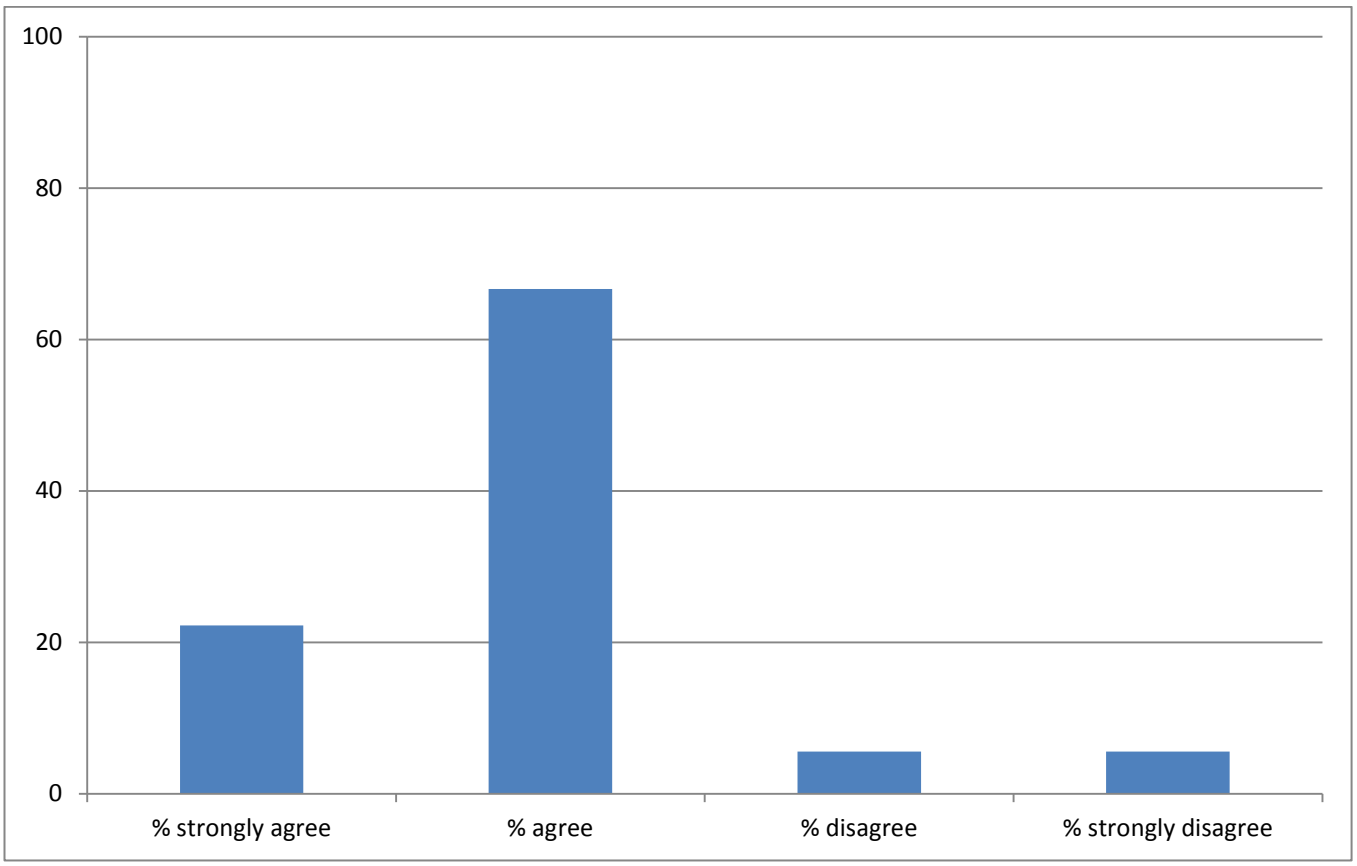



Figure 2: Response to Question 10. The aims comprehensively describe the intended learning as a result of studying the subject (n=21)

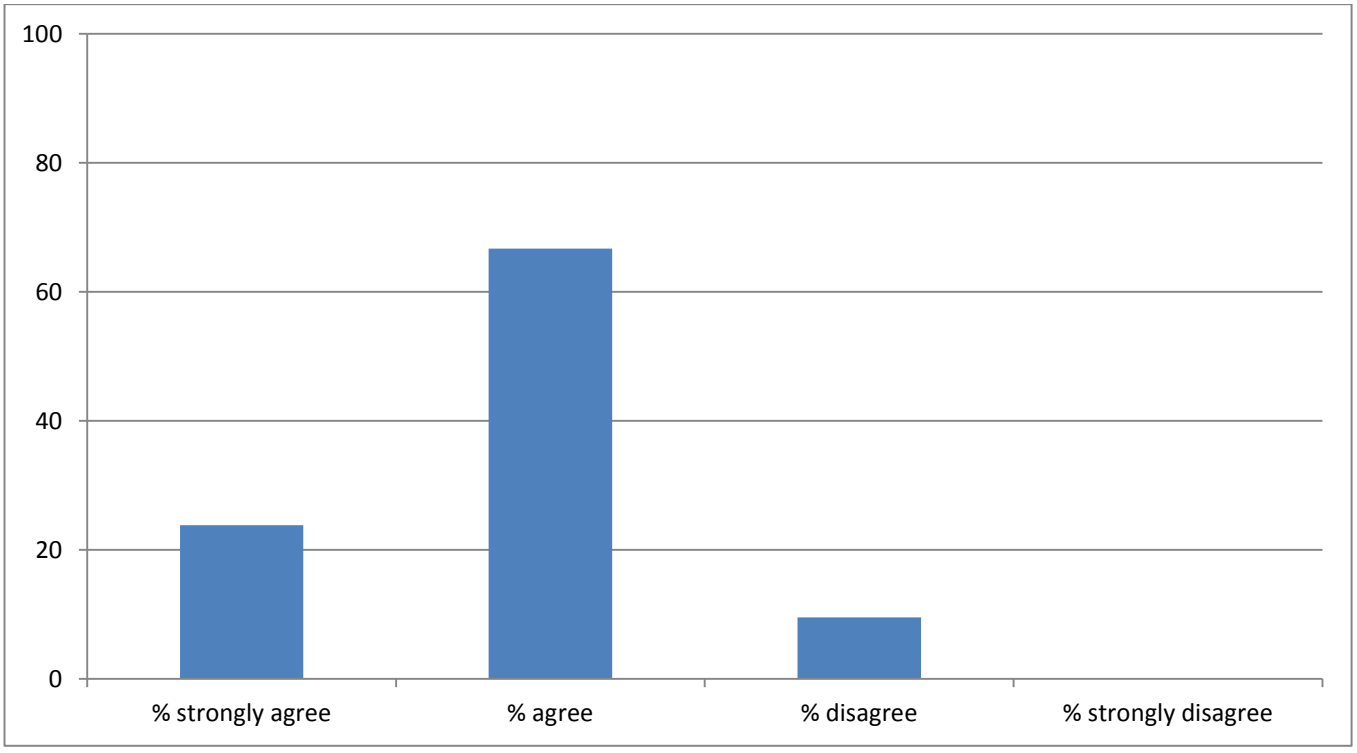


Figure 3: Response to Question 11. The four-unit structure has internal logic and coherence (n=29)

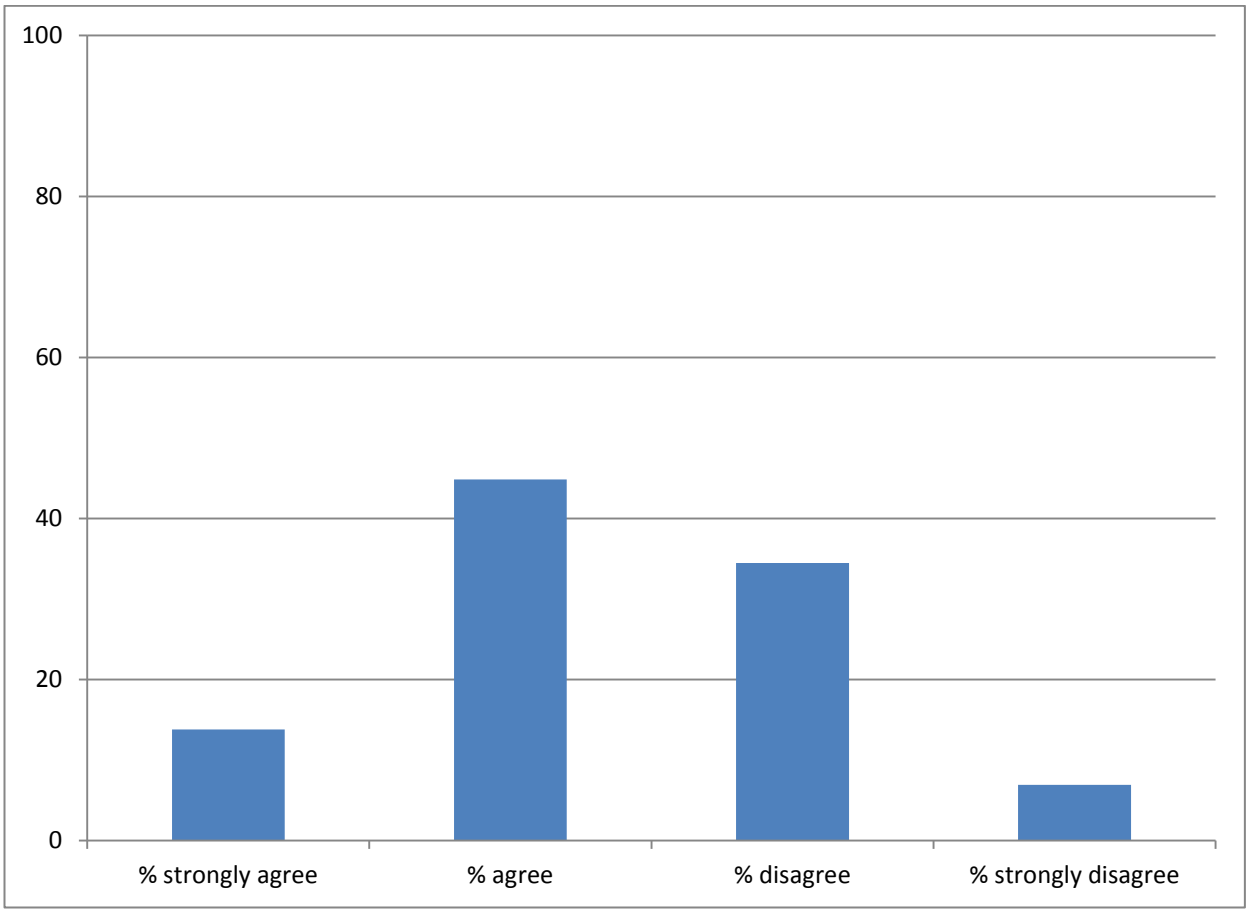



Figure 4: Response to Question 12. Units 3 and 4 are more cognitively demanding than Units 1 and 2 (n=28)

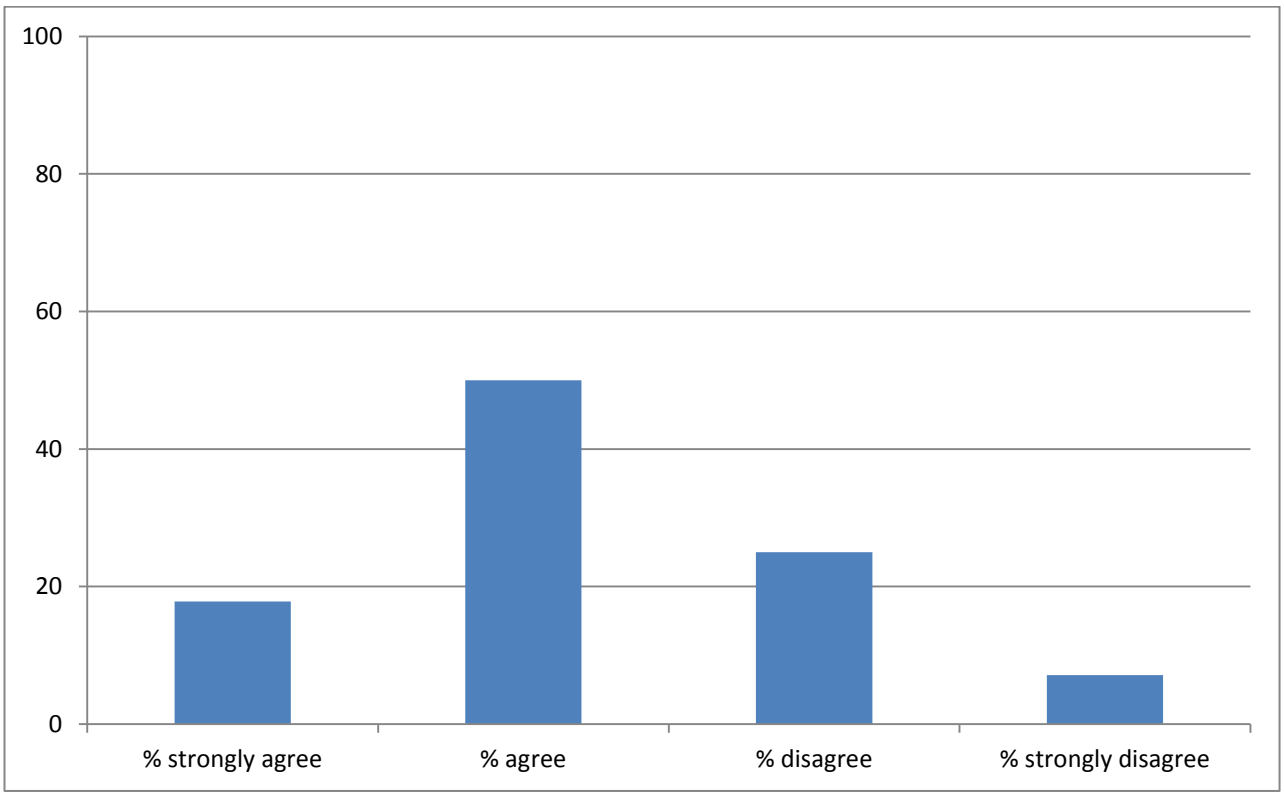


Figure 5: Response to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum (n=26)

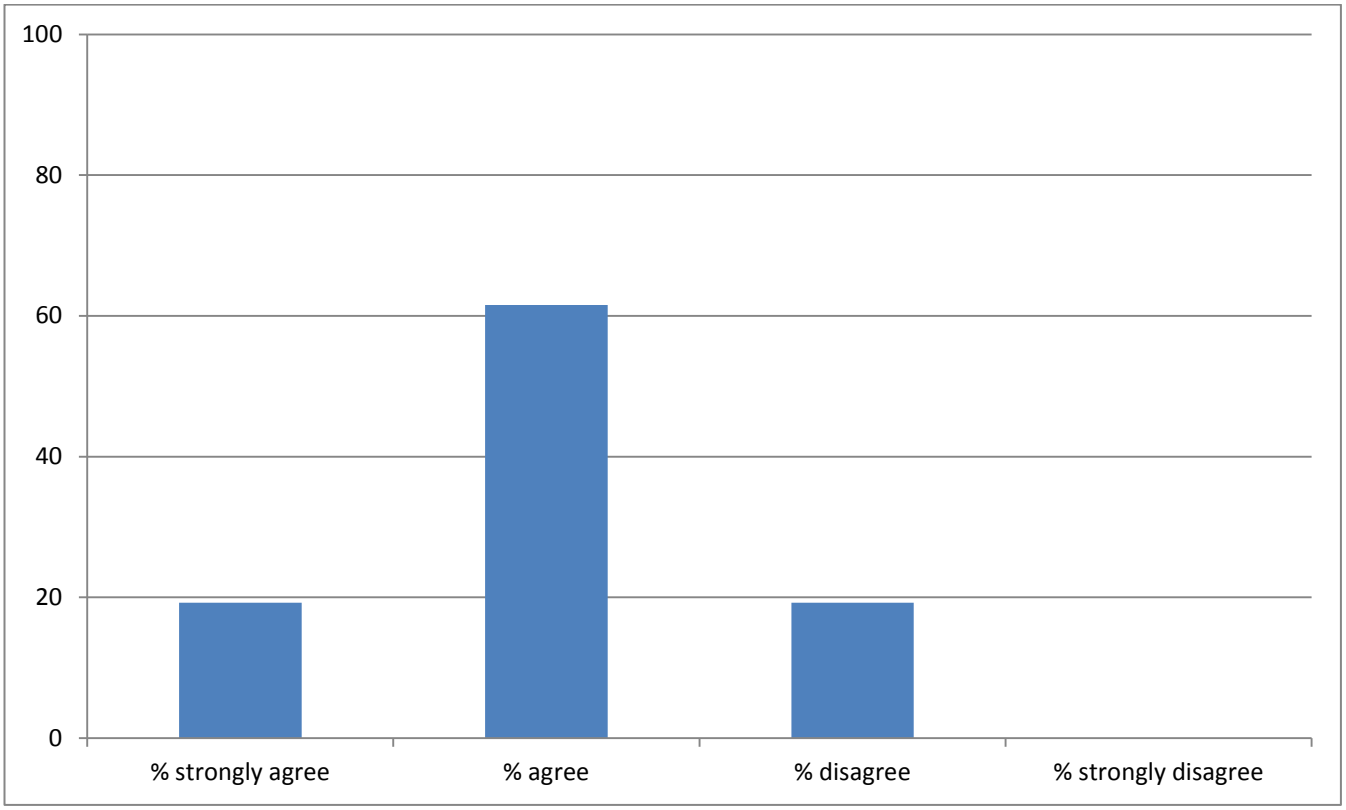



Figure 6: Response to Question 14. The achievement standards across Units 1 and 2 and Units 3 and 4 are organised in an order consistent with your experience (n=28)

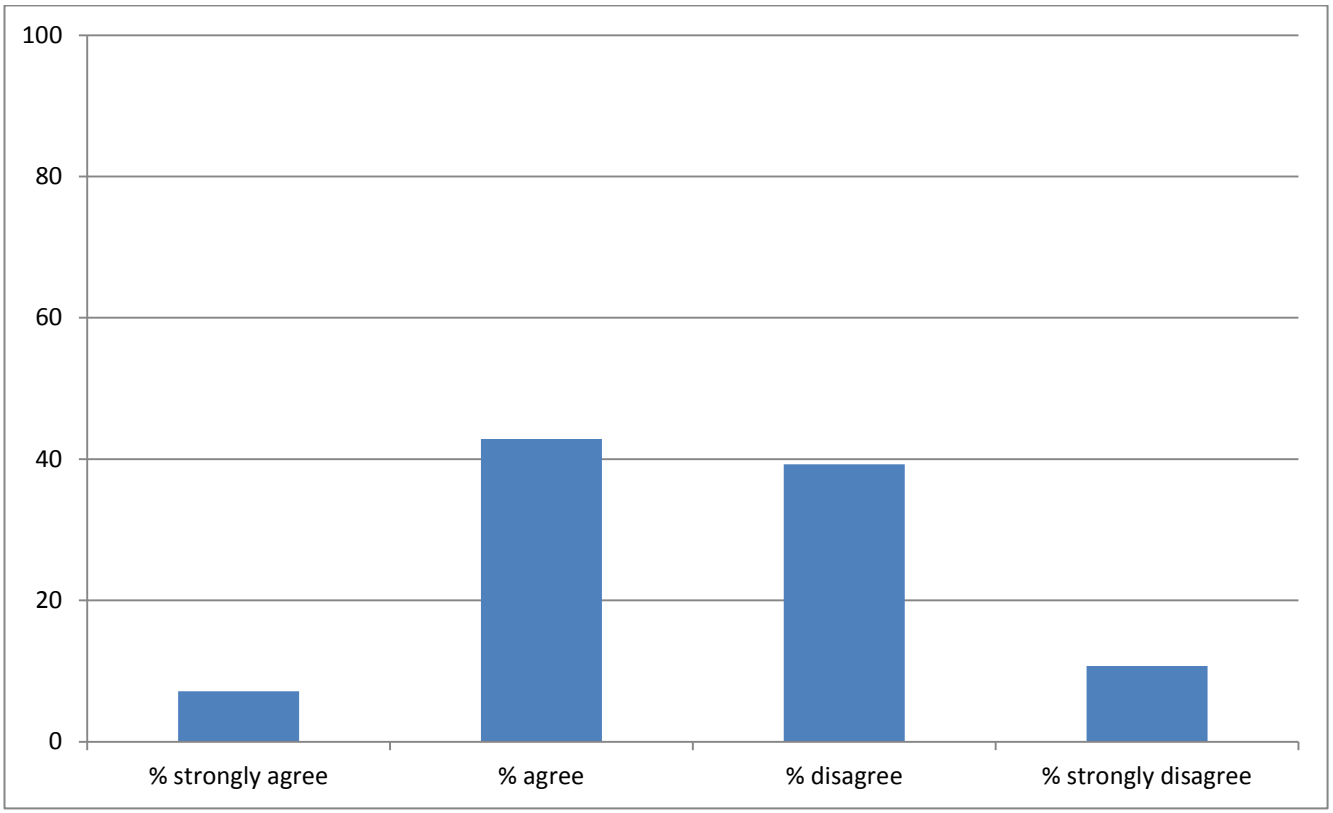


Figure 7: Response to Question 15. Unit 1: The unit description describes the focus and scope for this unit (n=26)

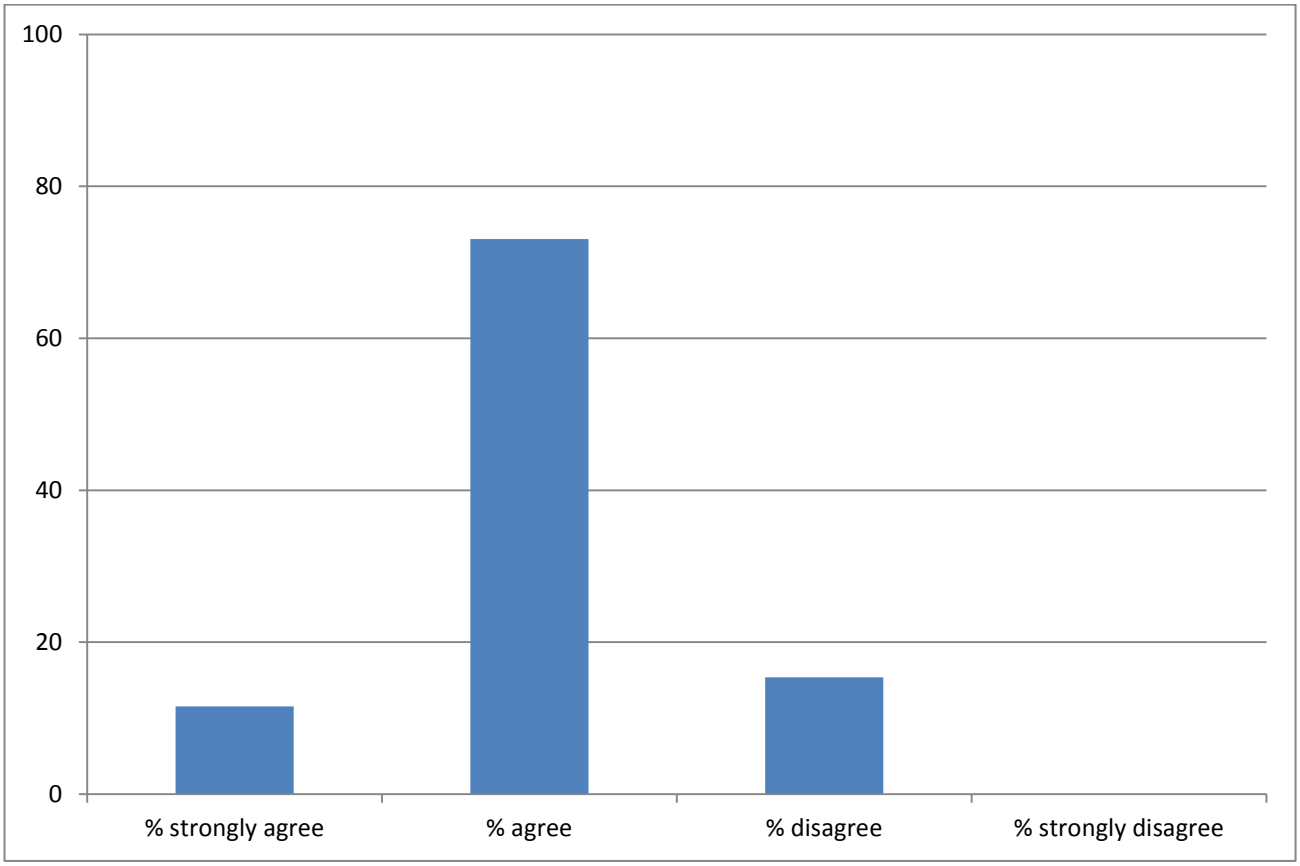



Figure 8: Response to Question 16. The outcomes describe clearly the expected learning for this unit (n=25)

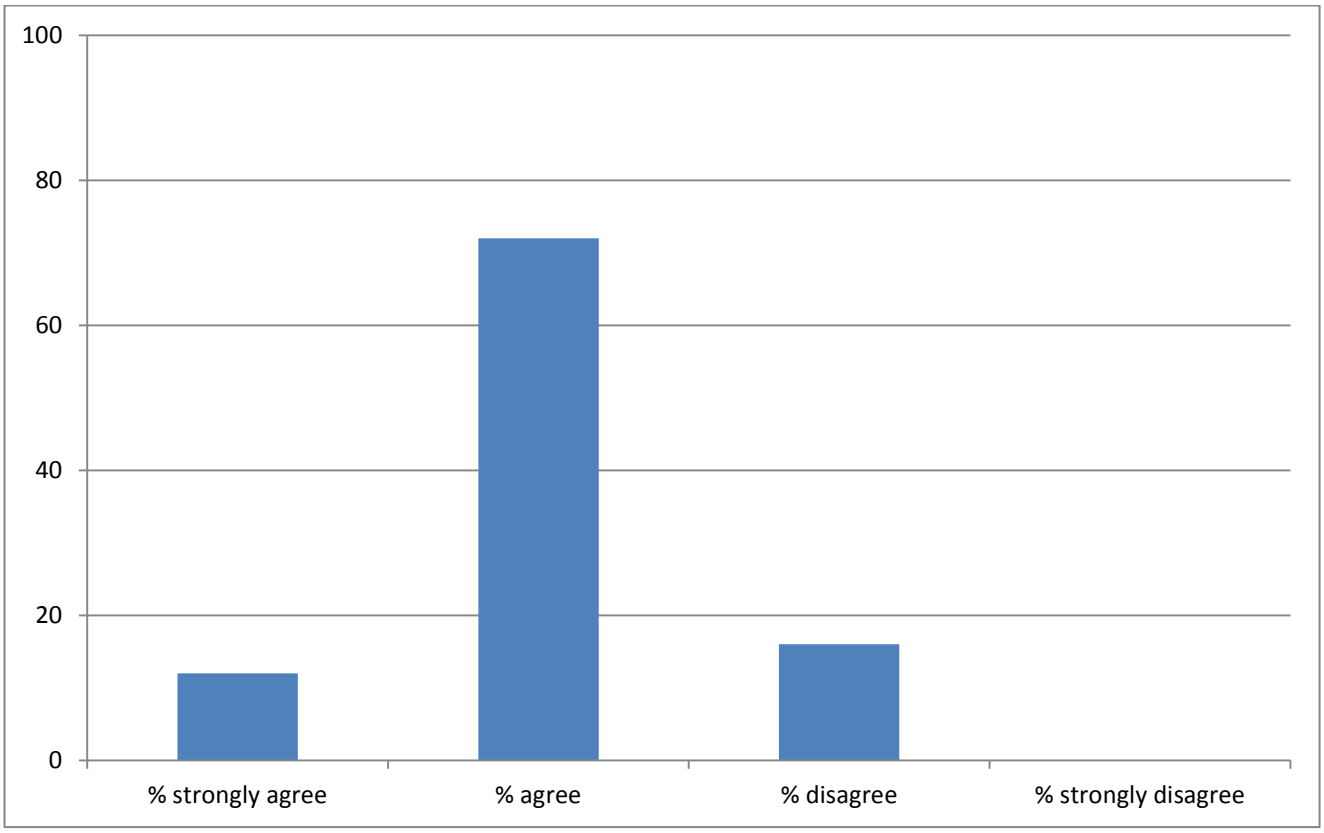


Figure 9: Response to Question 17. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=24)

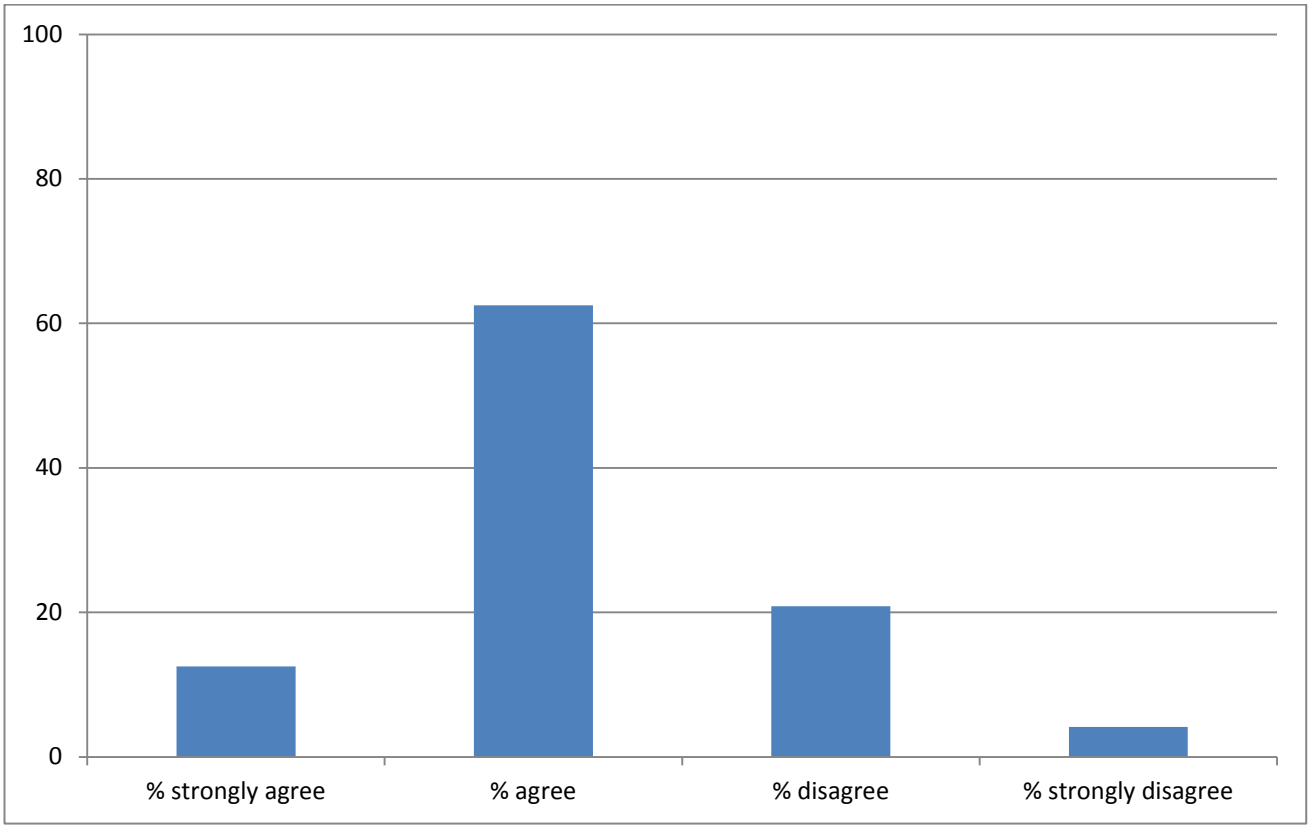



Figure10: Response to Question 18. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=25)

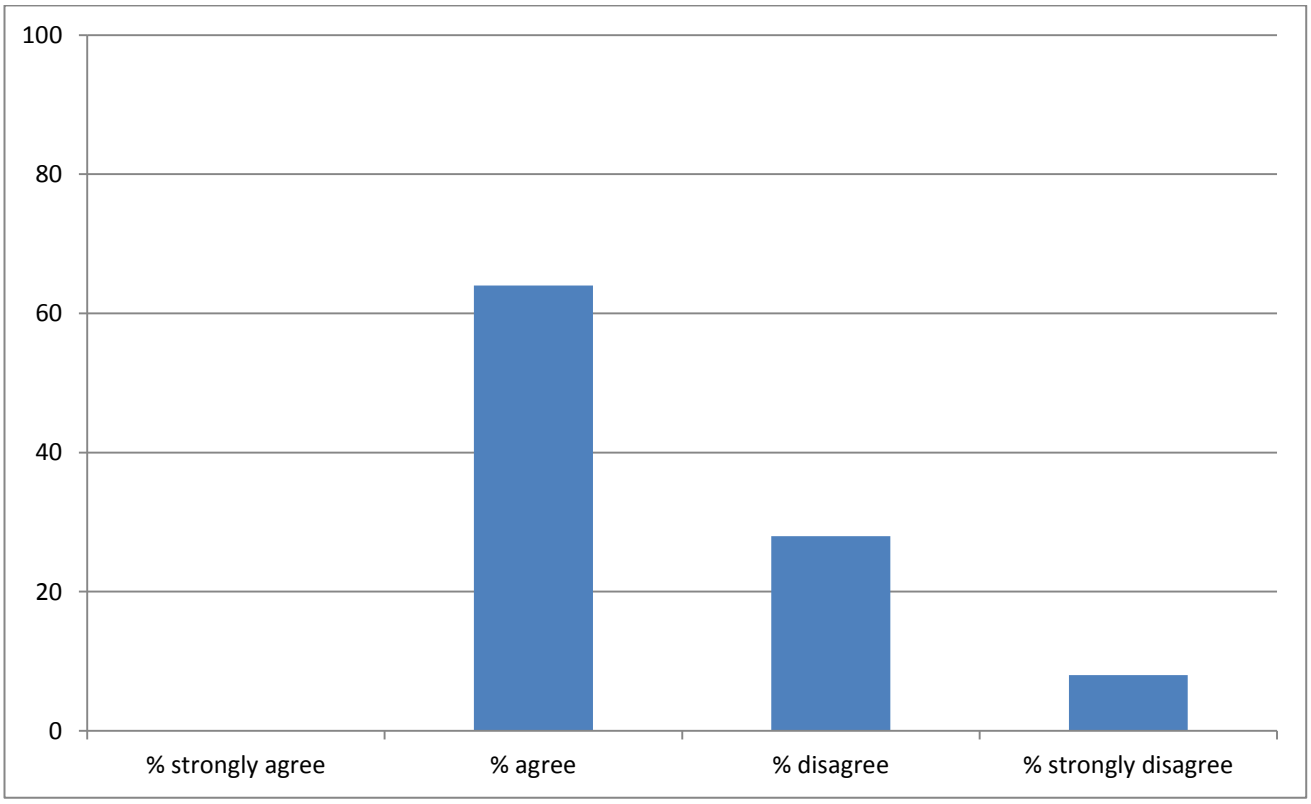


Figure 11: Response to Question 19. The content descriptions are specific about what is to be taught (n=26)

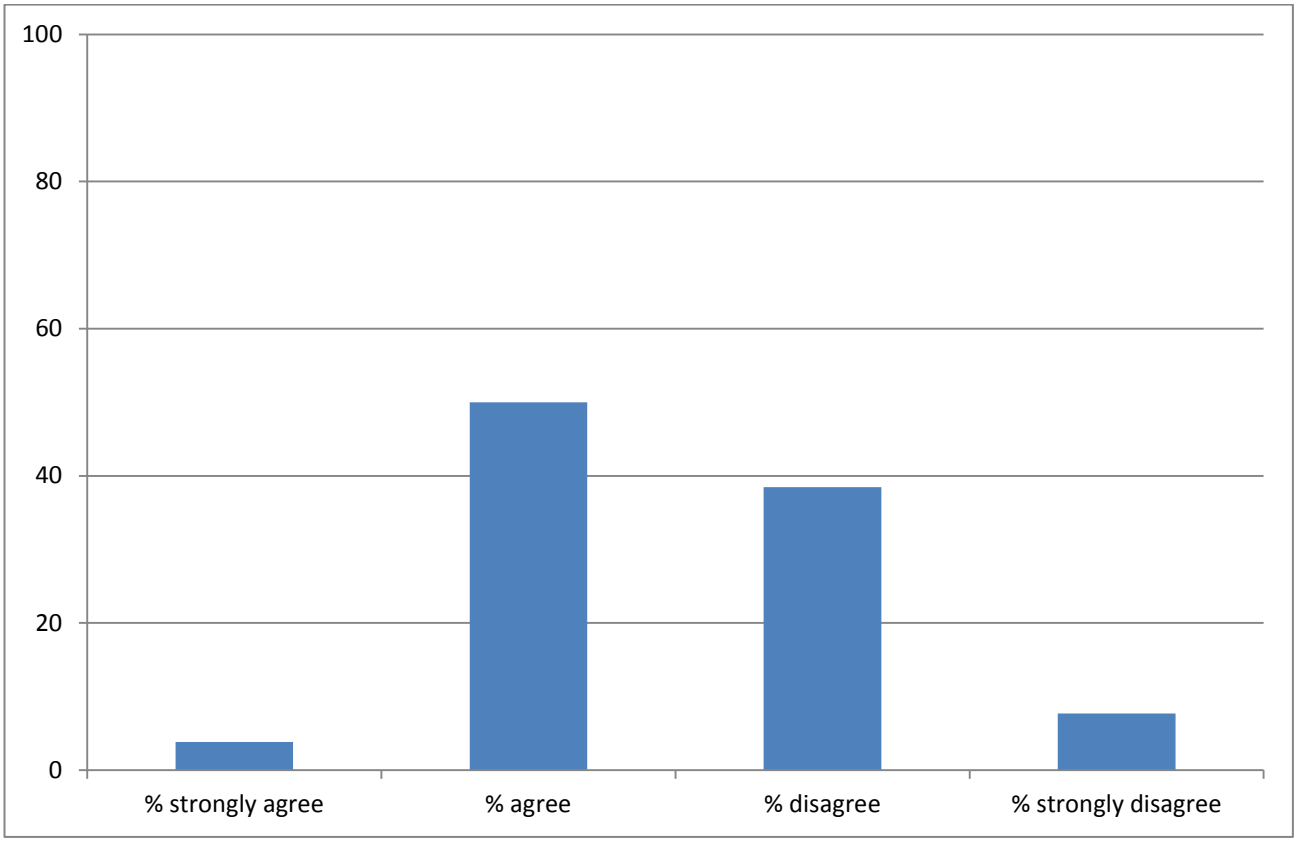



Figure 12: Response to Question 20. Unit 2: The unit description clearly describes the focus and scope for this unit (n=25)

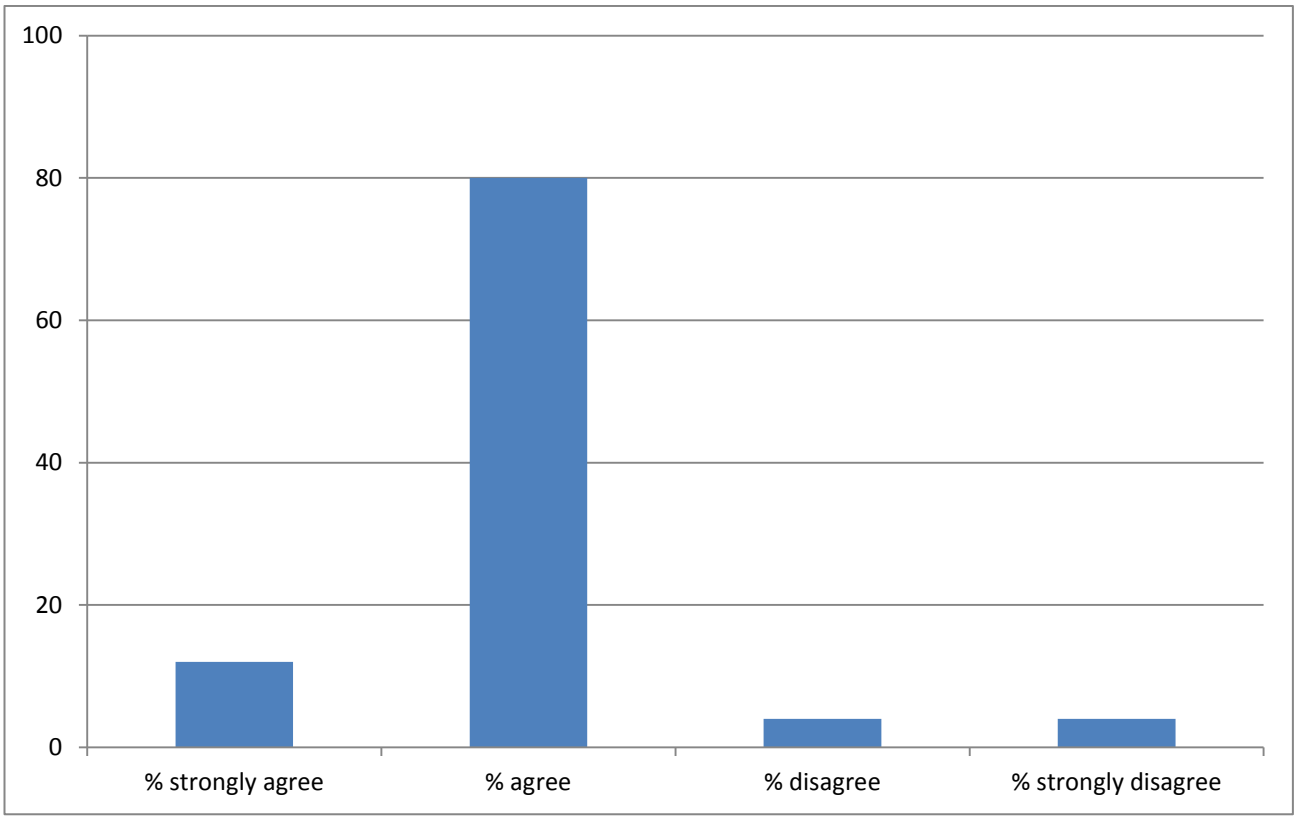


Figure 13: Response to Question 21. The unit outcomes describe clearly the expected learning for this unit (n=25)

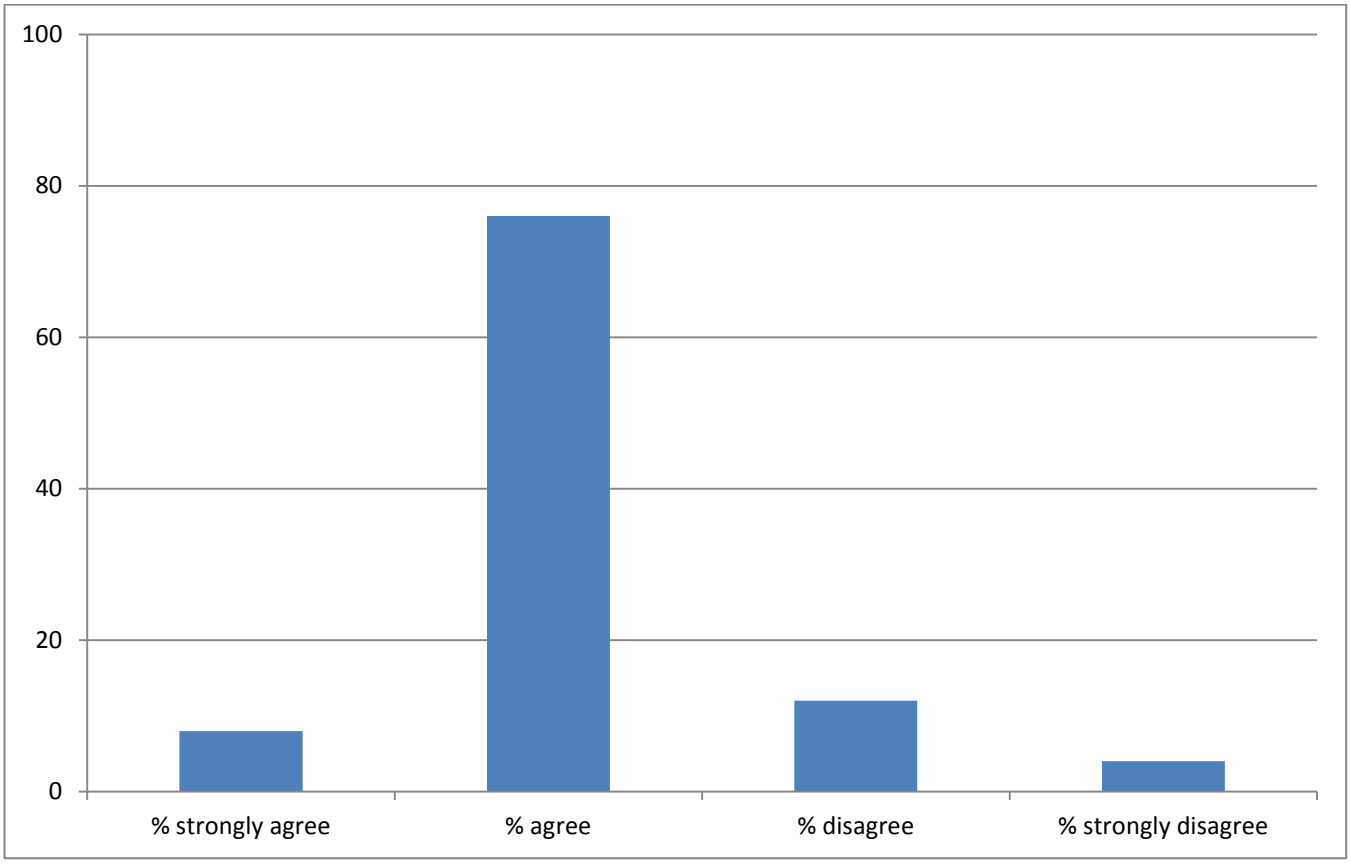



Figure 14: Response to Question 22. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=25)

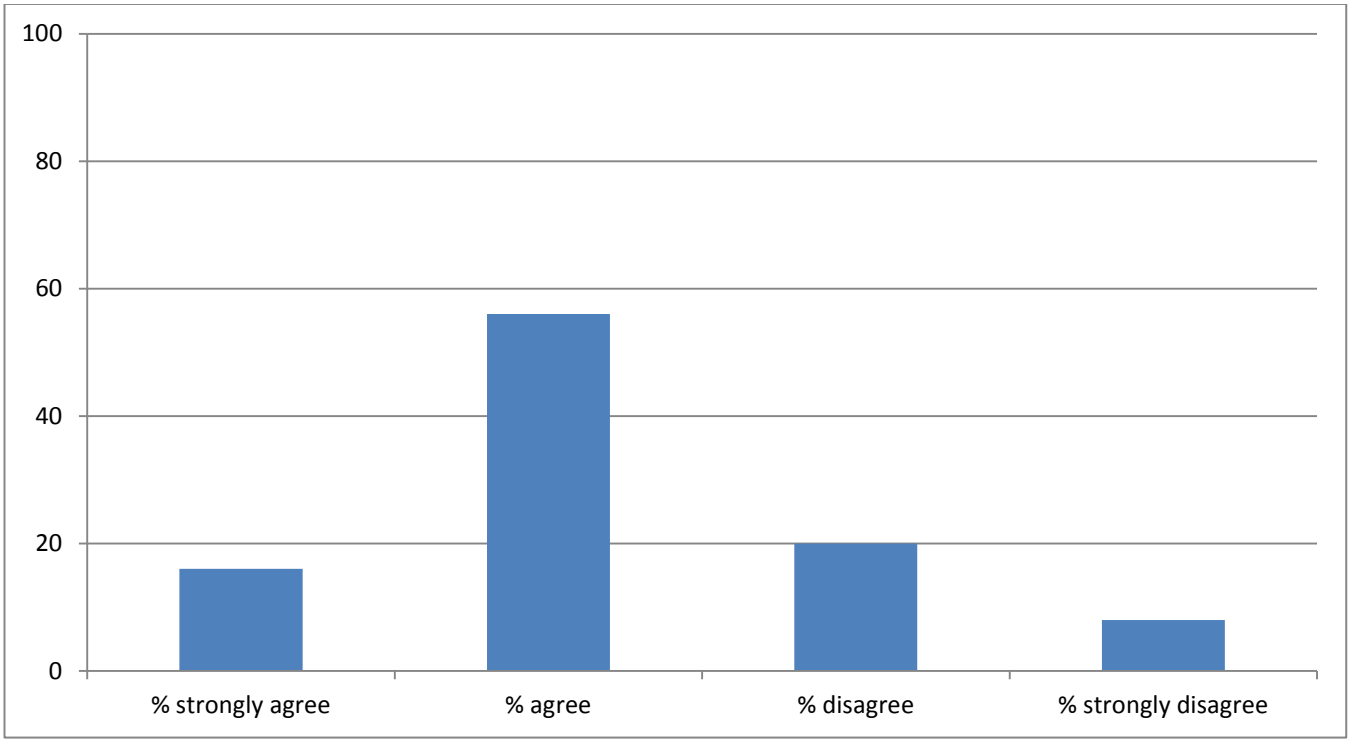


Figure 15: Response to Question 23. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=24)

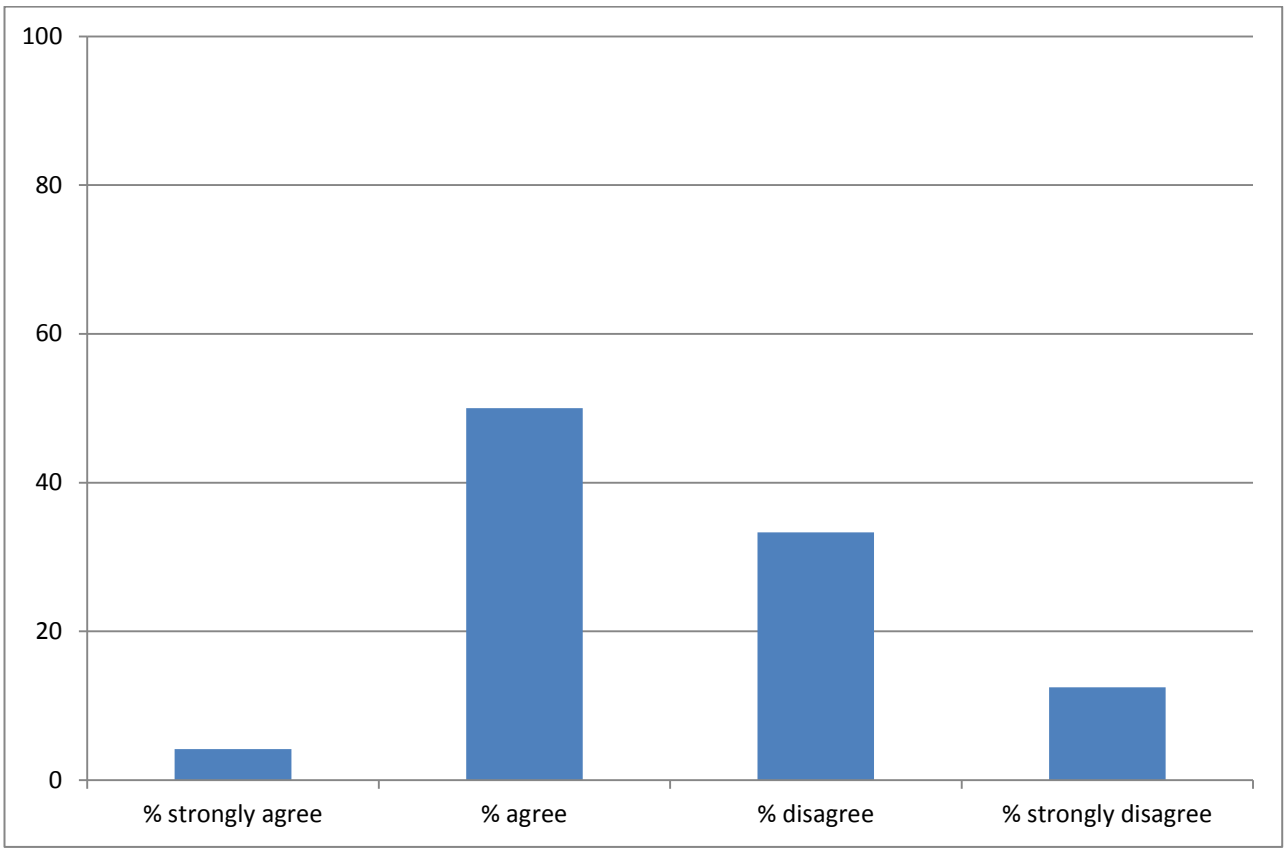



Figure 16: Response to Question 24. The content descriptions are specific about what is to be taught (n=25)

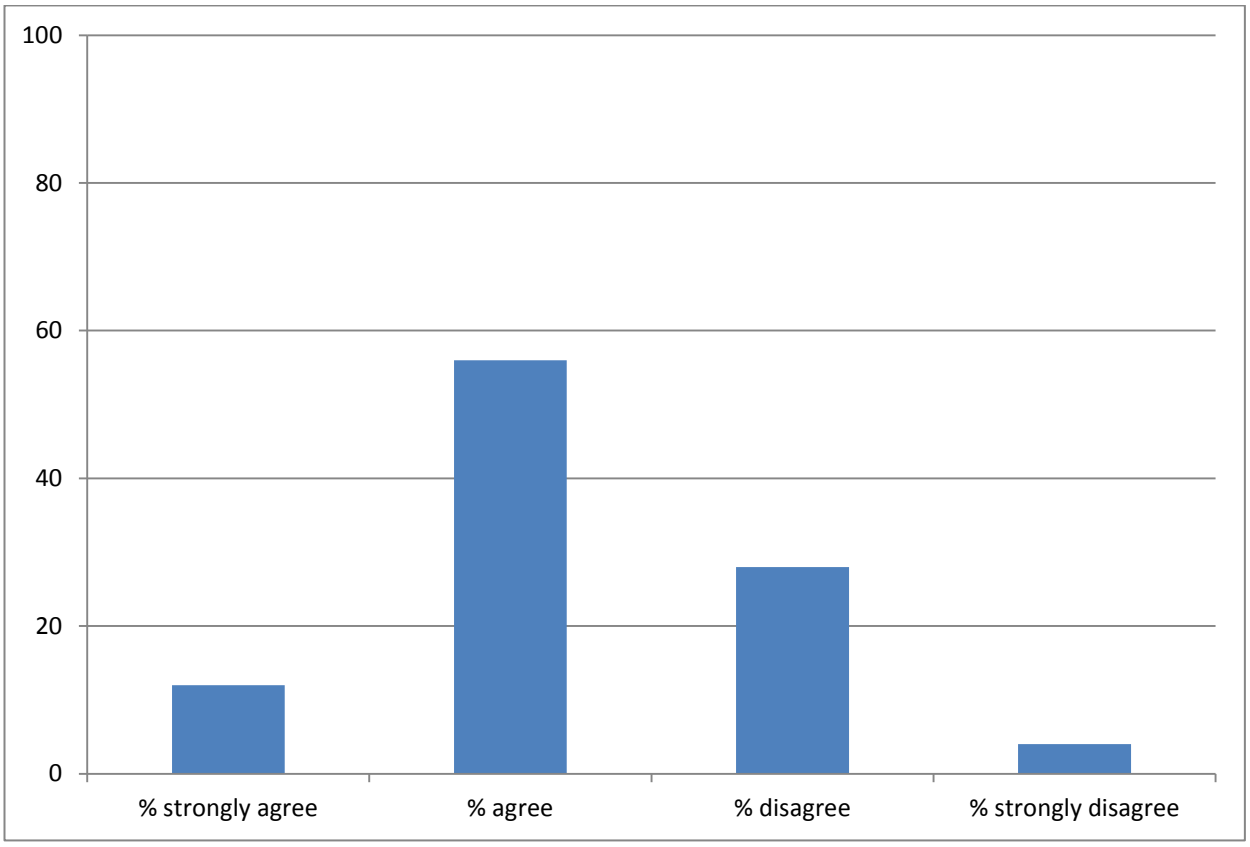


Figure 17: Response to Question 25. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=21)

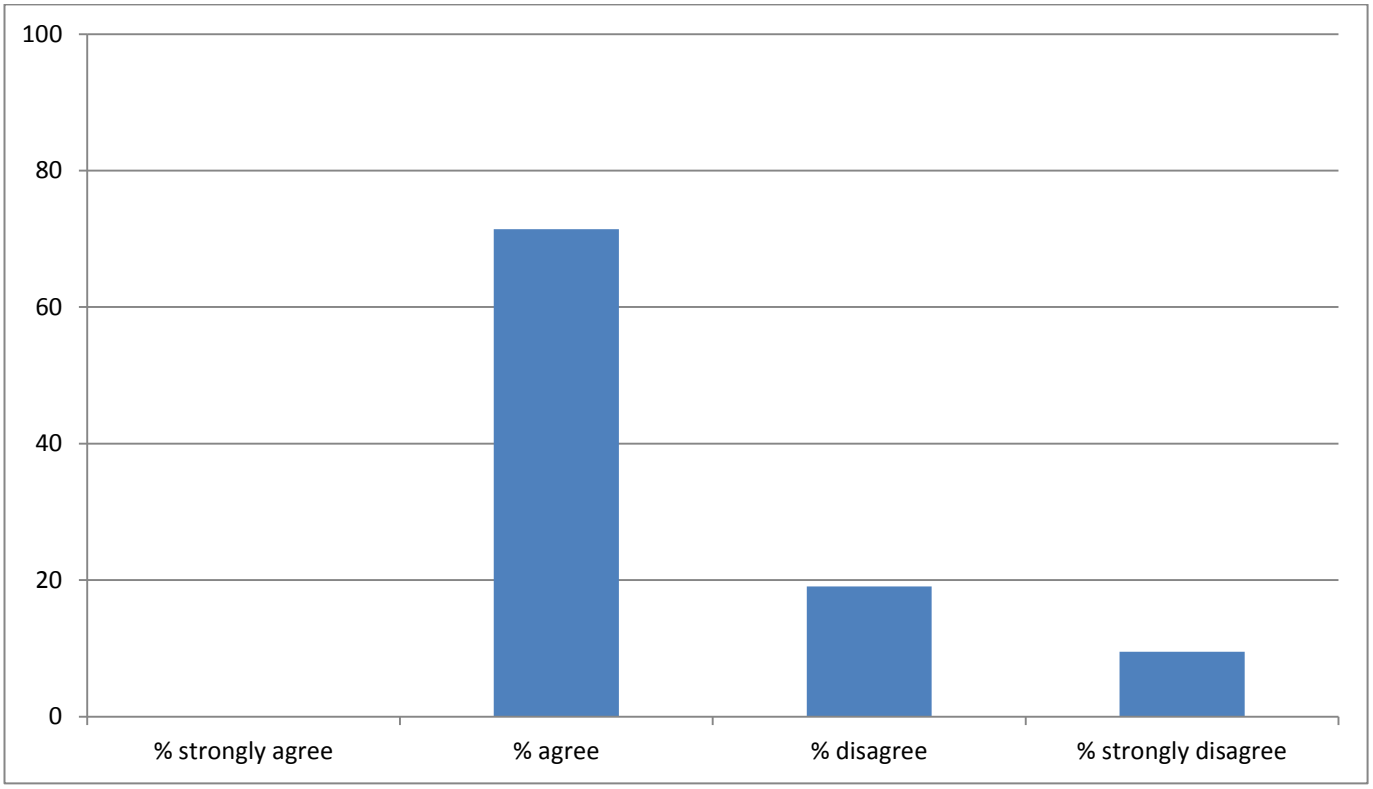



Figure 18: Response to Question 26. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=22)

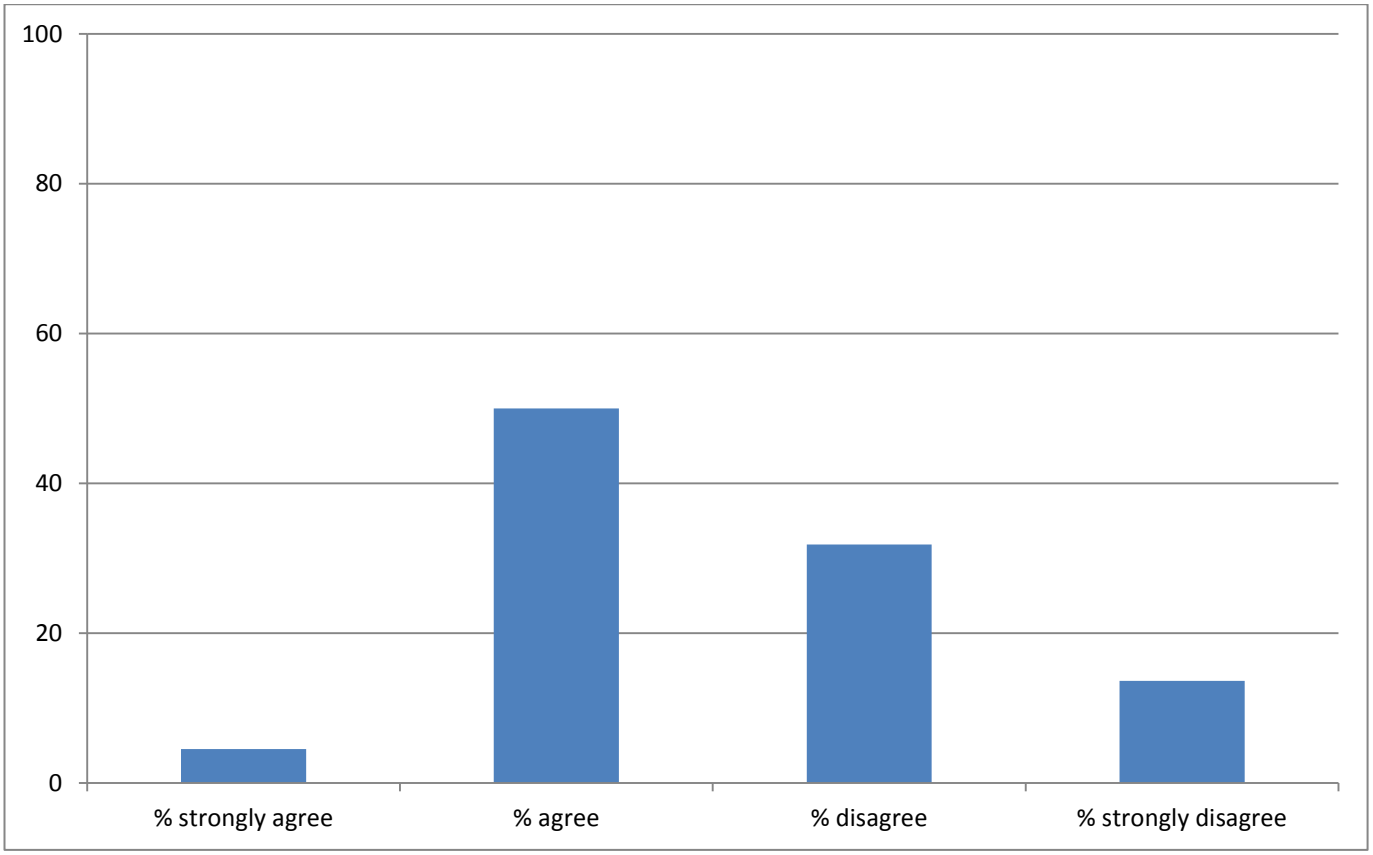


Figure 19: Response to Question 27. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=22)

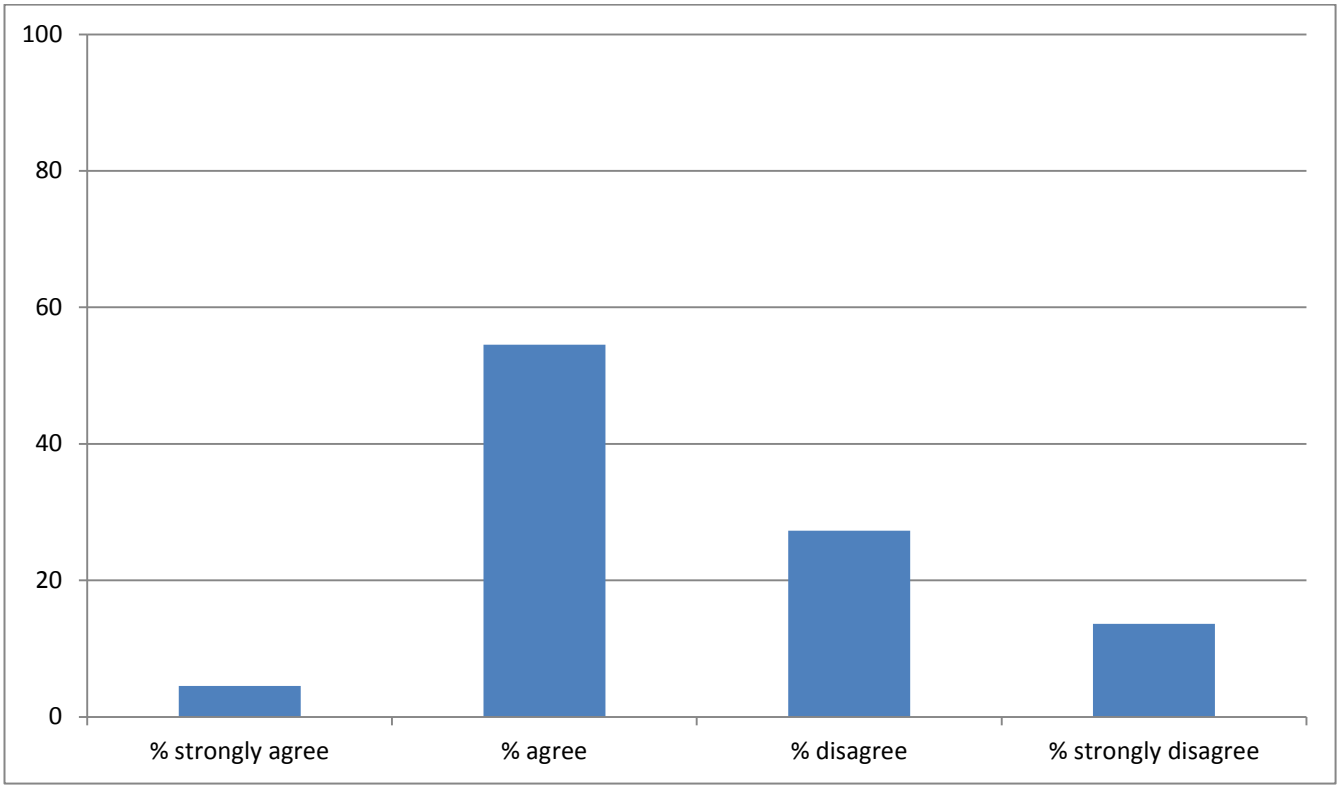



Figure 20: Response to Question 28. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=21)

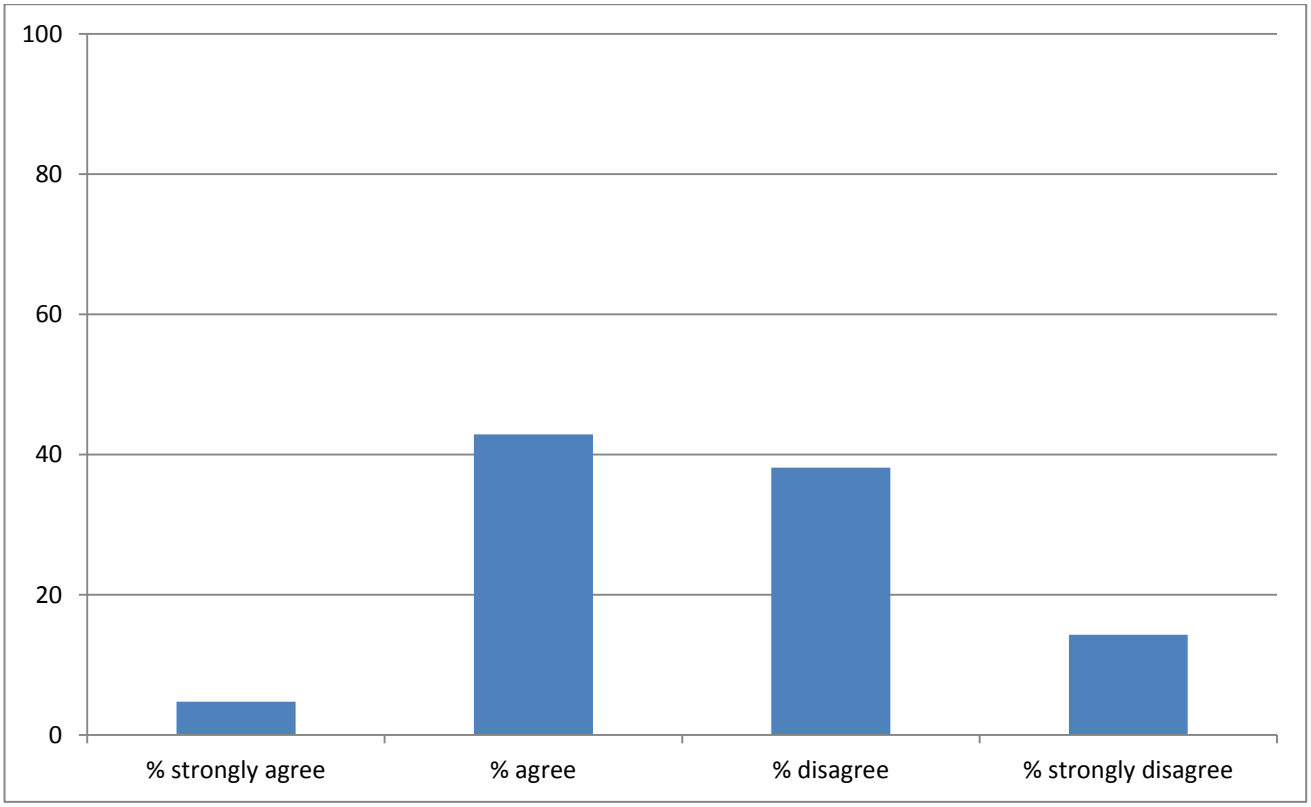


Figure 21: Response to Question 29. Unit 3: The unit description clearly describes the focus and scope for this unit (n=23)

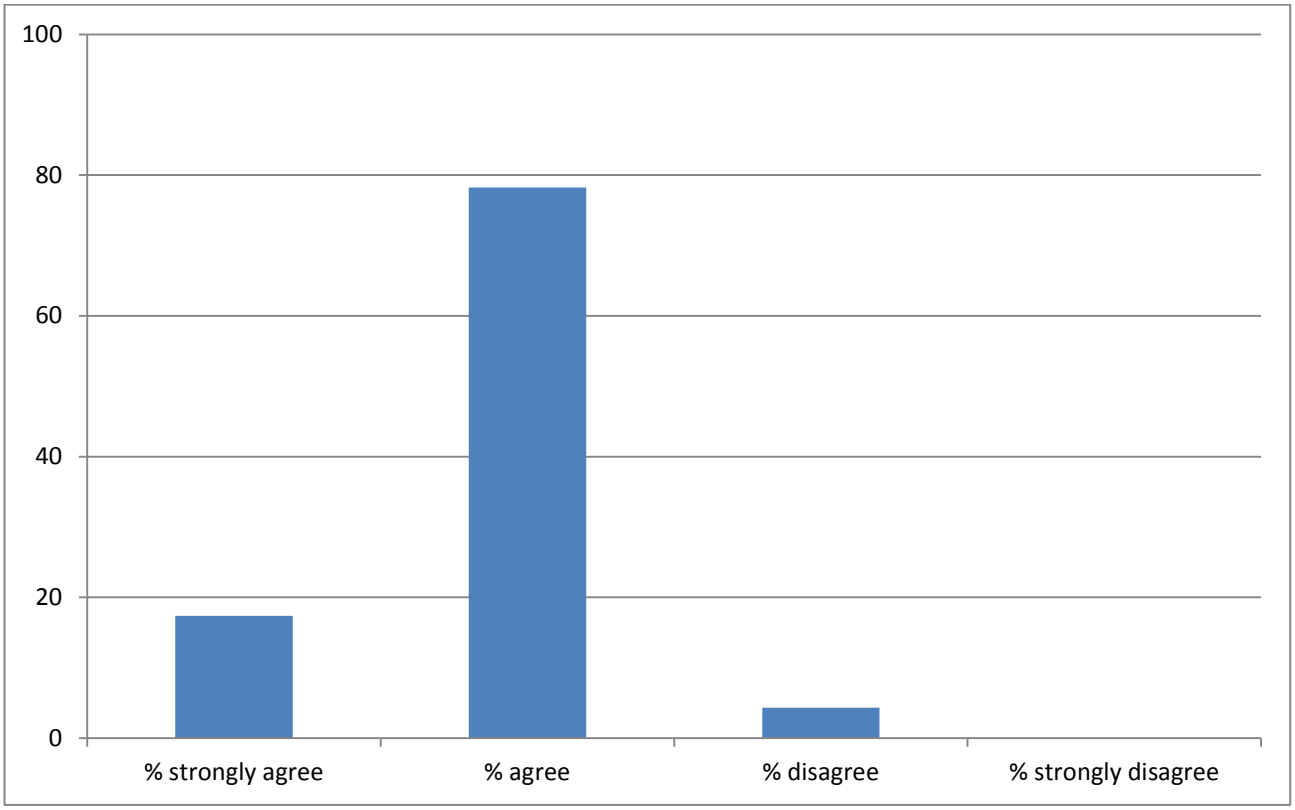



Figure 22: Response to Question 30. Unit 3: The unit outcomes describe clearly the expected learning for this unit (n=23)

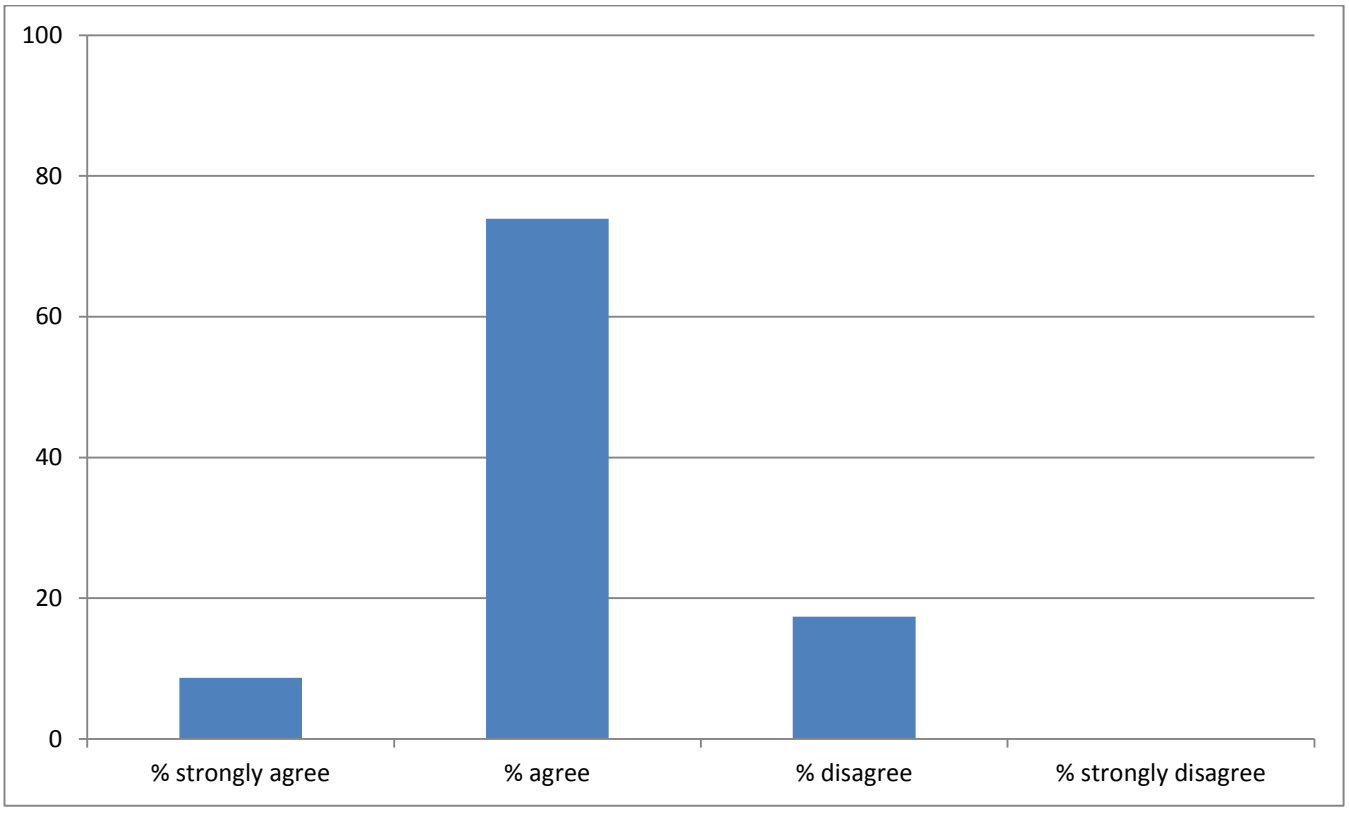


Figure 23: Response to Question 31. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=24)

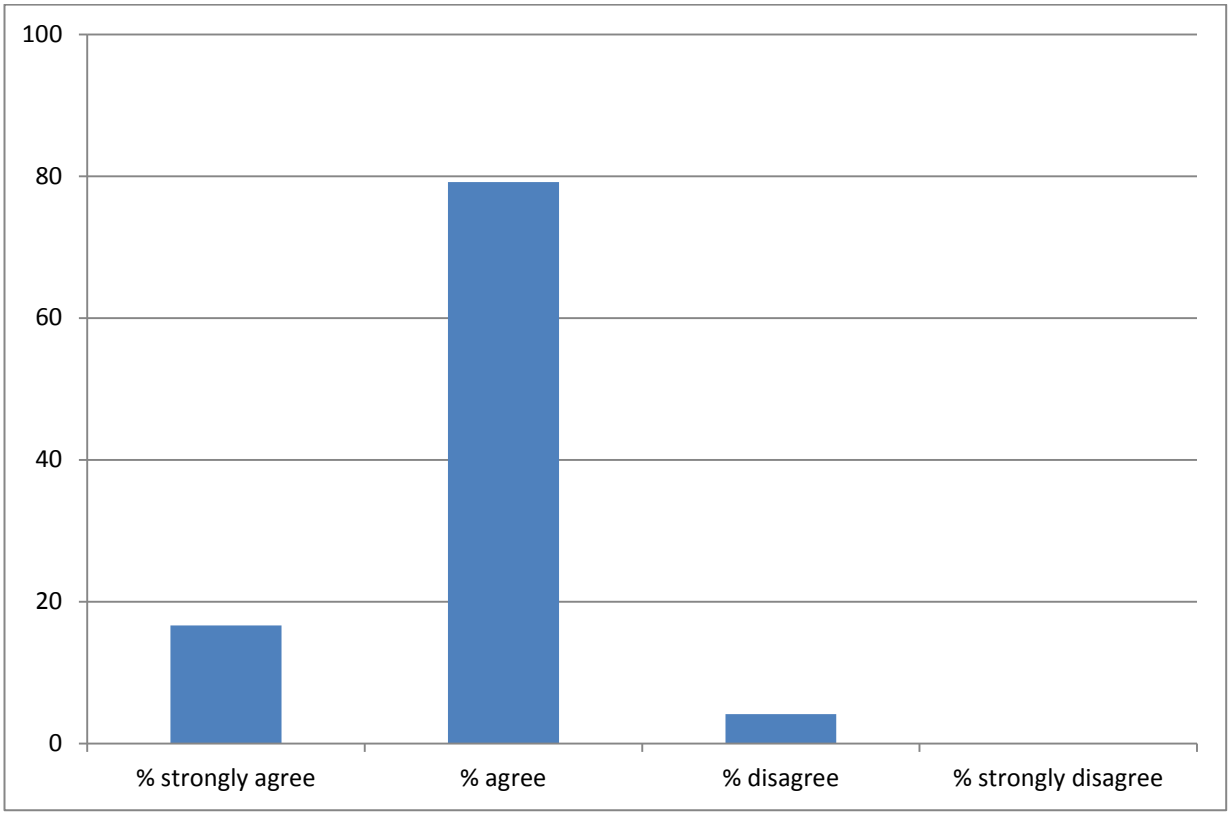



Figure 24: Response to Question 32. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=24)

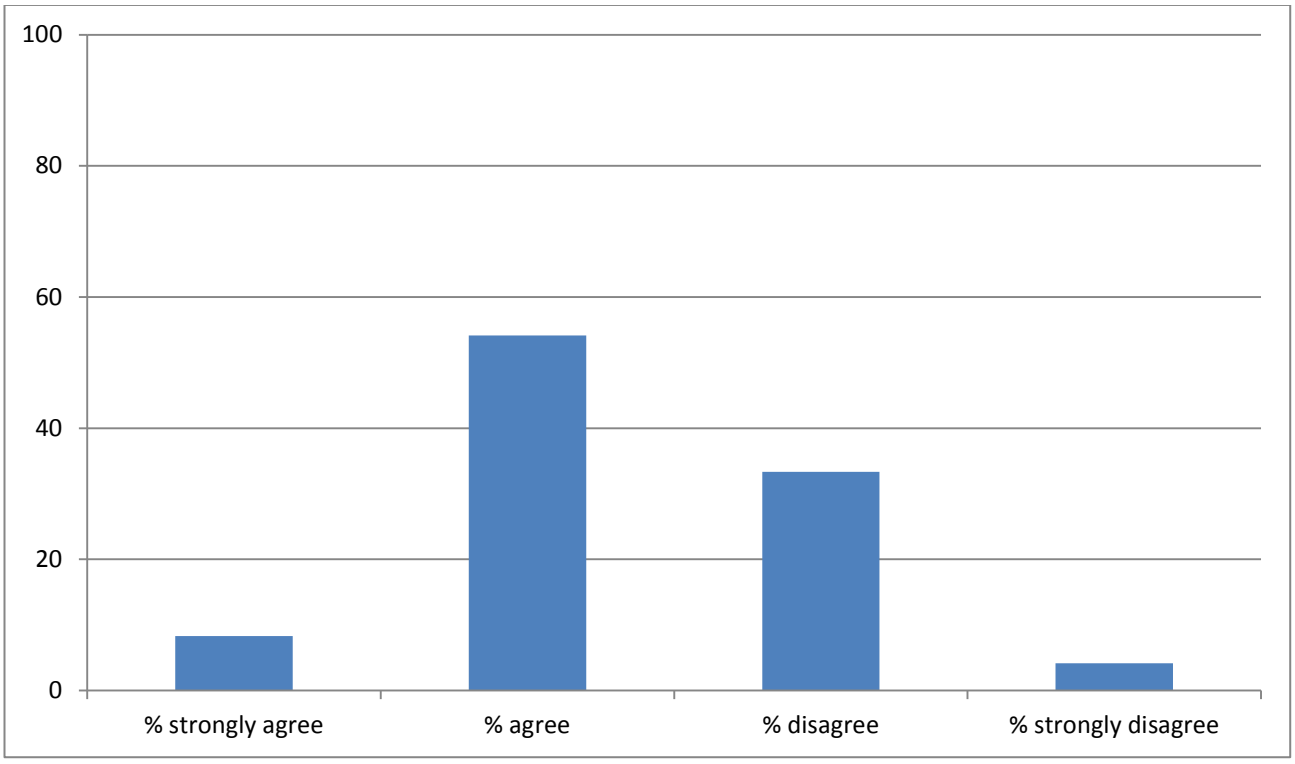


Figure 25: Response to Question 33. The content descriptions are specific about what is to be taught (n=24)

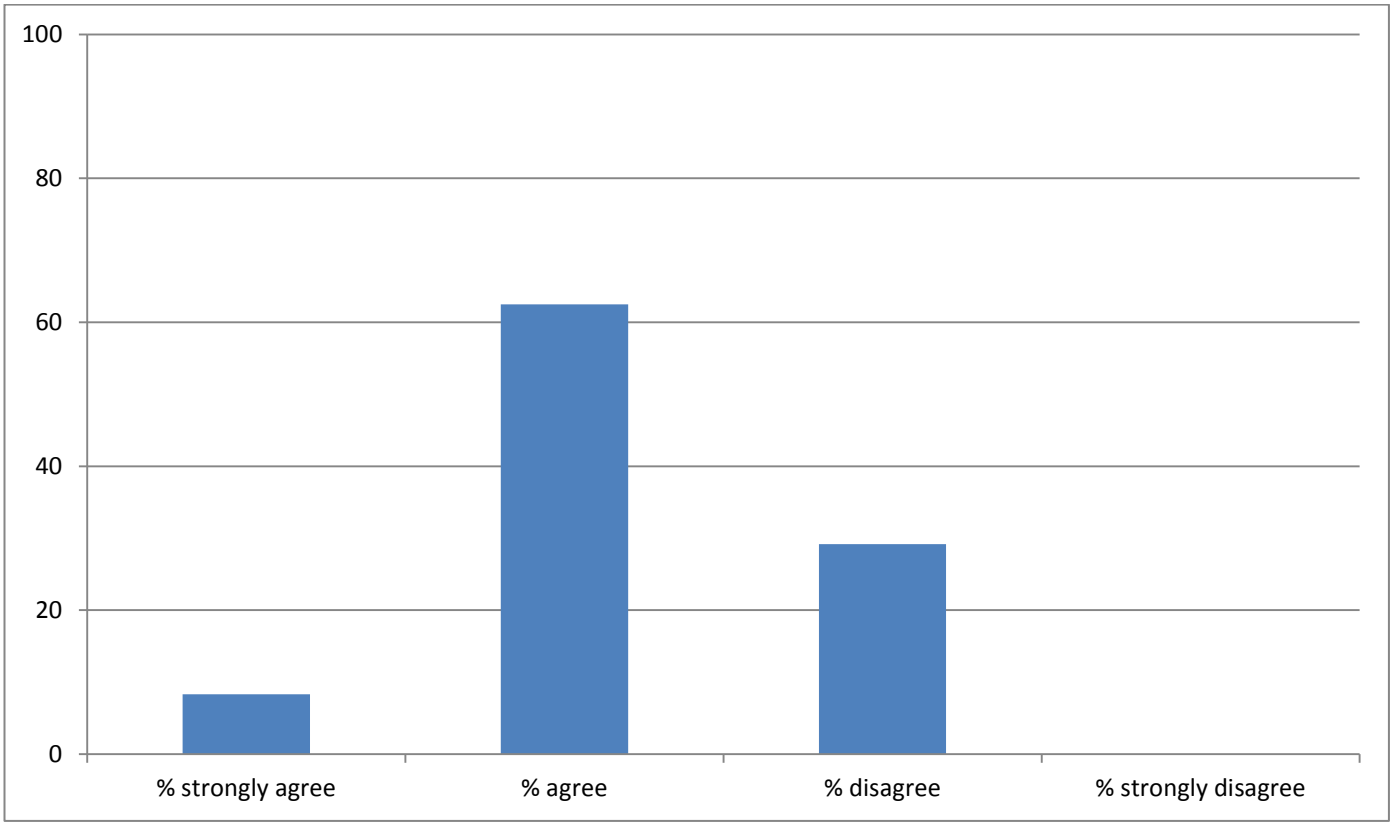



Figure 26: Response to Question 34. Unit 4: The unit description clearly describes the focus and scope for this unit (n=23)

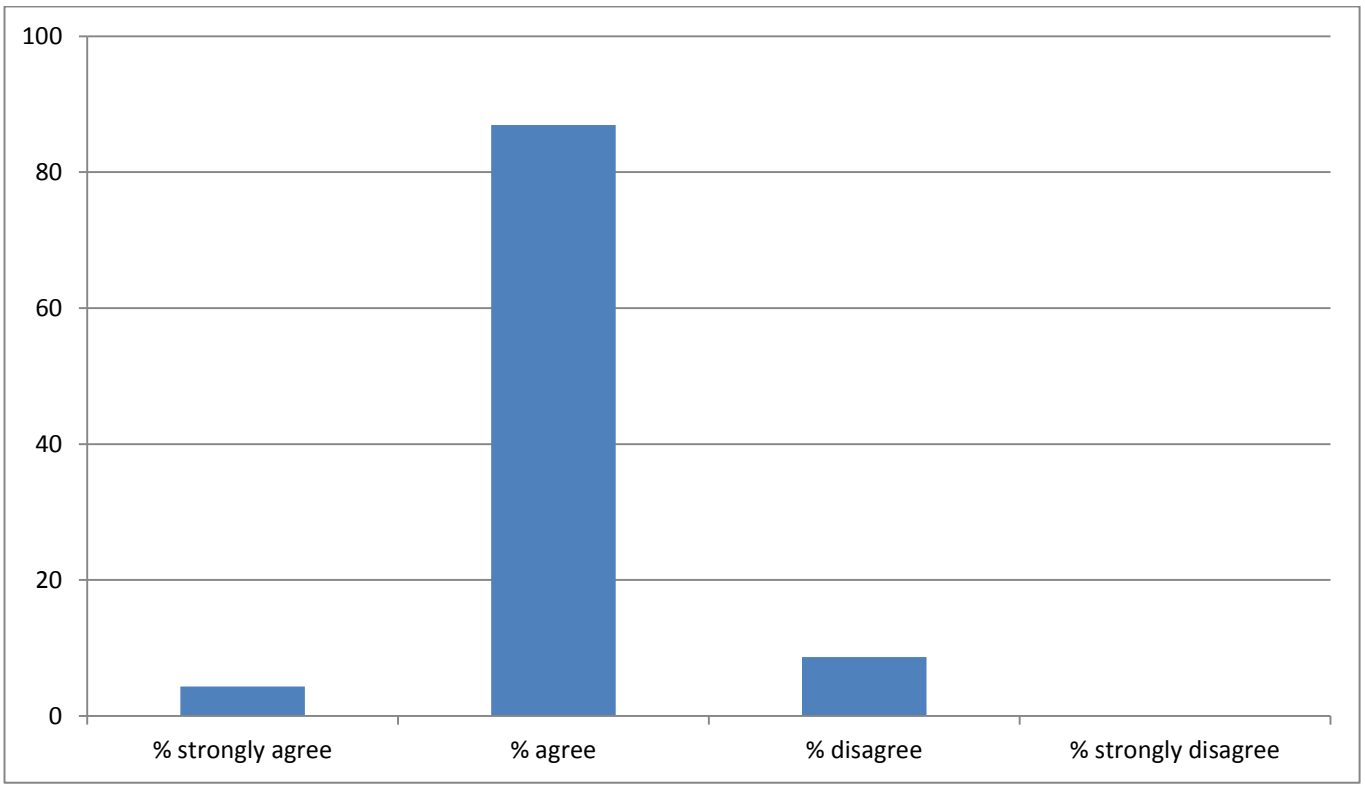


Figure 27: Response to Question 35. The unit outcomes describe clearly the expected learning for this unit (n=23)

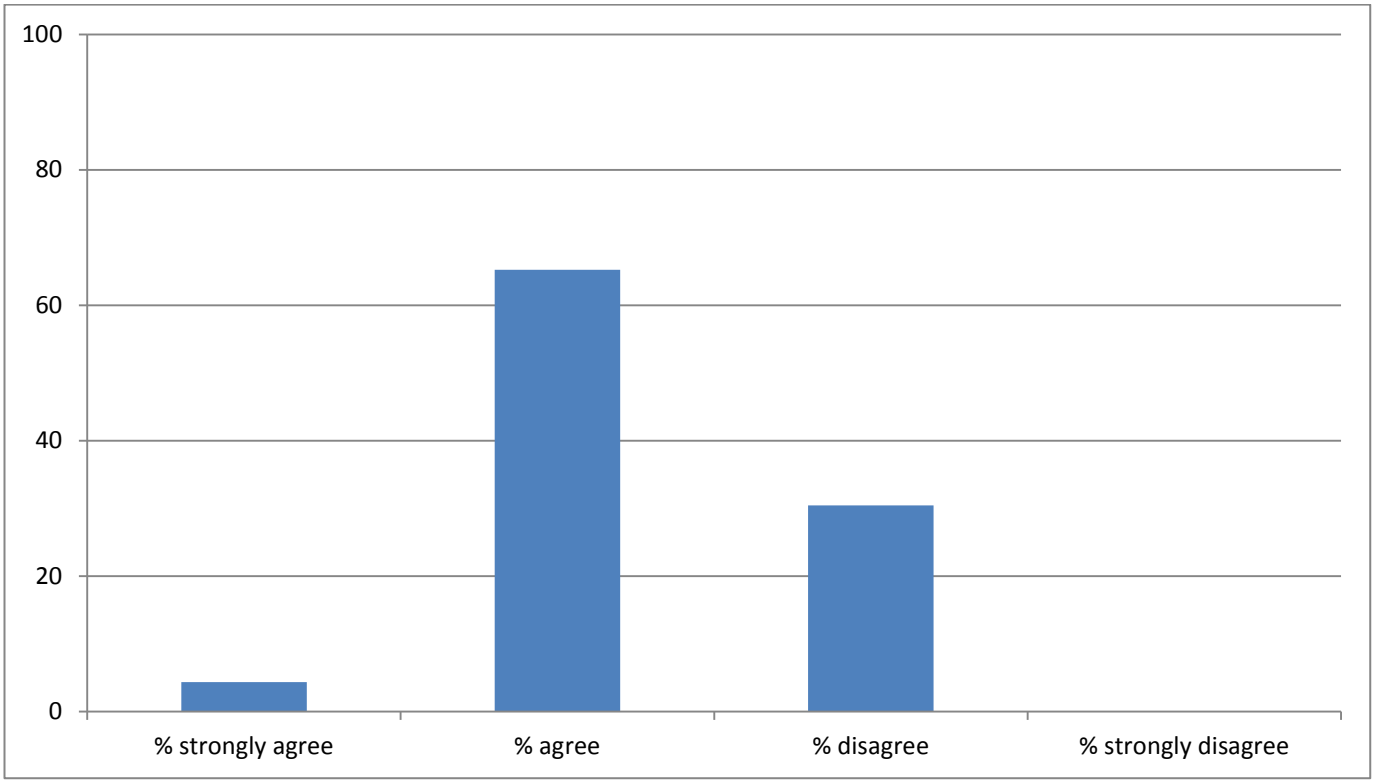



Figure 28: Response to Question 36. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=24)

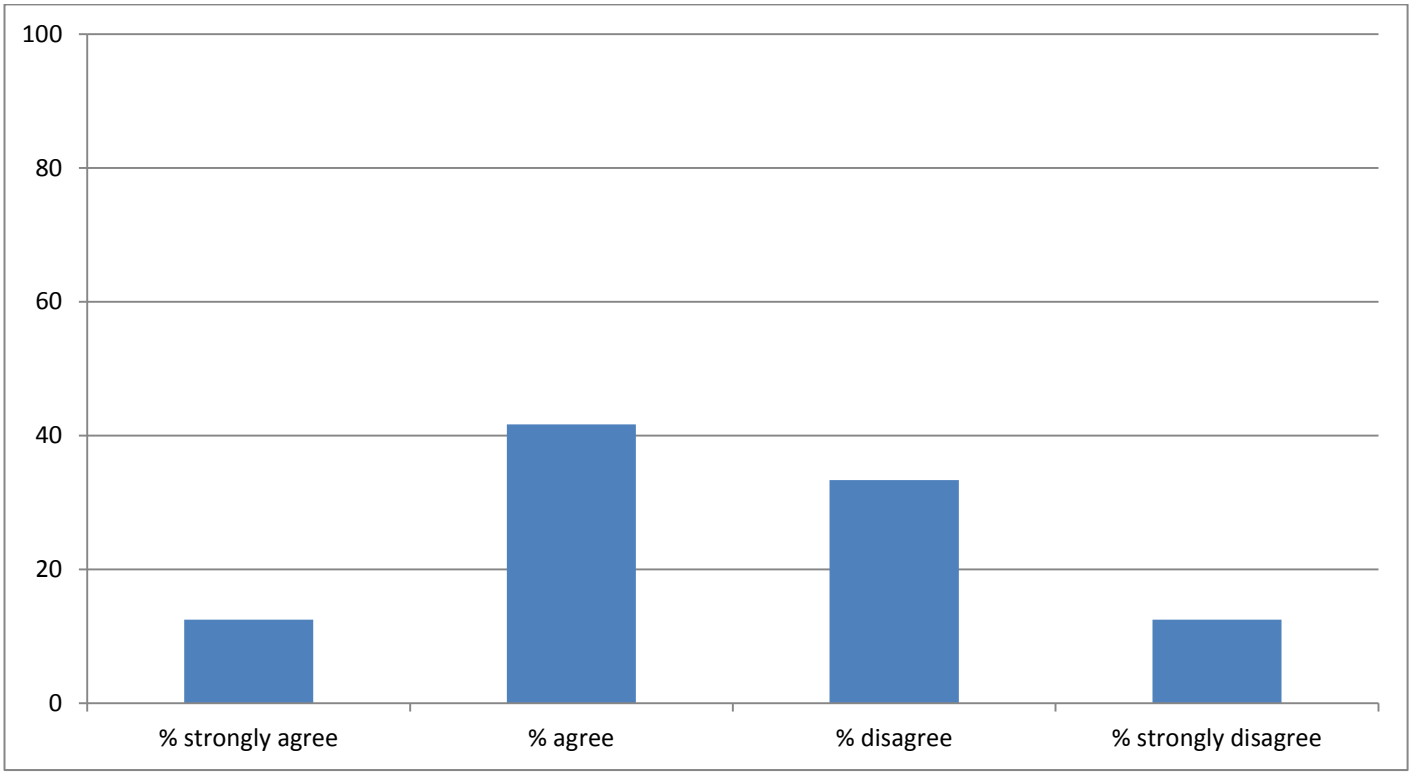


Figure 29: Response to Question 37. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=23)

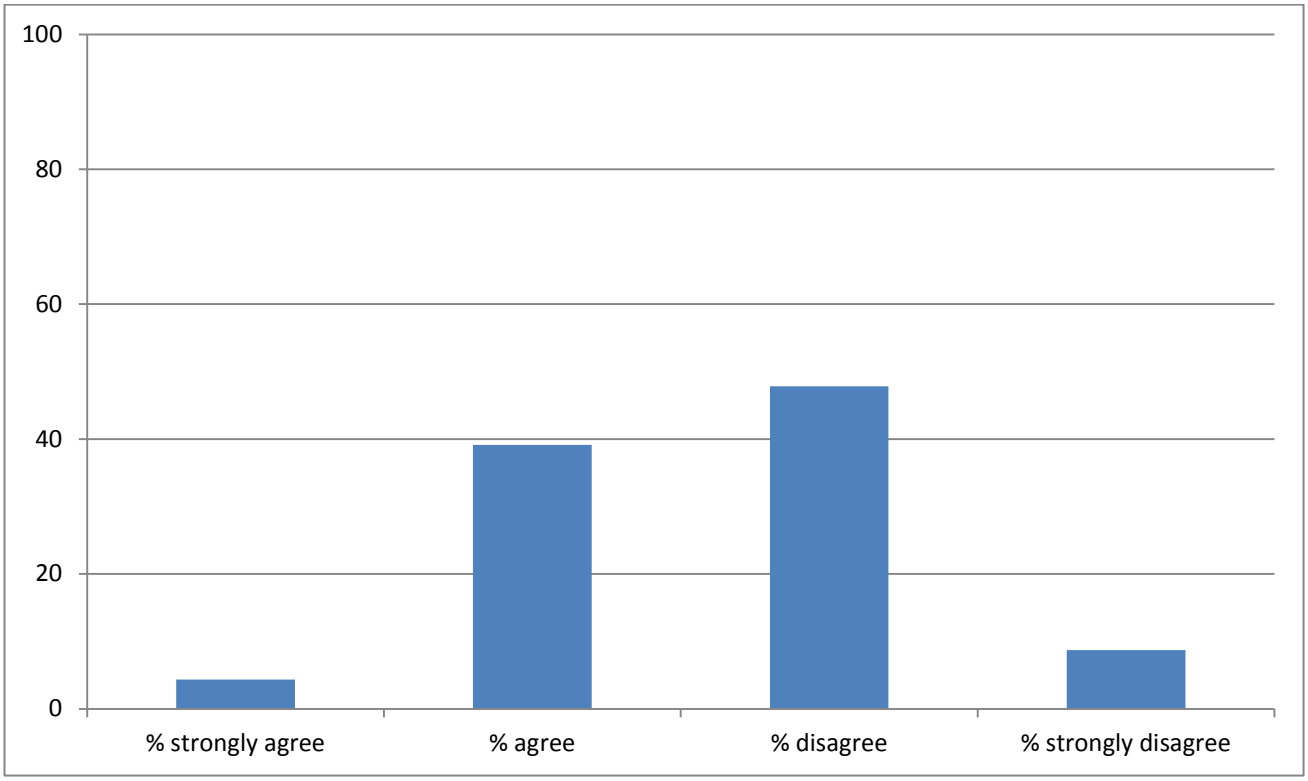



Figure 30: Response to Question 38. The content descriptions are specific about what is to be taught (n=23)

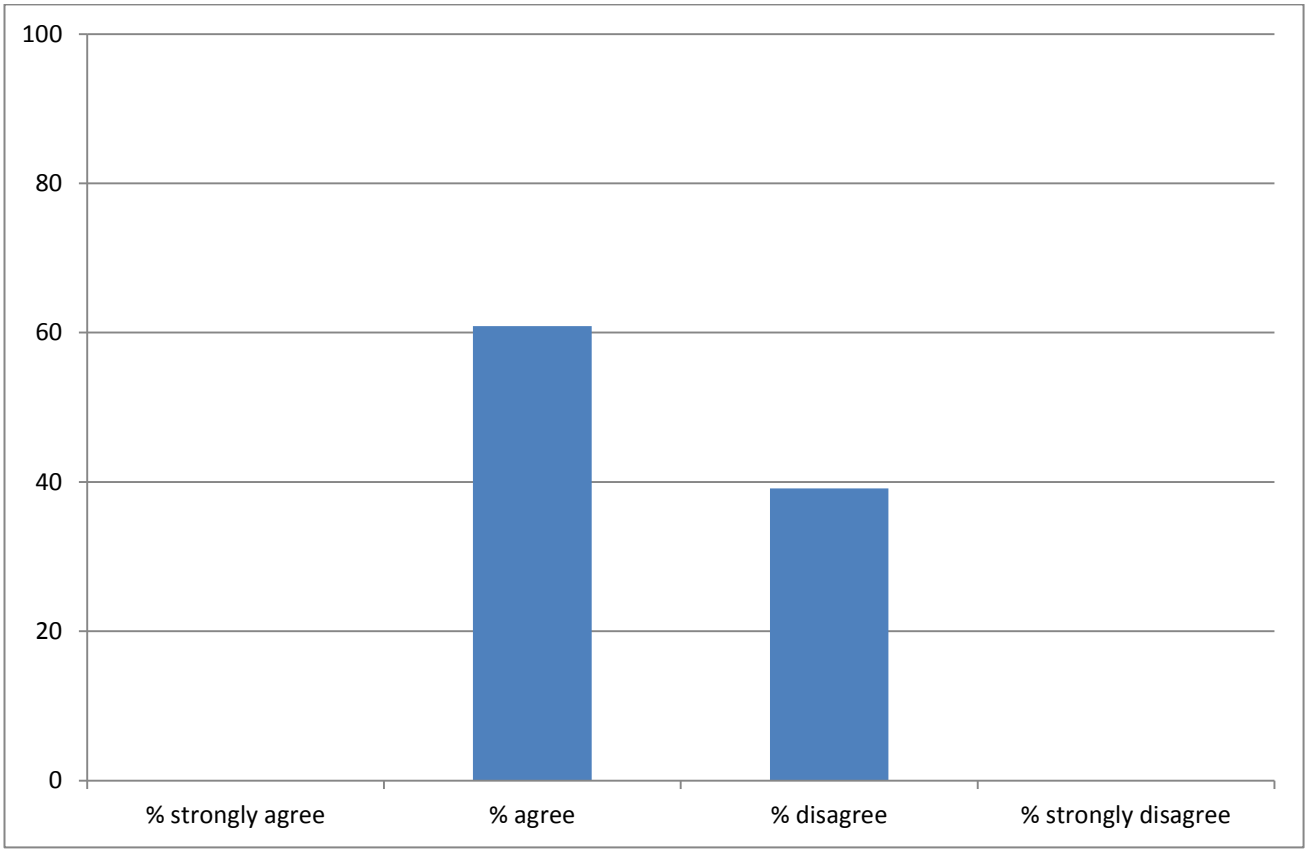


Figure 31: Response to Question 39. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=21)

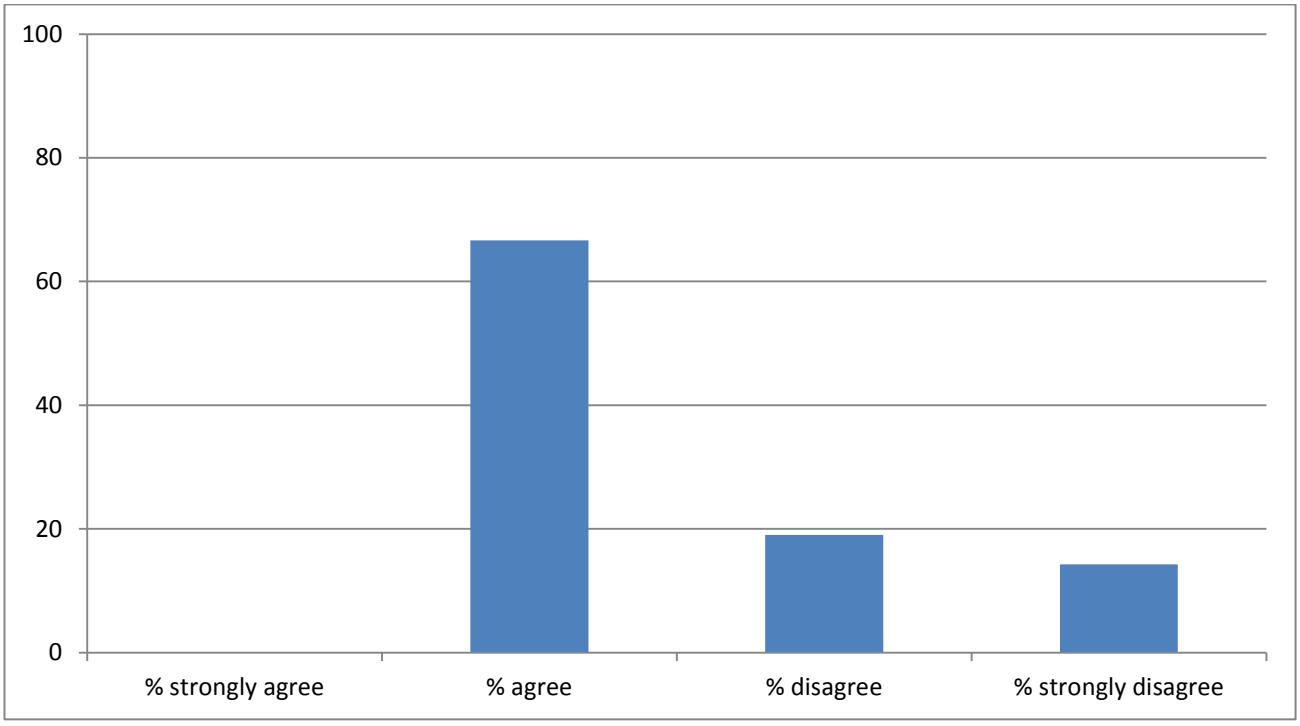



Figure 32: Response to Question 40. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=20)

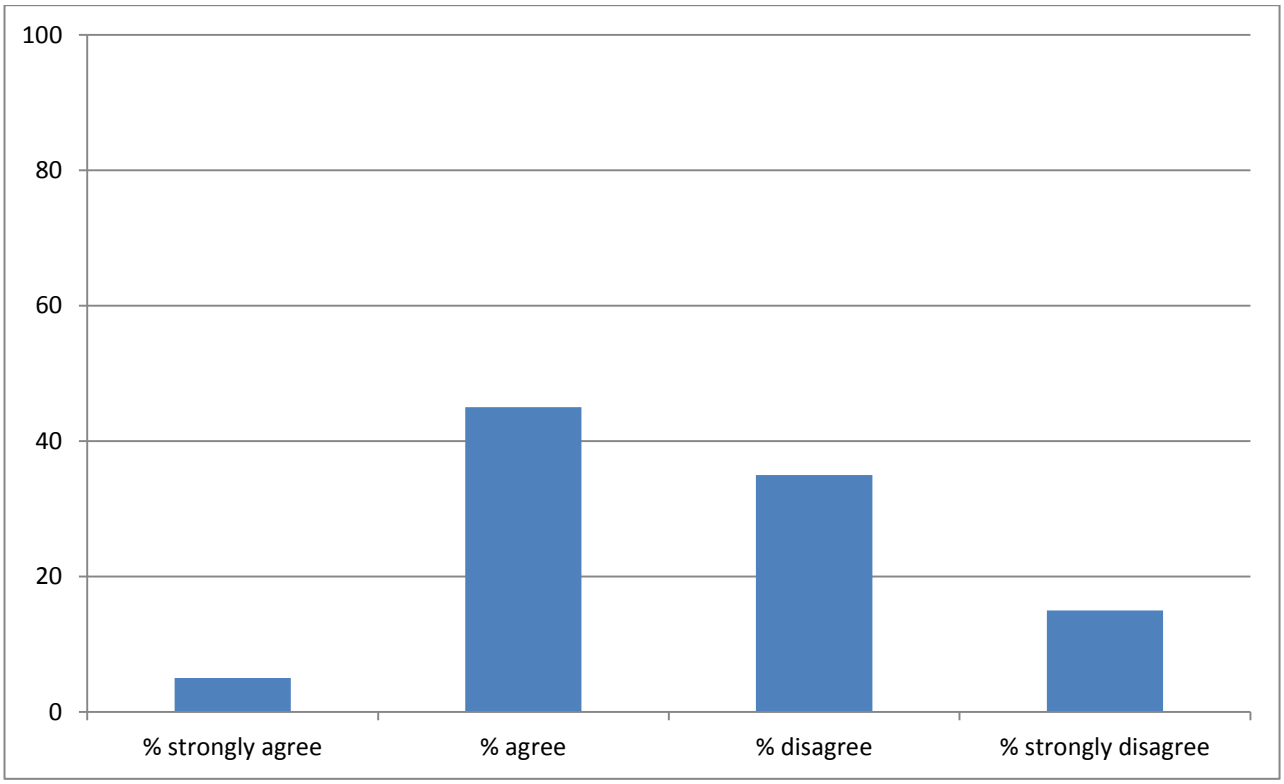


Figure 33: Response to Question 41. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=21)

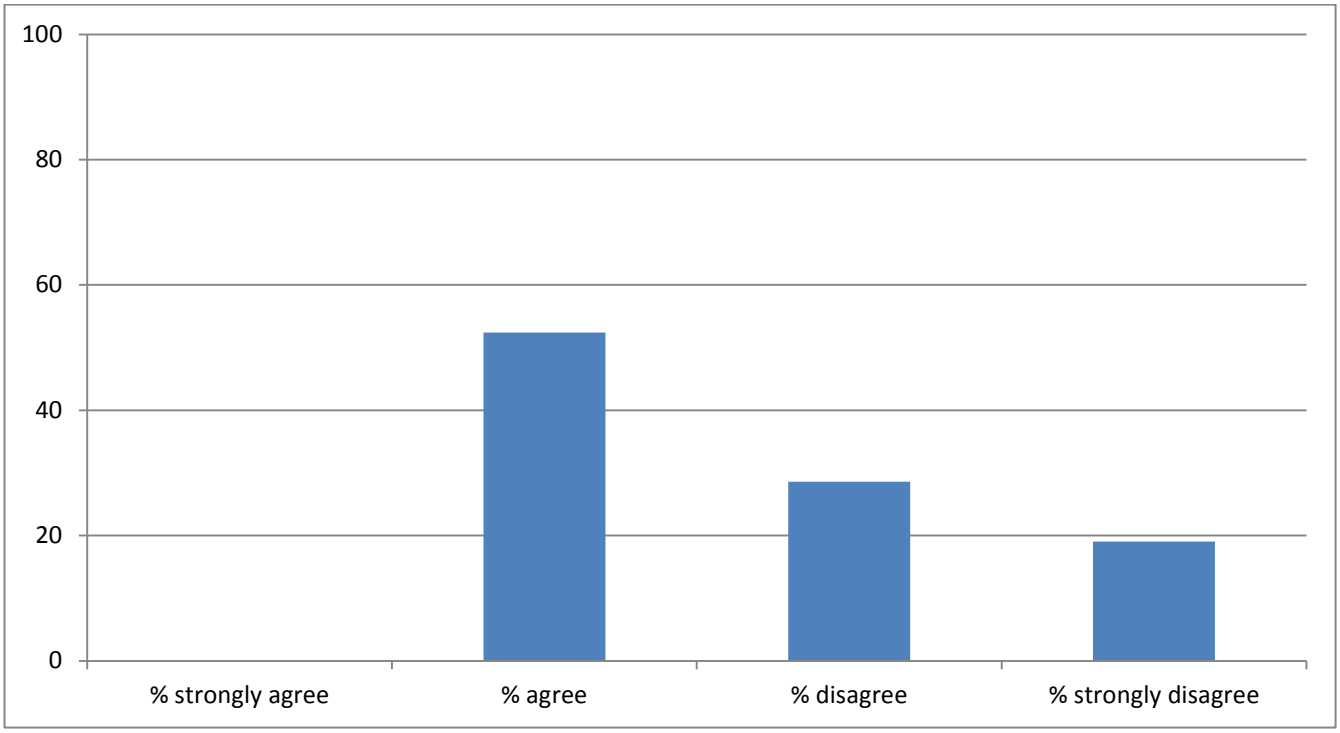



Figure 34: Response to Question 42. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=22)

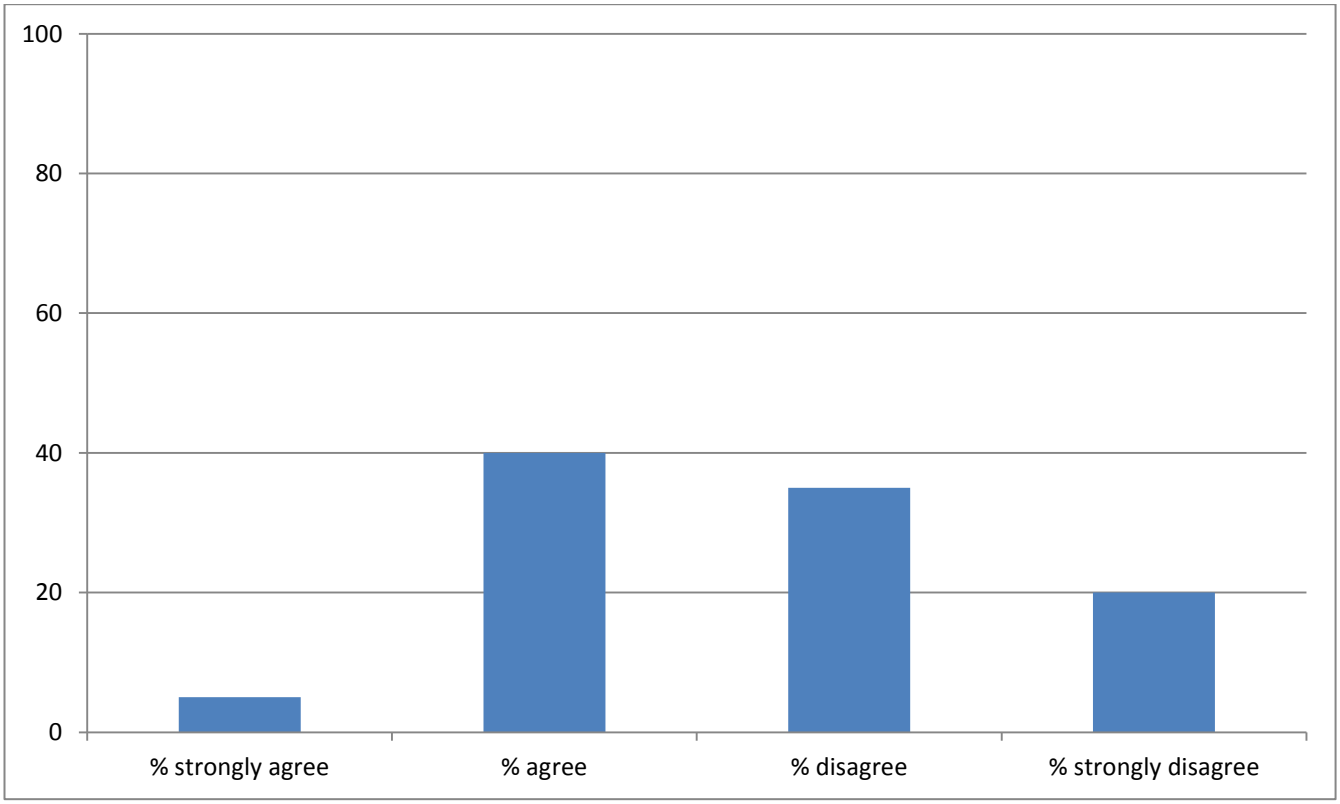


Figure 35: Response to Question 43. The general capabilities that naturally fit with this subject are appropriately represented (n=22)

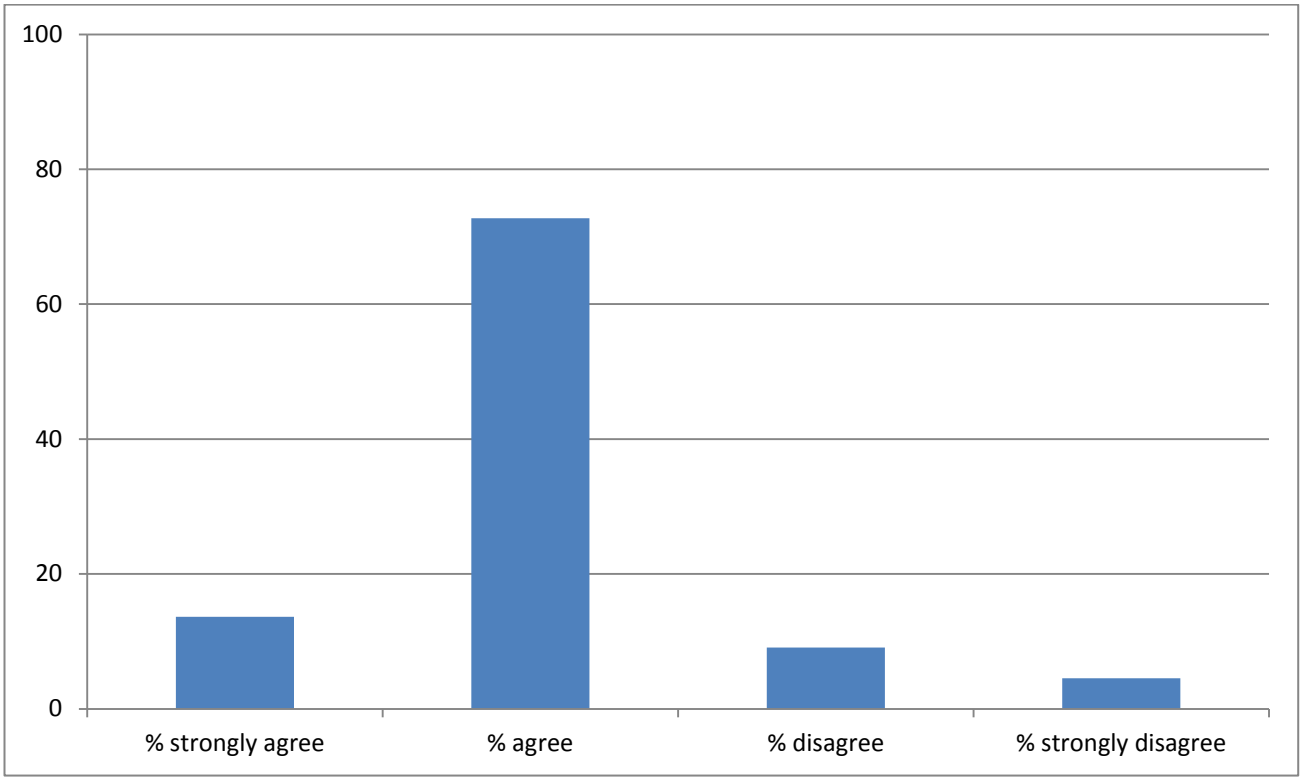



Figure 36: Response to Question 44. The cross-curriculum priorities that naturally fit with this subject are appropriately represented (n=22)

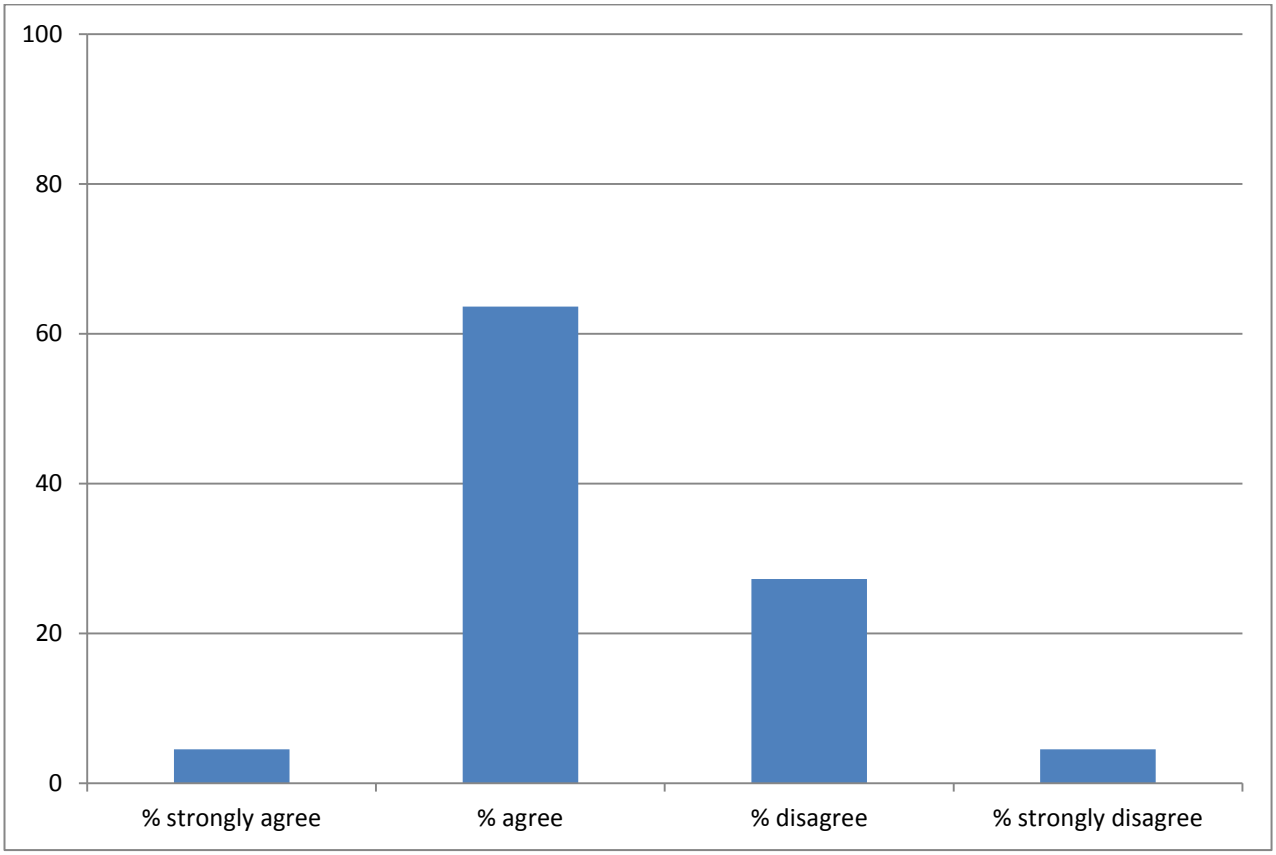
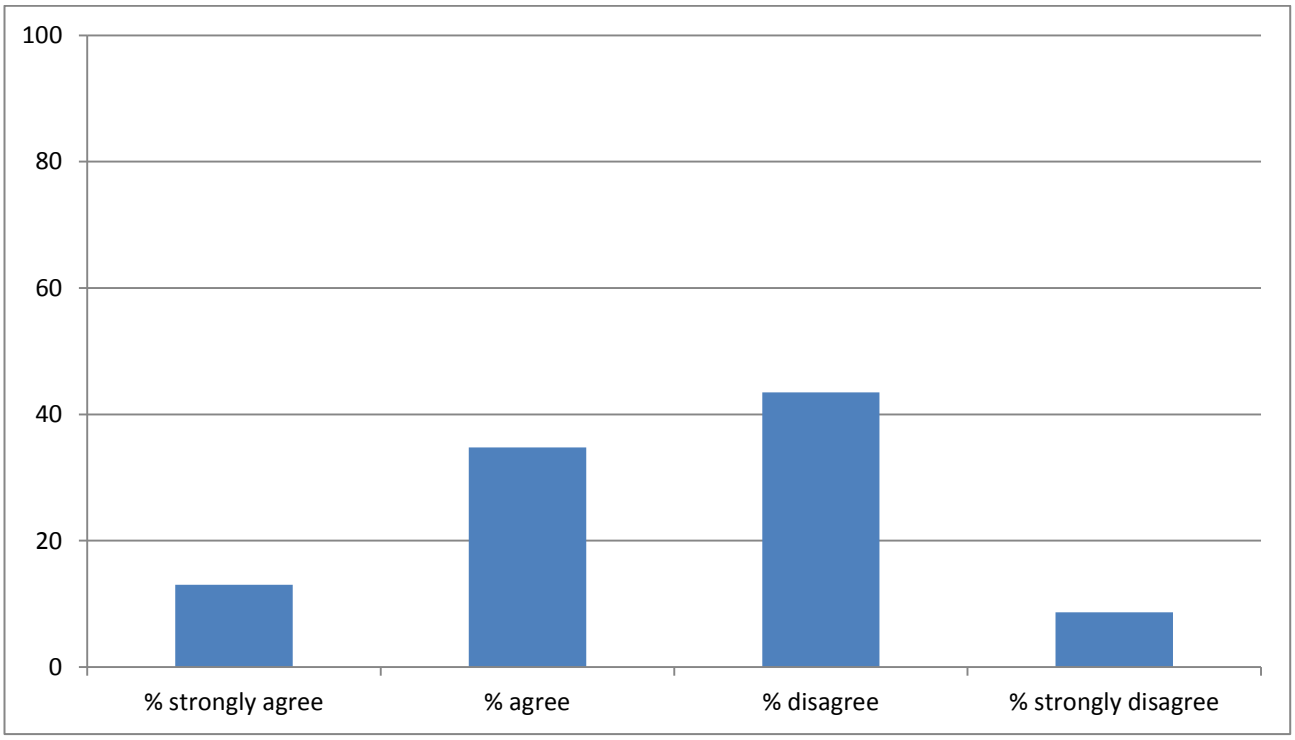


Figure 37: Response to Question 45. The glossary is comprehensive (n=23)



## Chemistry

Figure 1: Response to Question 9. The rationale provides clarity about the subject's broad scope, distinctive nature and importance (n=16)

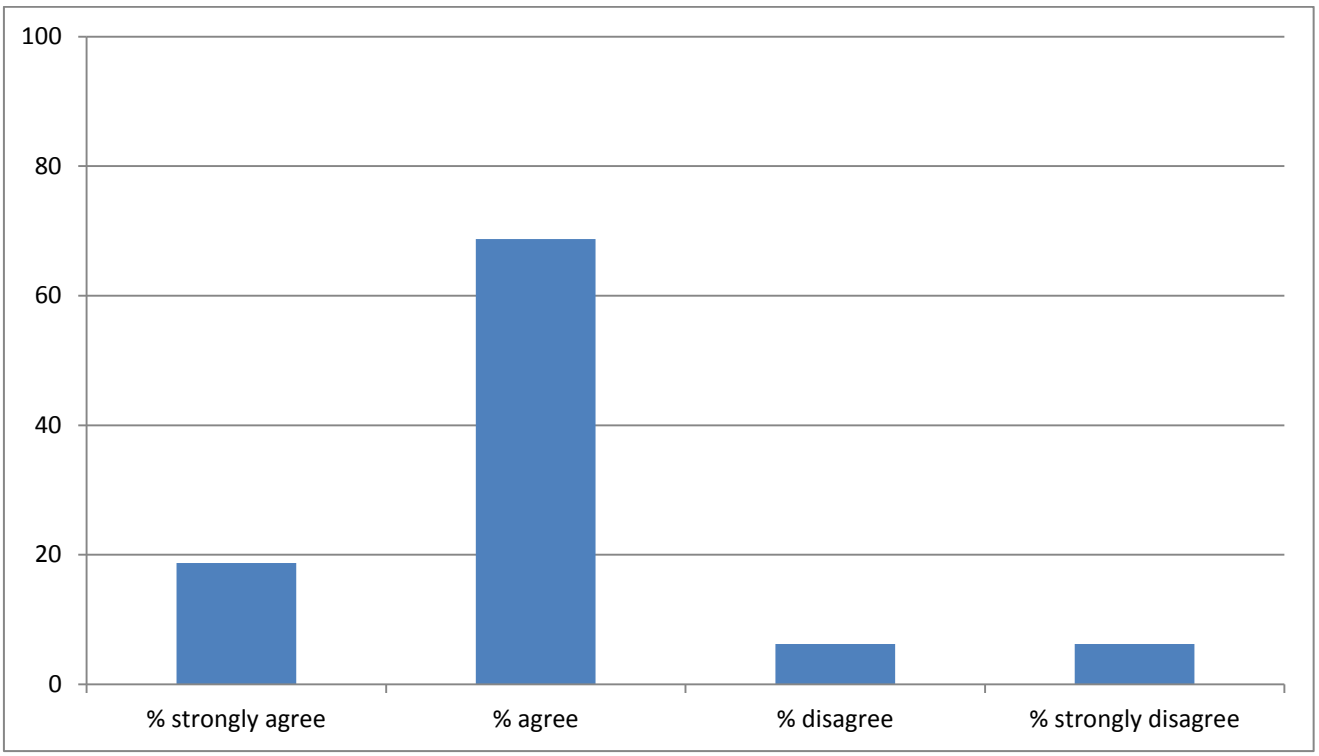



Figure 2: Response to Question 10. The aims comprehensively describe the intended learning as a result of studying the subject (n=12)

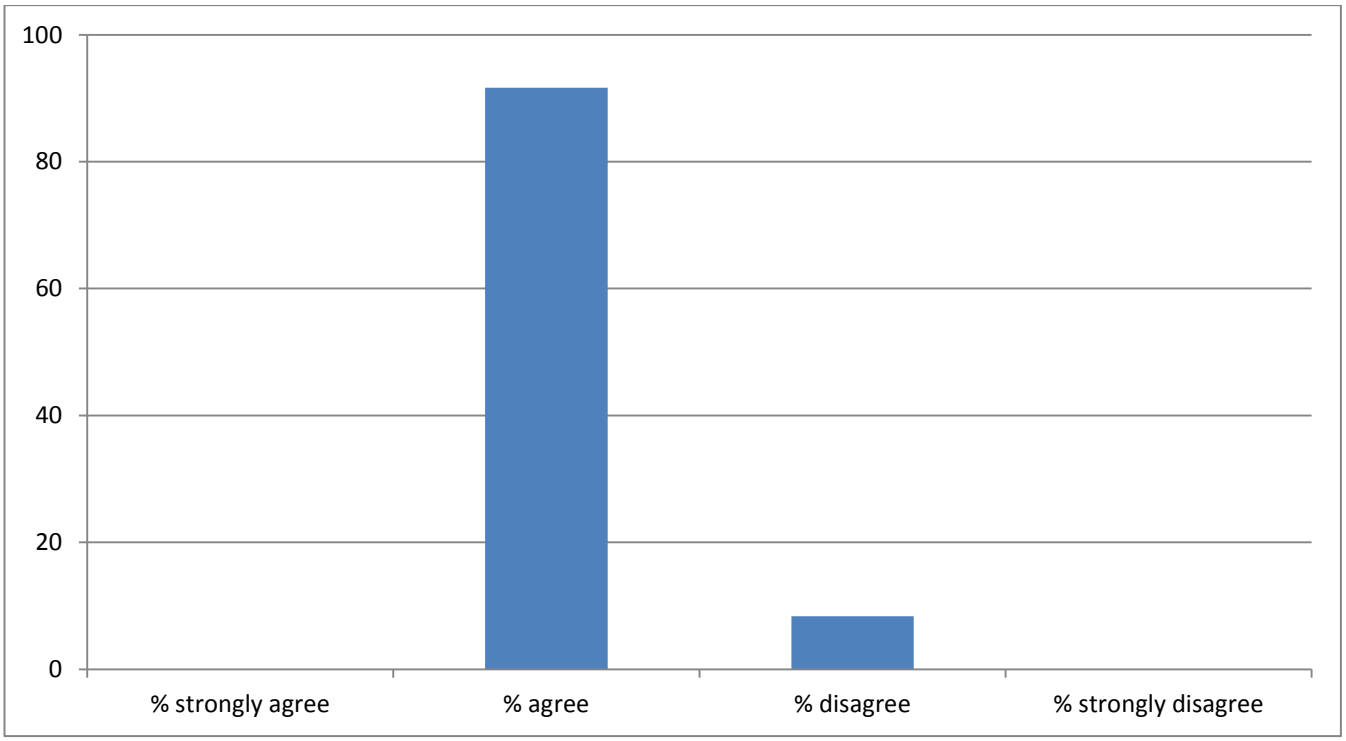


Figure 3: Response to Question 11. The four-unit structure has internal logic and coherence (n=21)

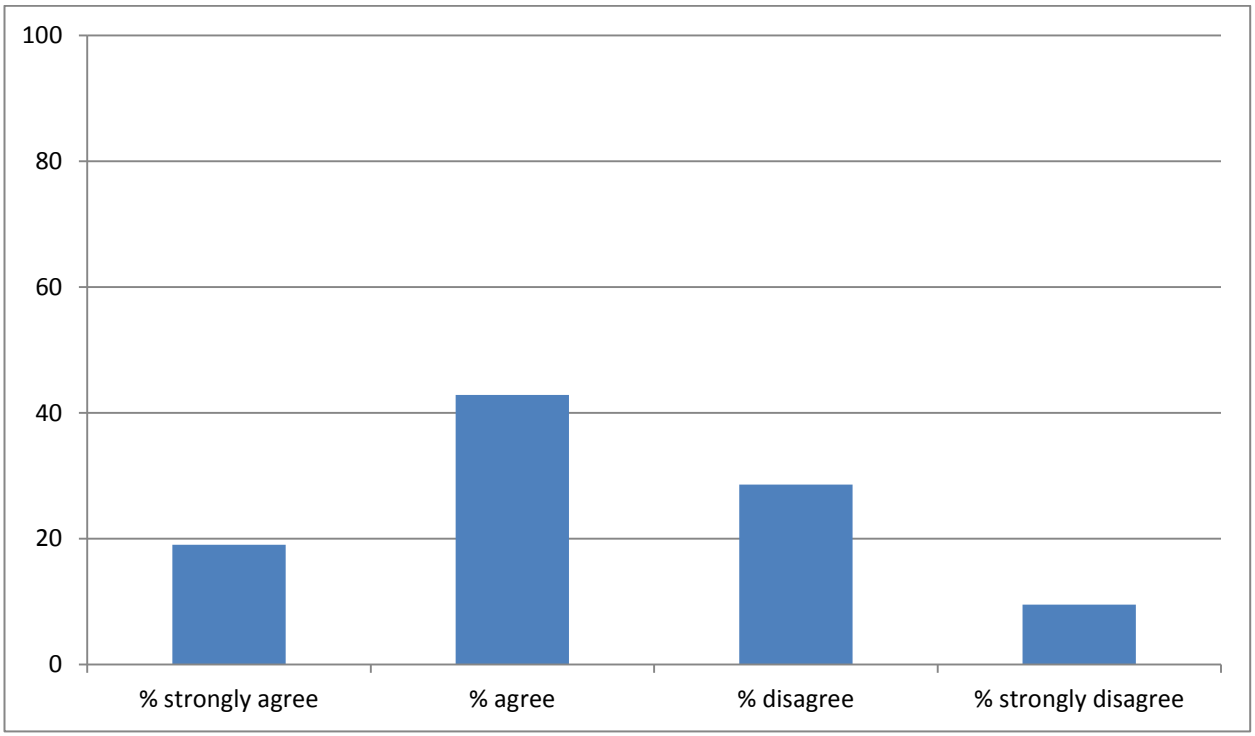



Figure 4: Response to Question 12. Units 3 and 4 are more cognitively demanding than Units 1 and 2 (n=22)

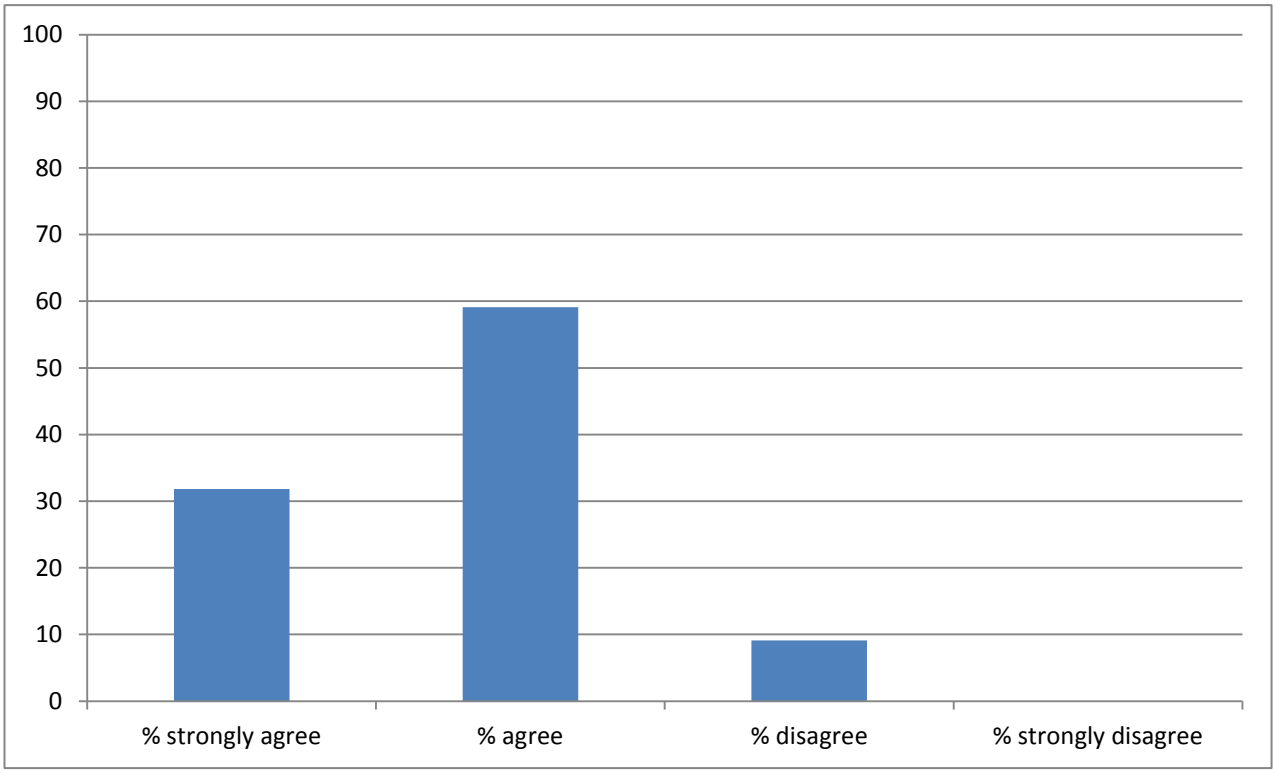


Figure 5: Response to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum (n=21)

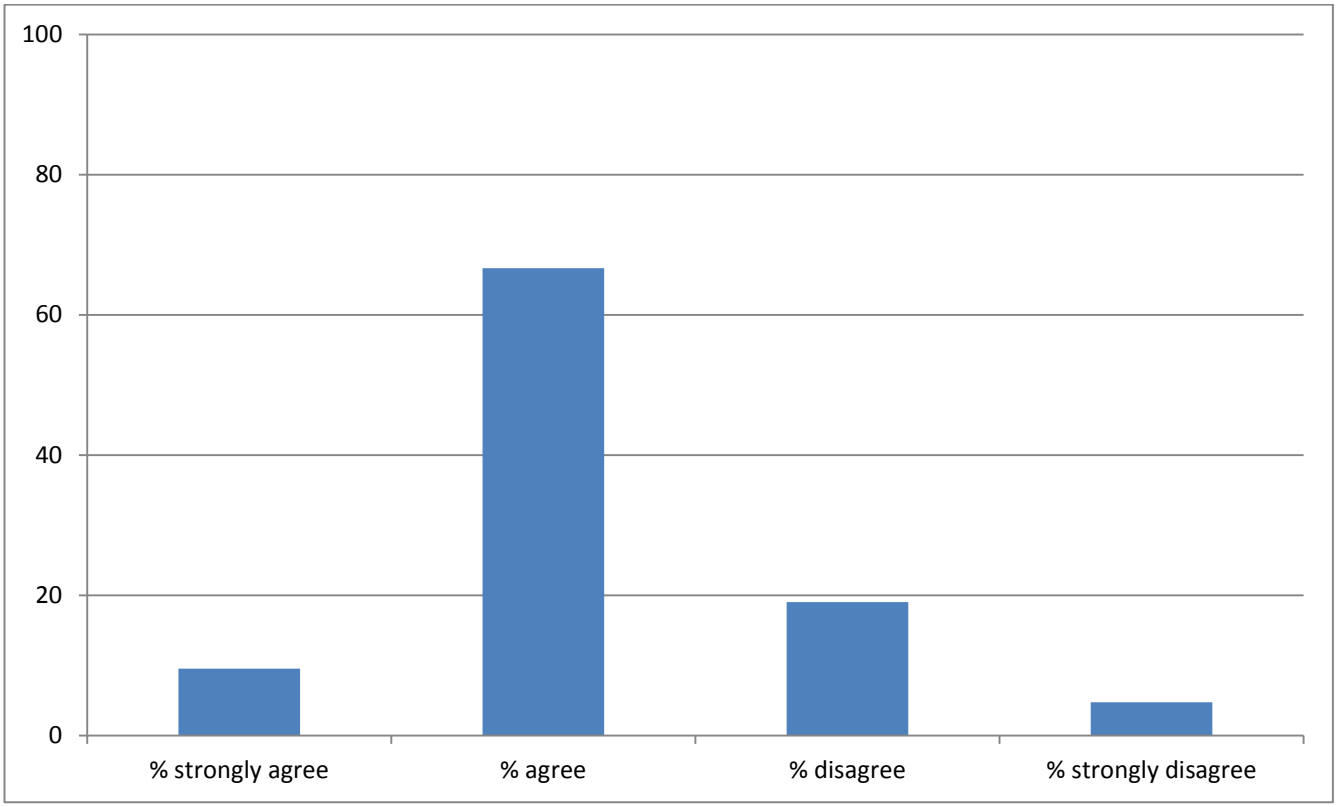



Figure 6: Response to Question 14. The achievement standards across Units 1 and 2 and Units 3 and 4 are organised in an order consistent with your experience (n=21)

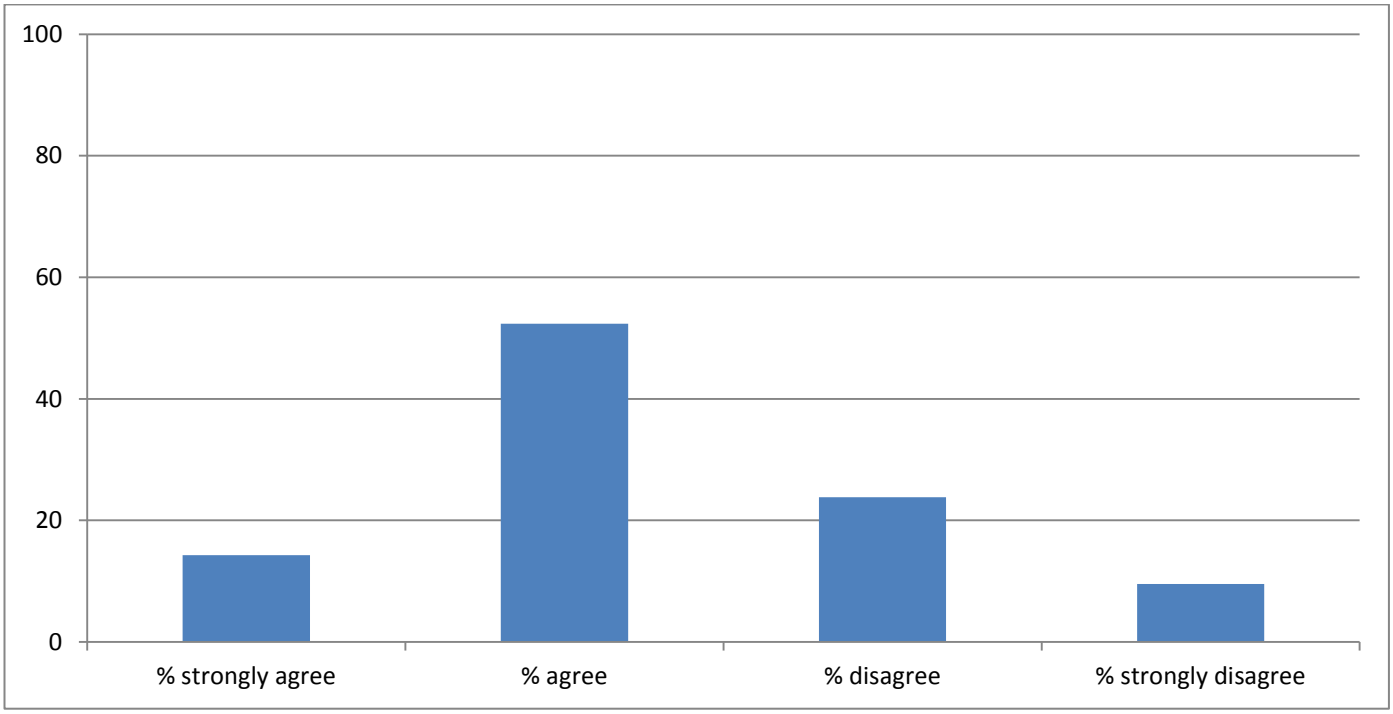


Figure 7: Response to Question 15. The unit description describes the focus and scope for this unit (n=21)

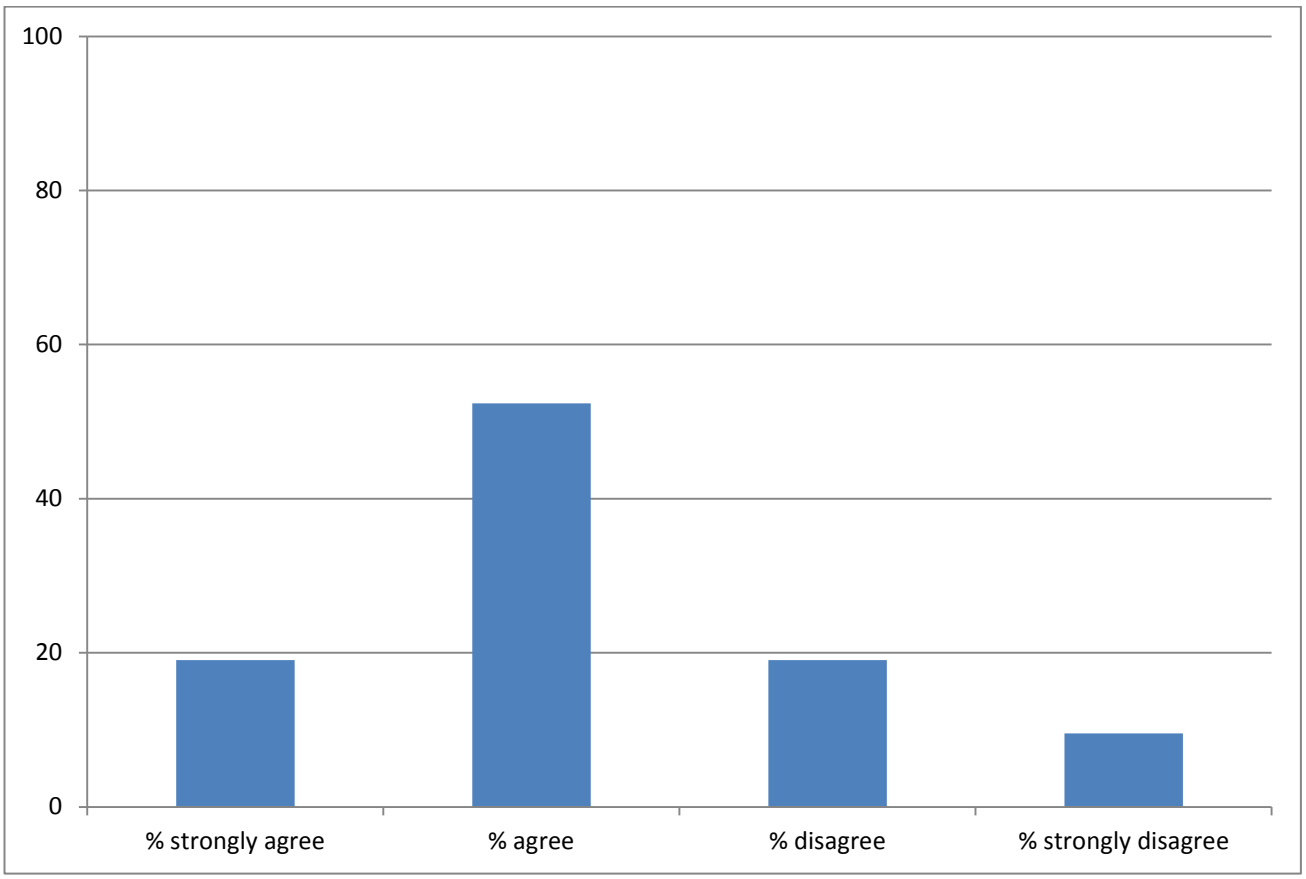



Figure 8: Response to Question 16. The outcomes describe clearly the expected learning for this unit (n=21)

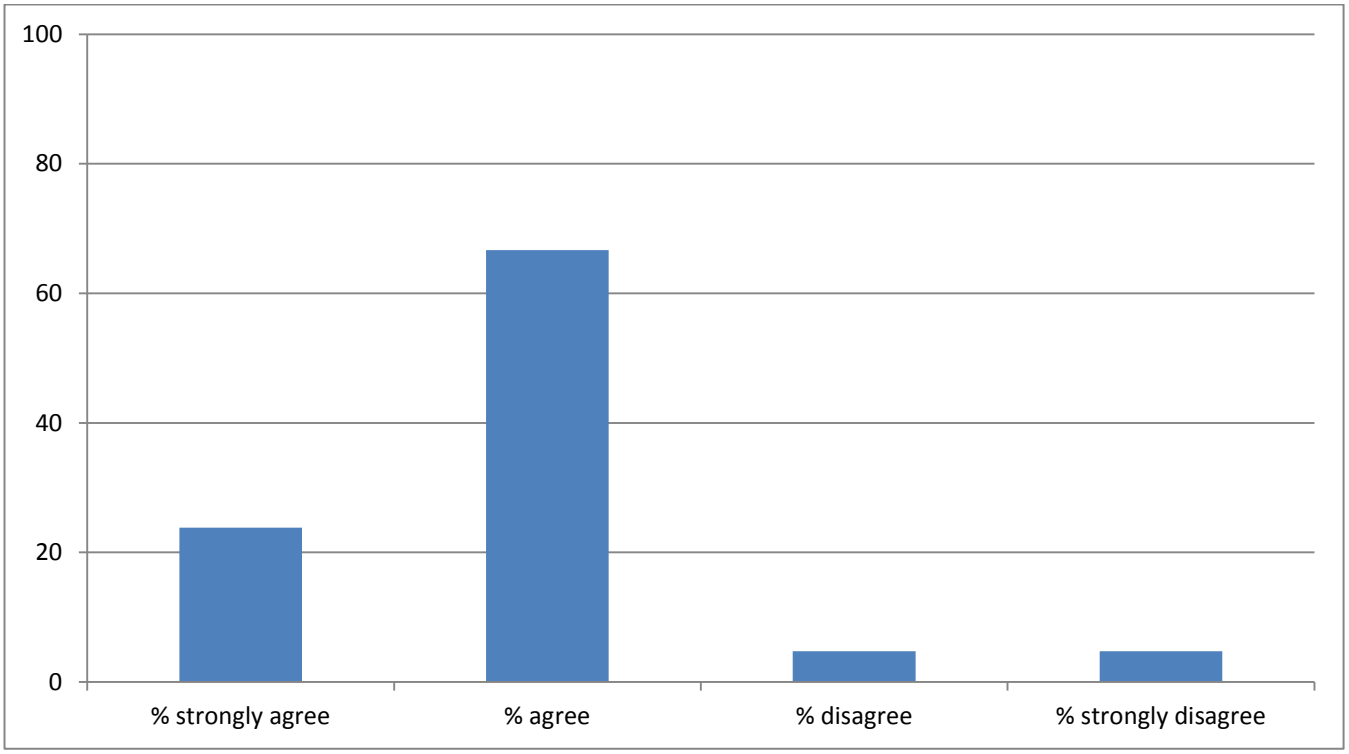


Figure 9: Response to Question 17. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=21)

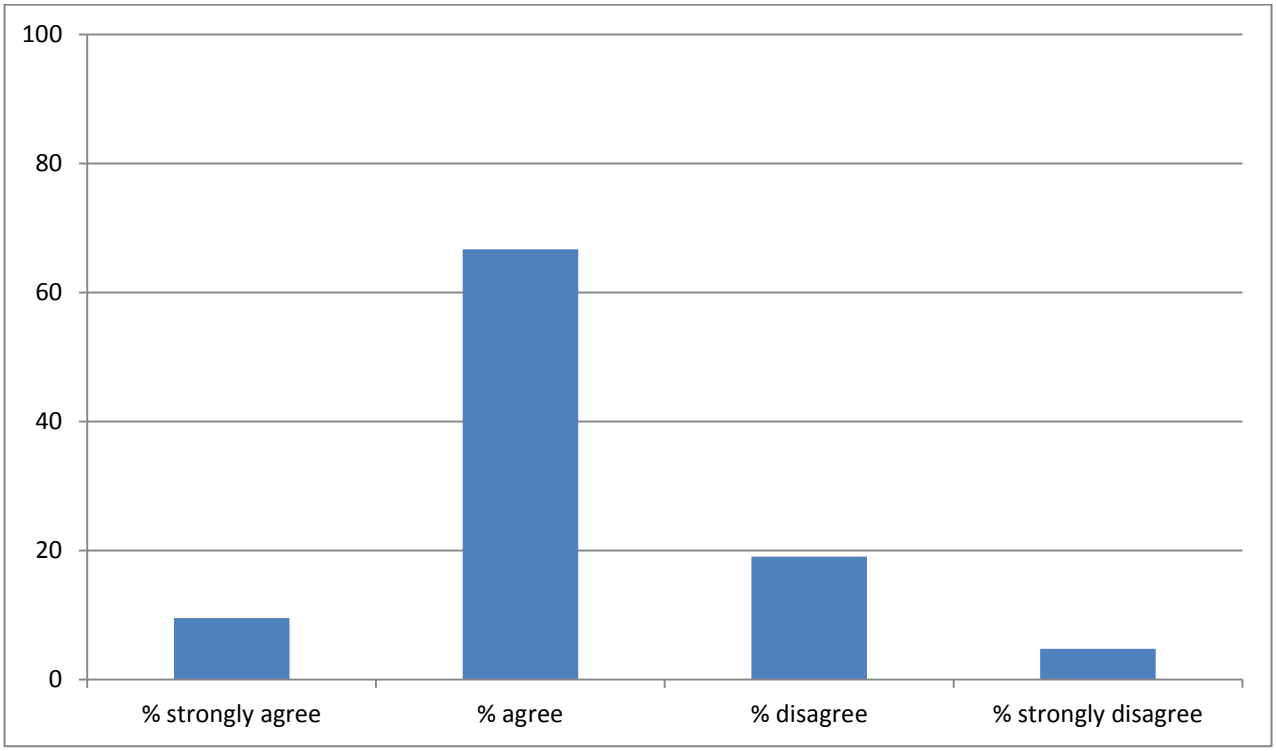



Figure 10: Response to Question 18. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=21)

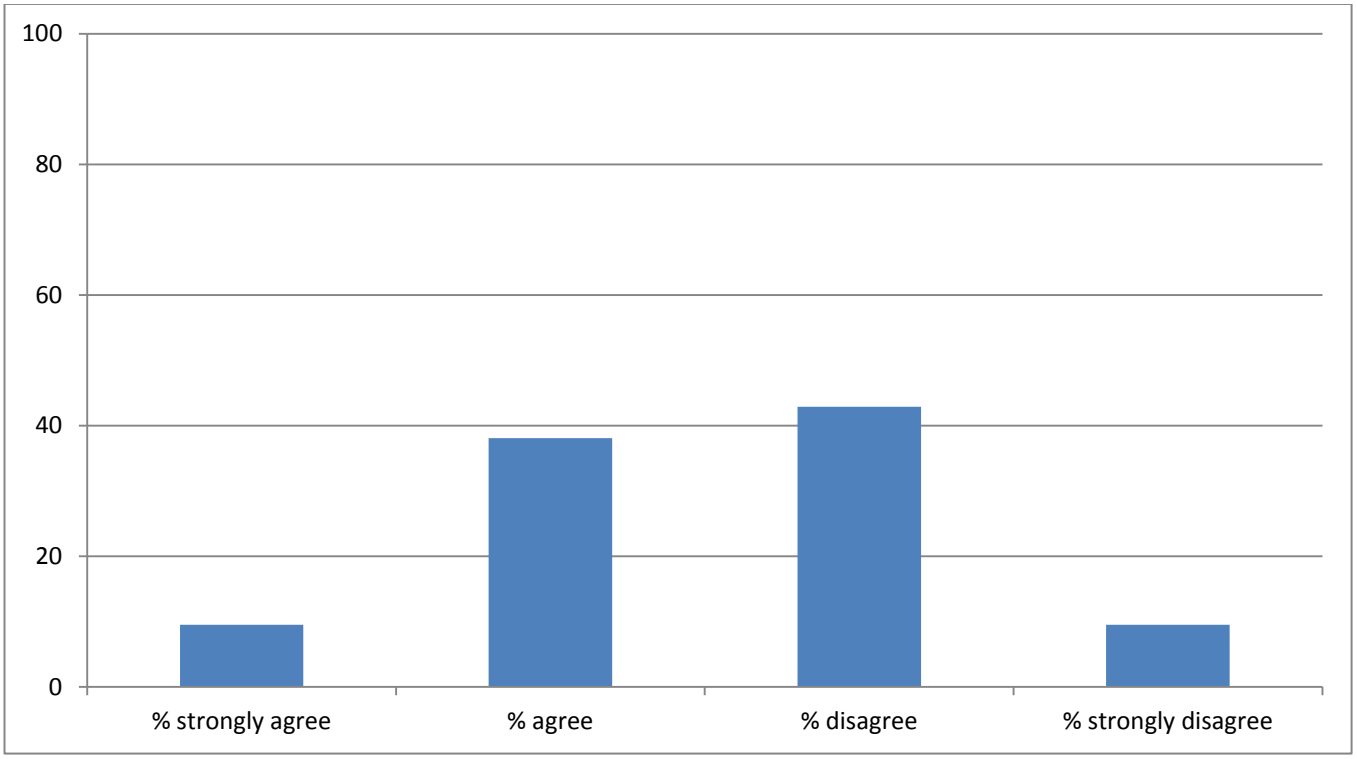


Figure 11: Response to Question 19. The content descriptions are specific about what is to be taught (n=21)

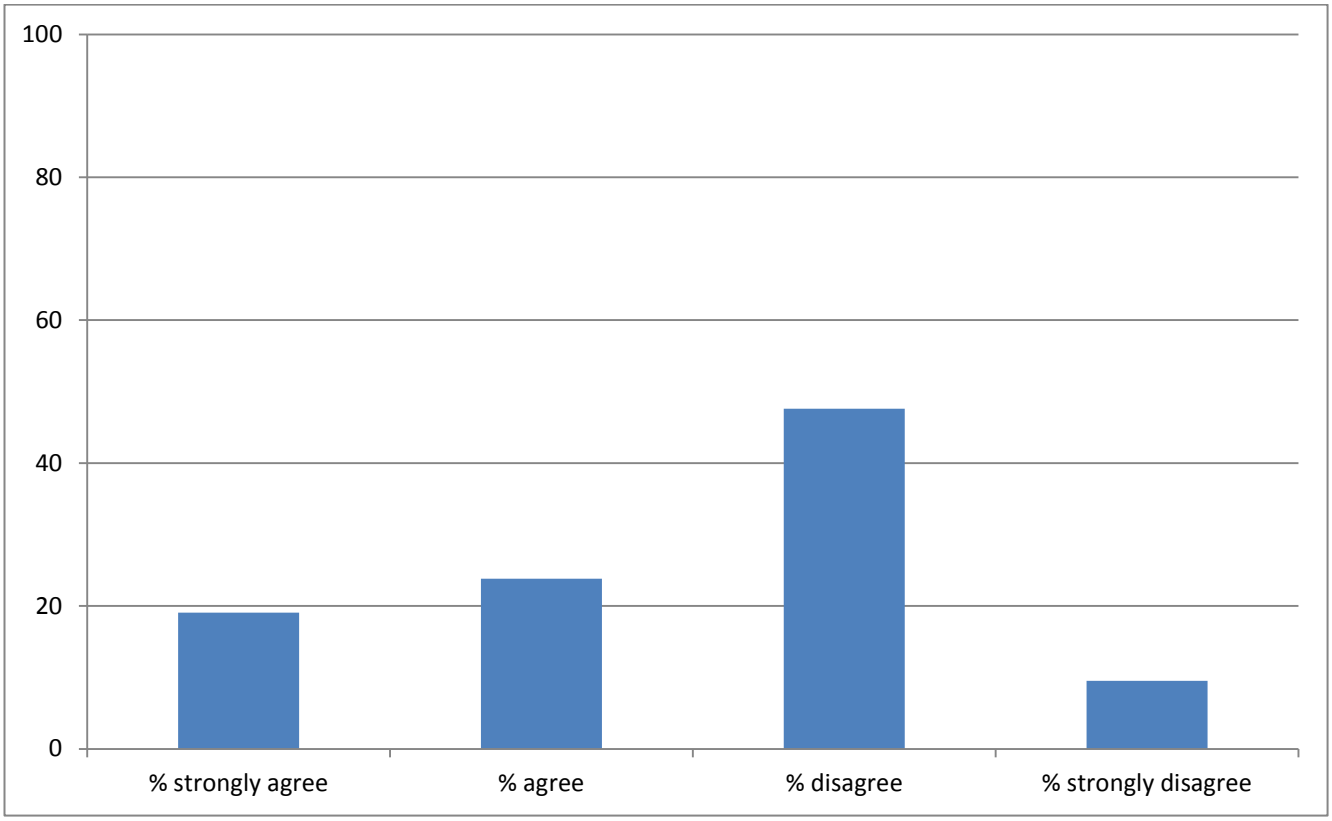



Figure 12: Response to Question 20. Unit 2: The unit description clearly describes the focus and scope for this unit (n=20)

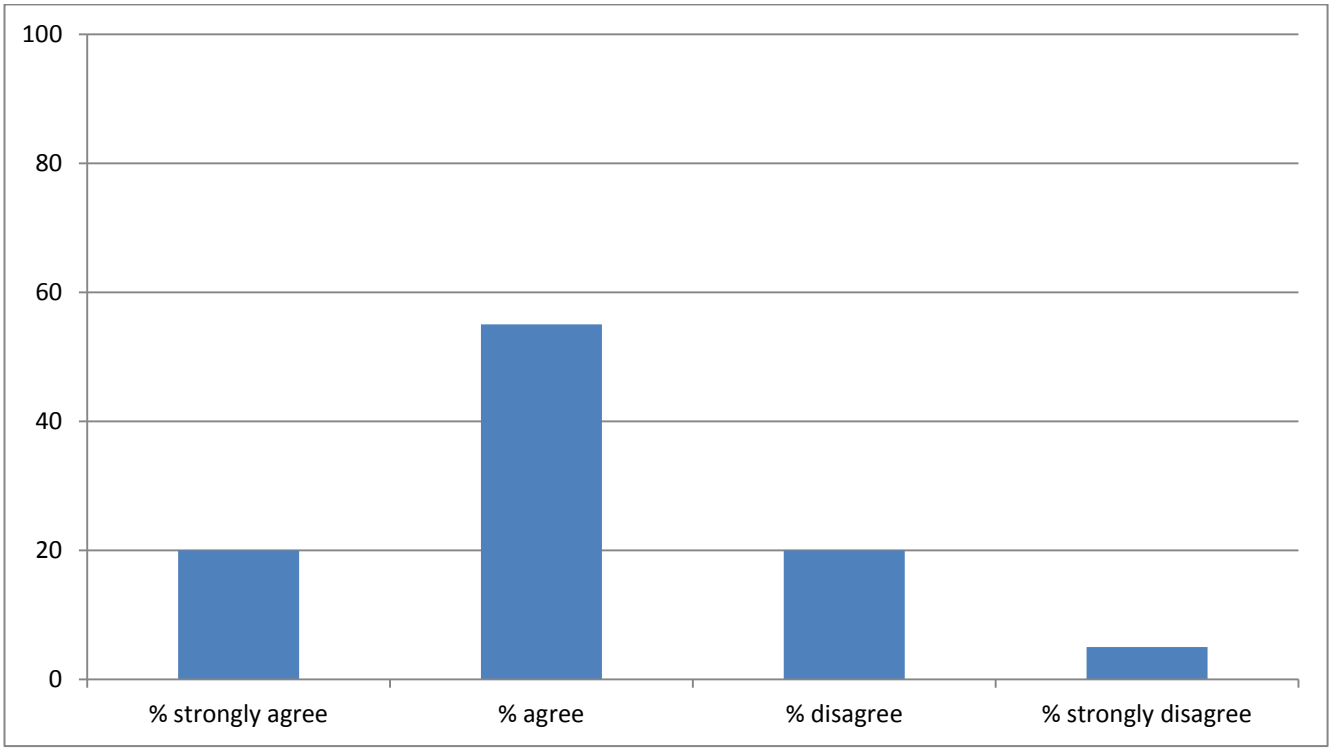


Figure 13: Response to Question 21. The unit outcomes describe clearly the expected learning for this unit (n=20)

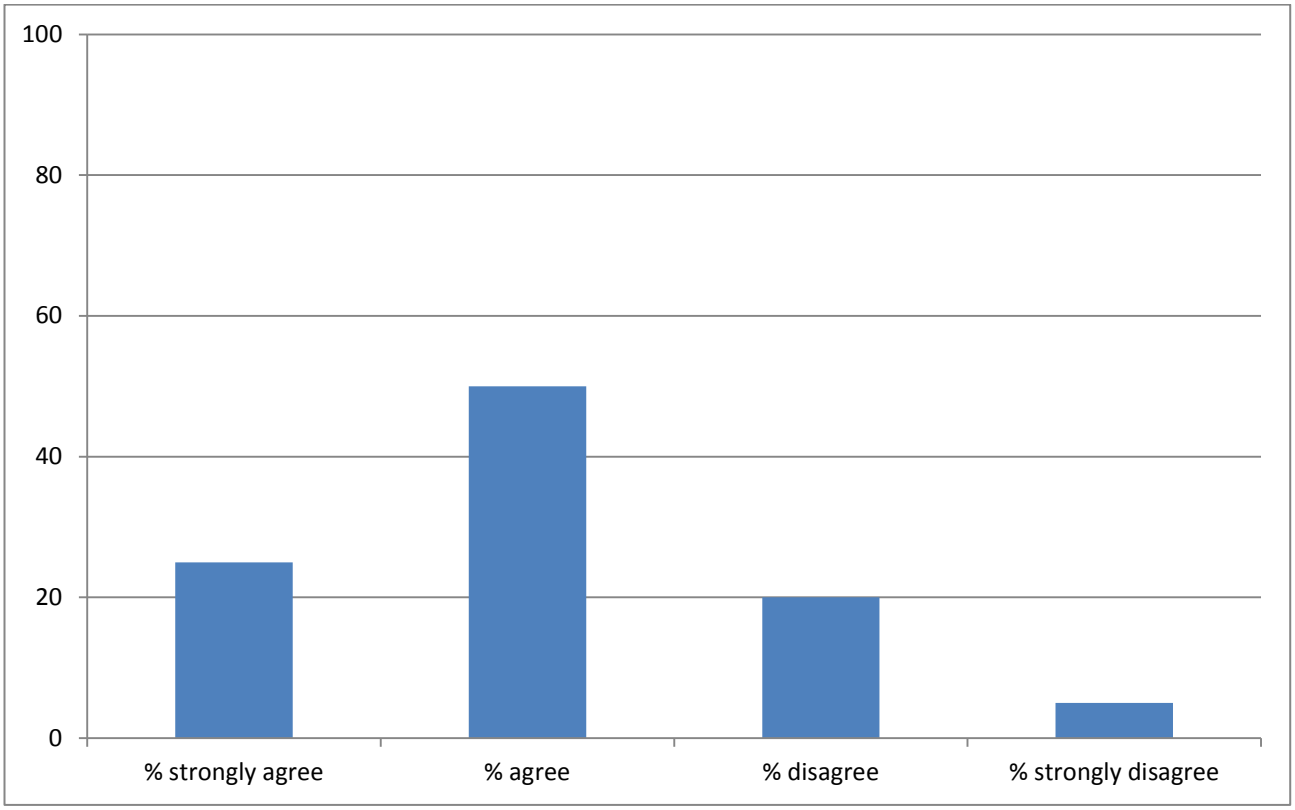



Figure 14: Response to Question 22. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=20)

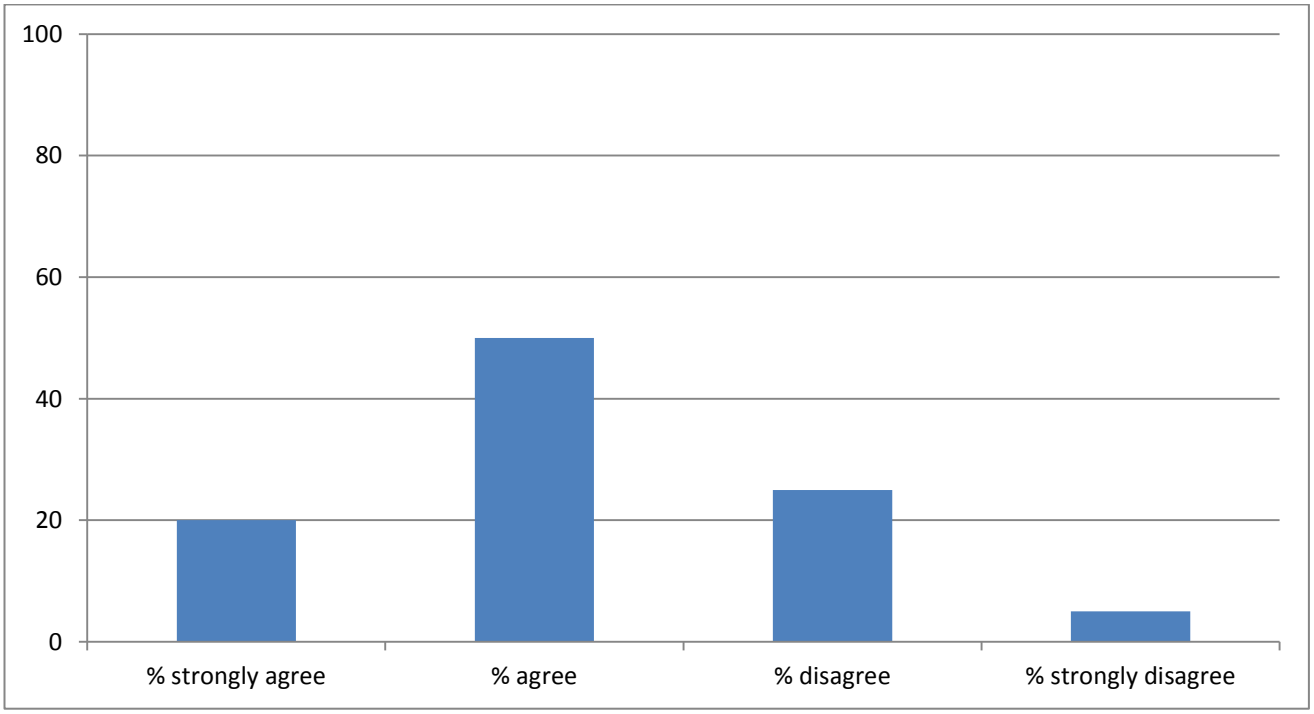


Figure 15: Response to Question 23. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=20)

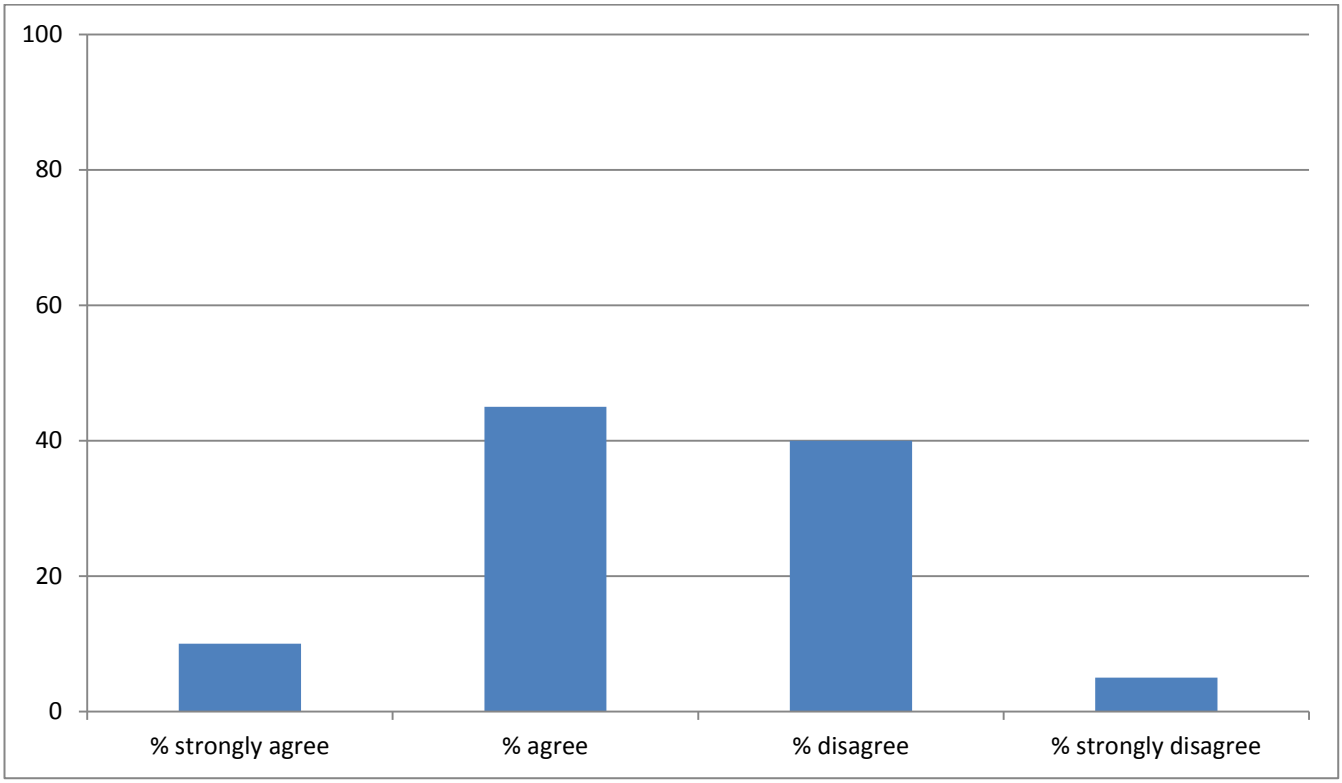



Figure 16: Response to Question 24. The content descriptions are specific about what is to be taught (n=20)

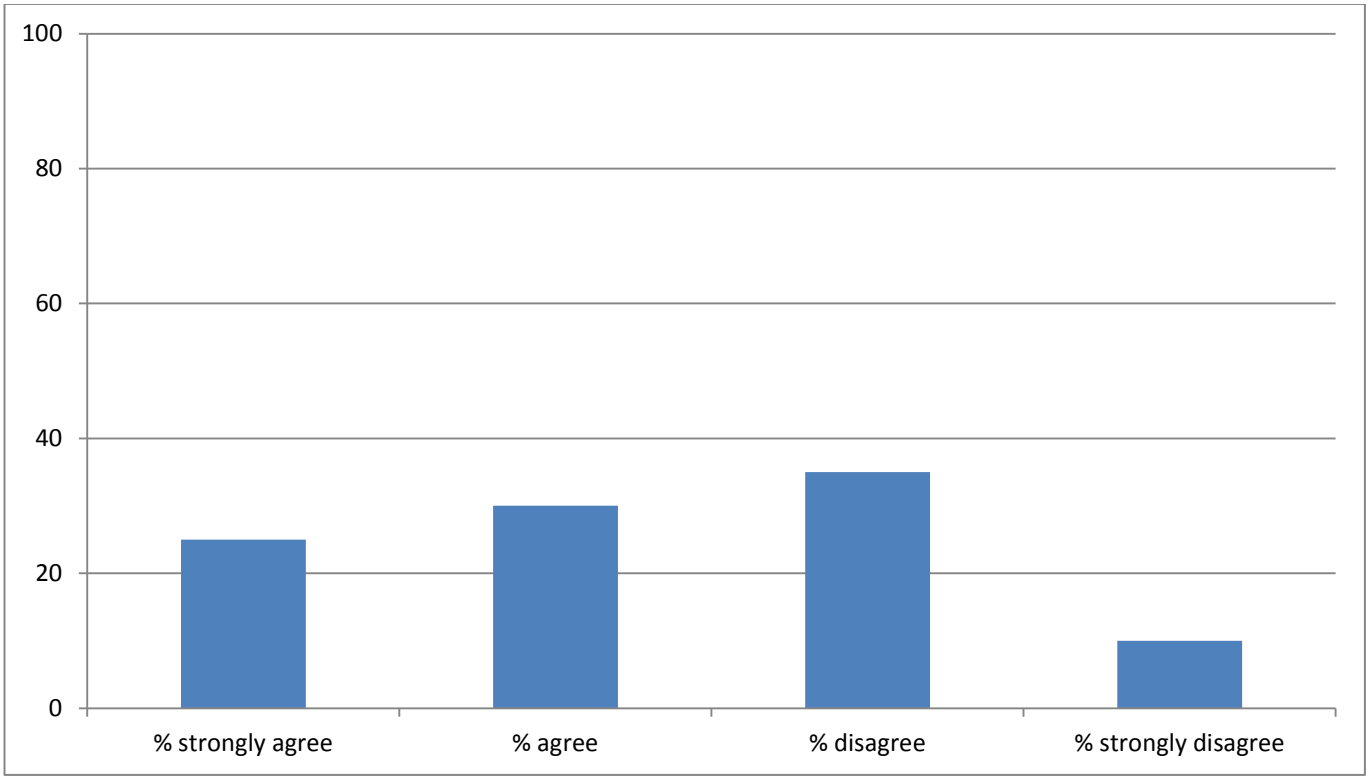


Figure 17: Reponse to Question 25. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=19)

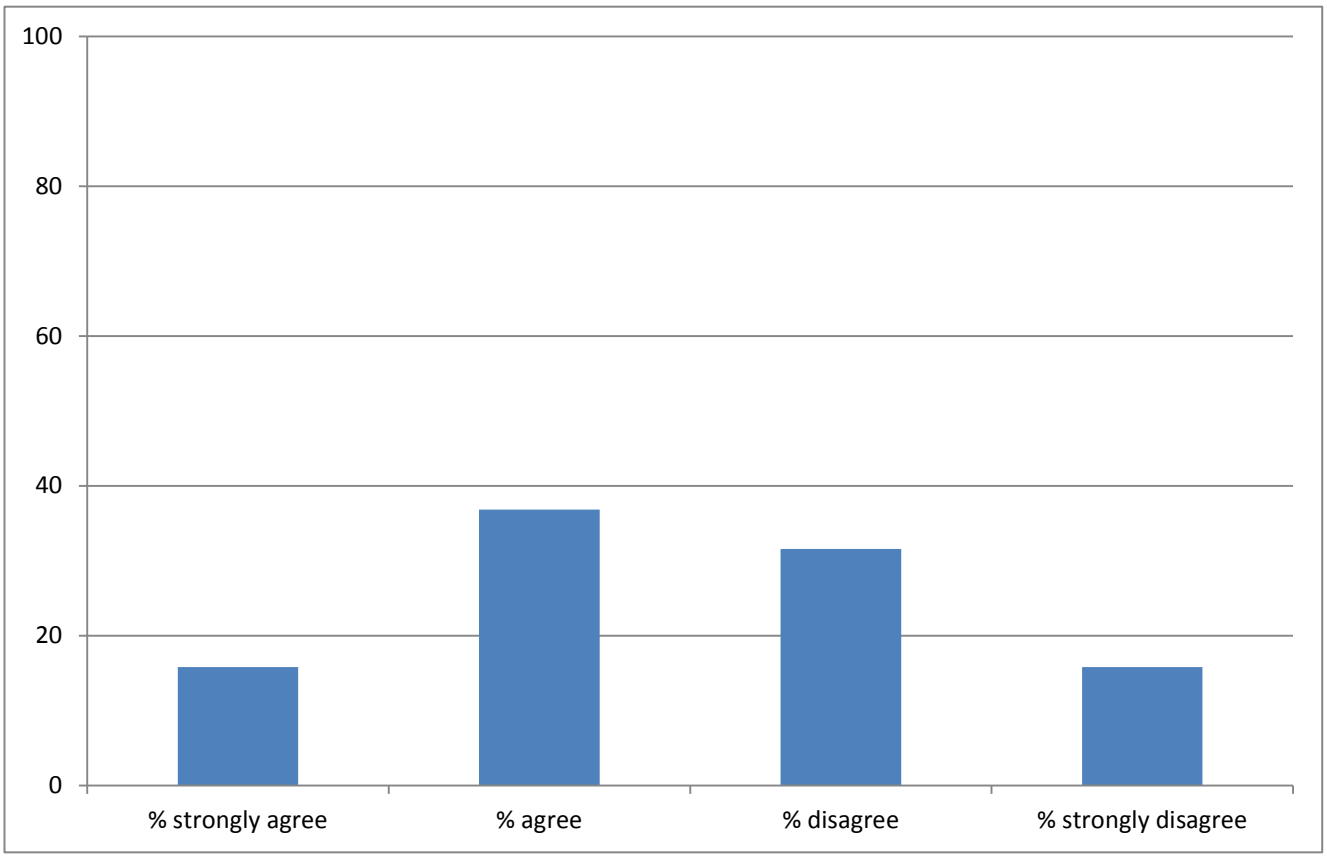



Figure 18: Response to Question 26. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=19)

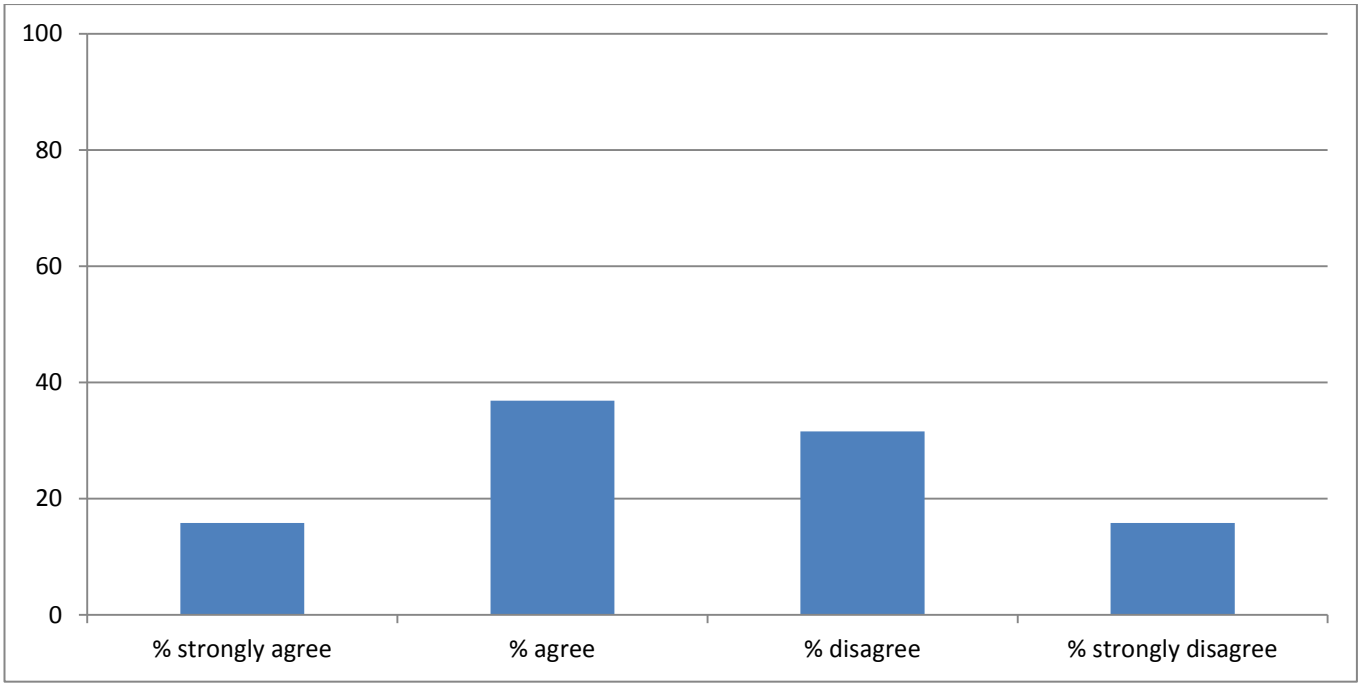


Figure 19: Response to Question 27. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=18)

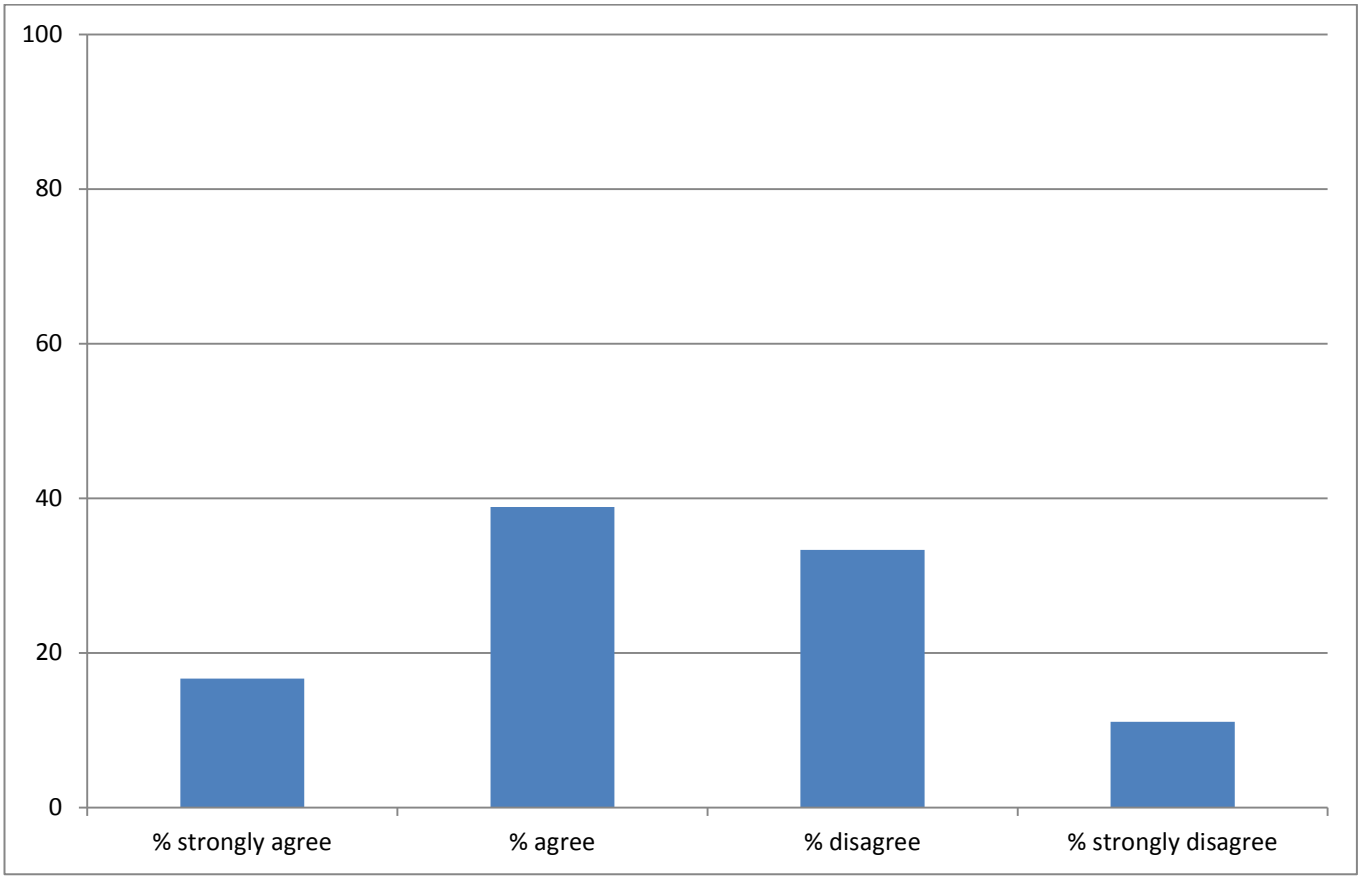



Figure 20: Response to Question 28. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=19)

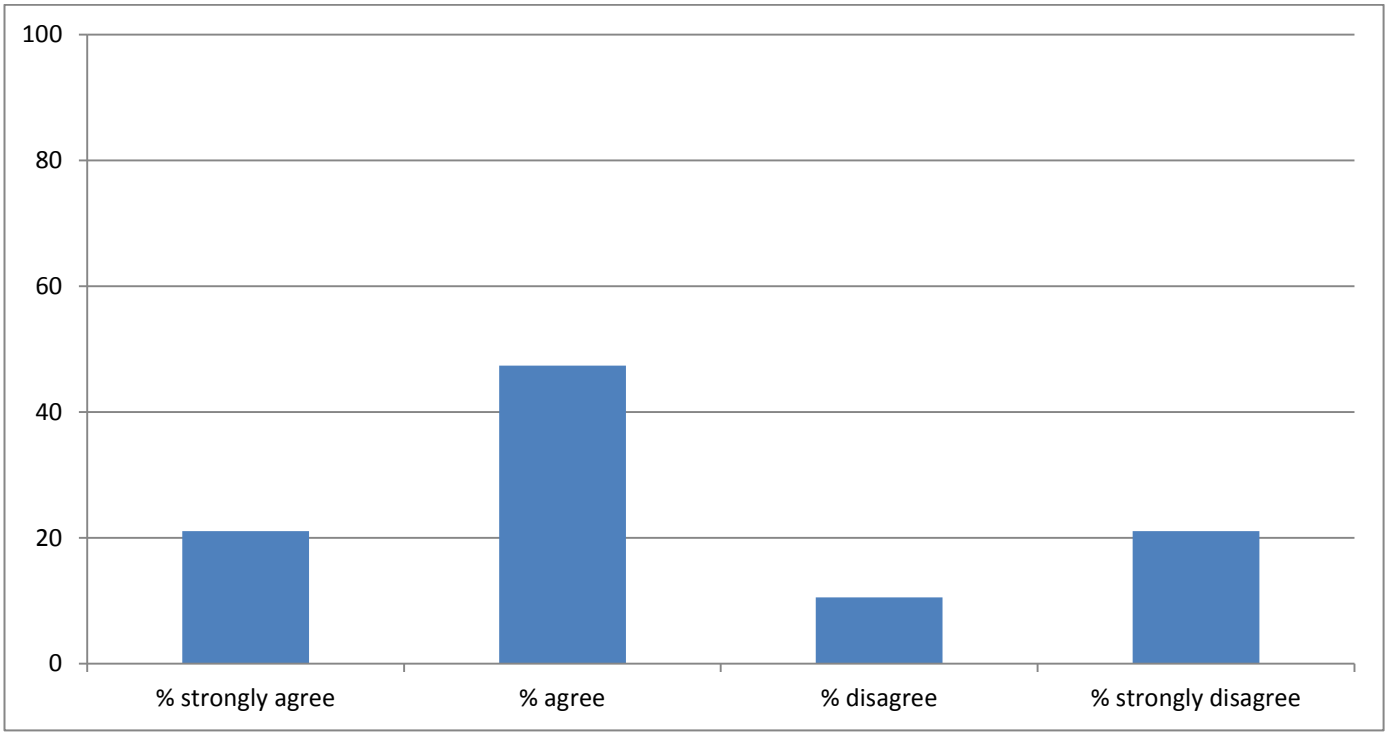


Figure 21: Response to Question 29. Unit 3: The unit description clearly describes the focus and scope for this unit (n=21)

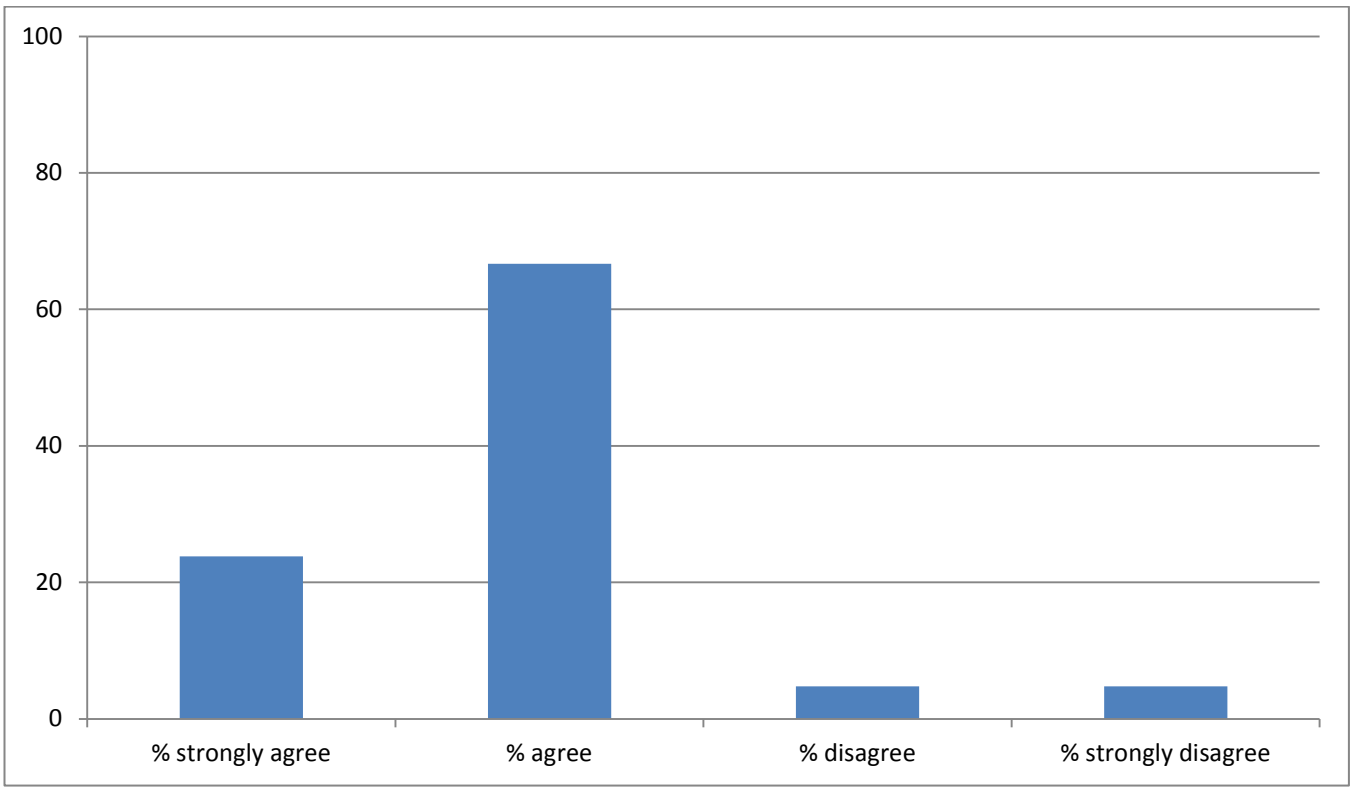



Figure 22: Response to Question 30. Unit 3: The unit outcomes describe clearly the expected learning for this unit (n=21)

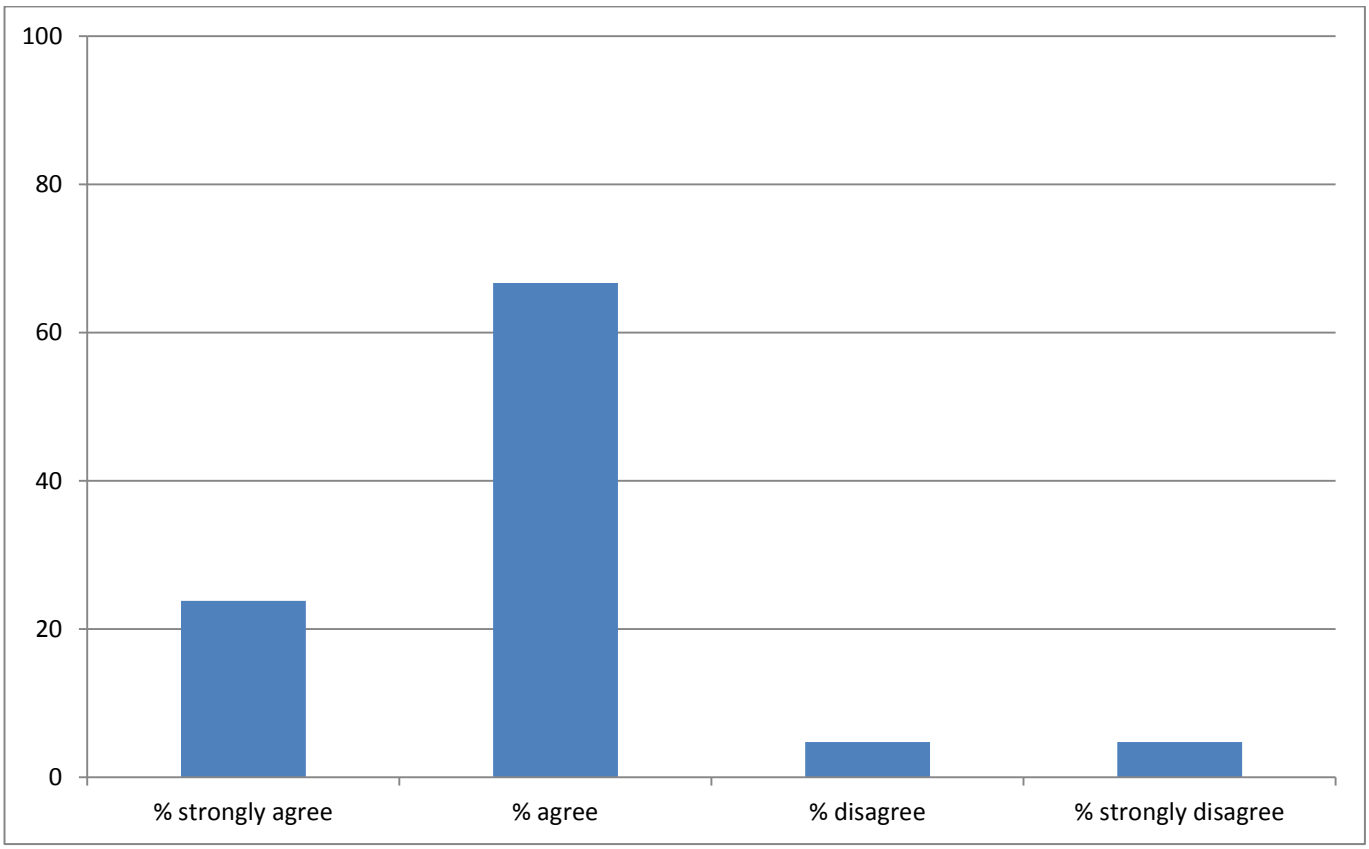


Figure 23: Response to Question 31. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=21)

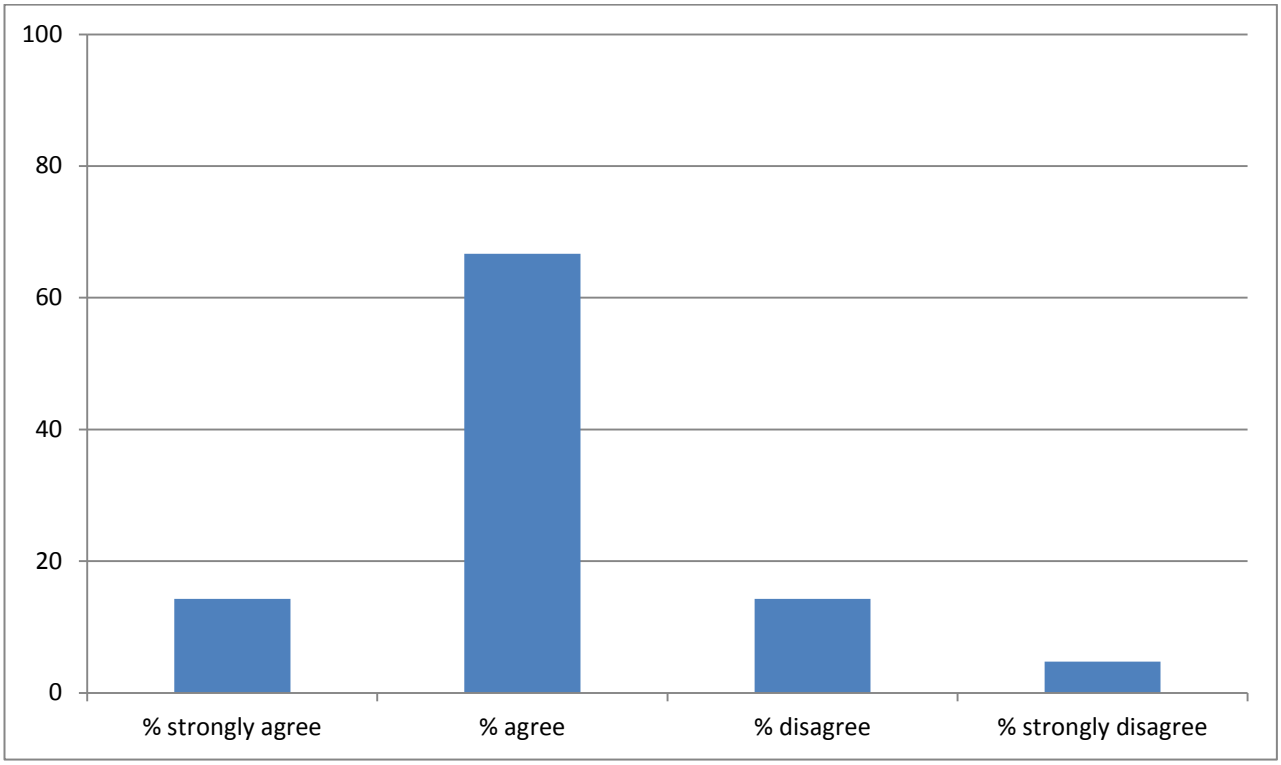



Figure 24: Response to Question 32. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=21)

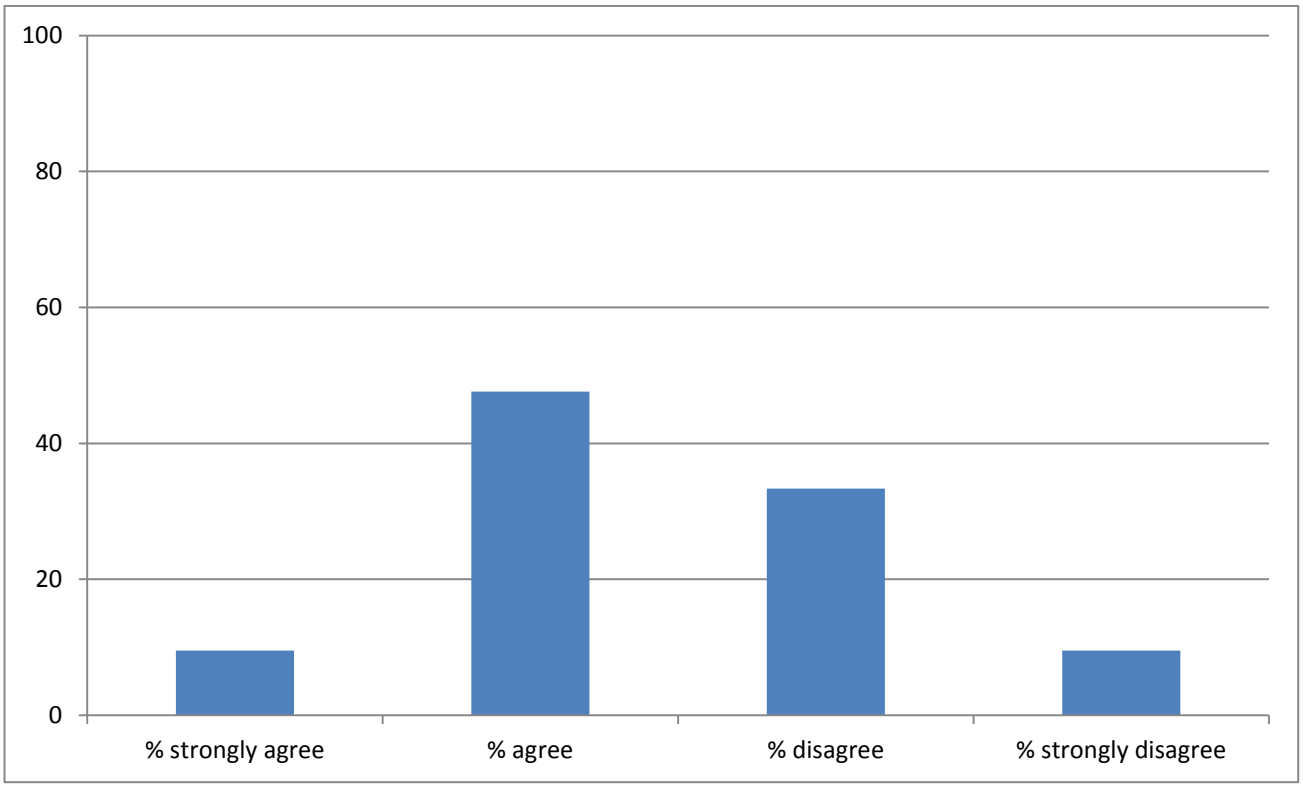


Figure 25: Response to Question 33. The content descriptions are specific about what is to be taught (n=21)

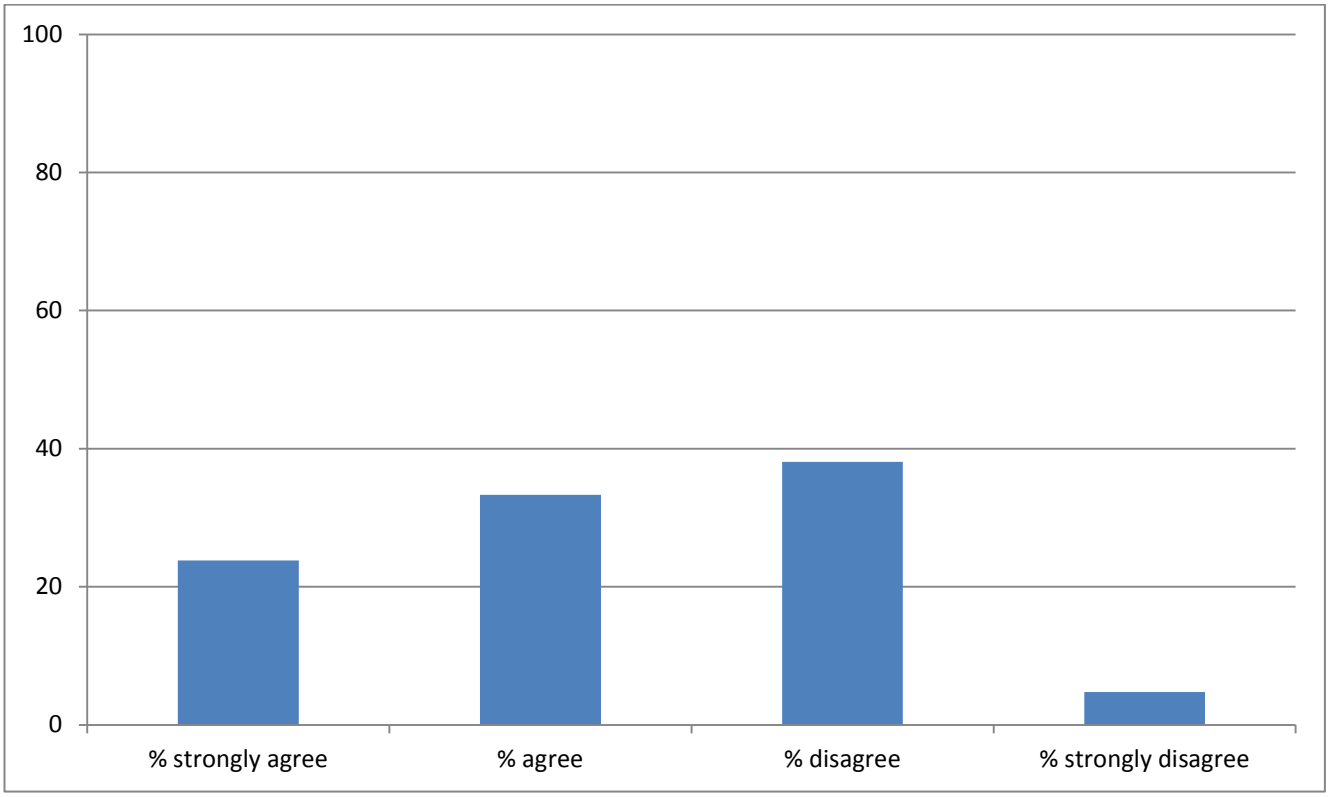



Figure 26: Response to Question 34. Unit 4: The unit description clearly describes the focus and scope for this unit (n=21)

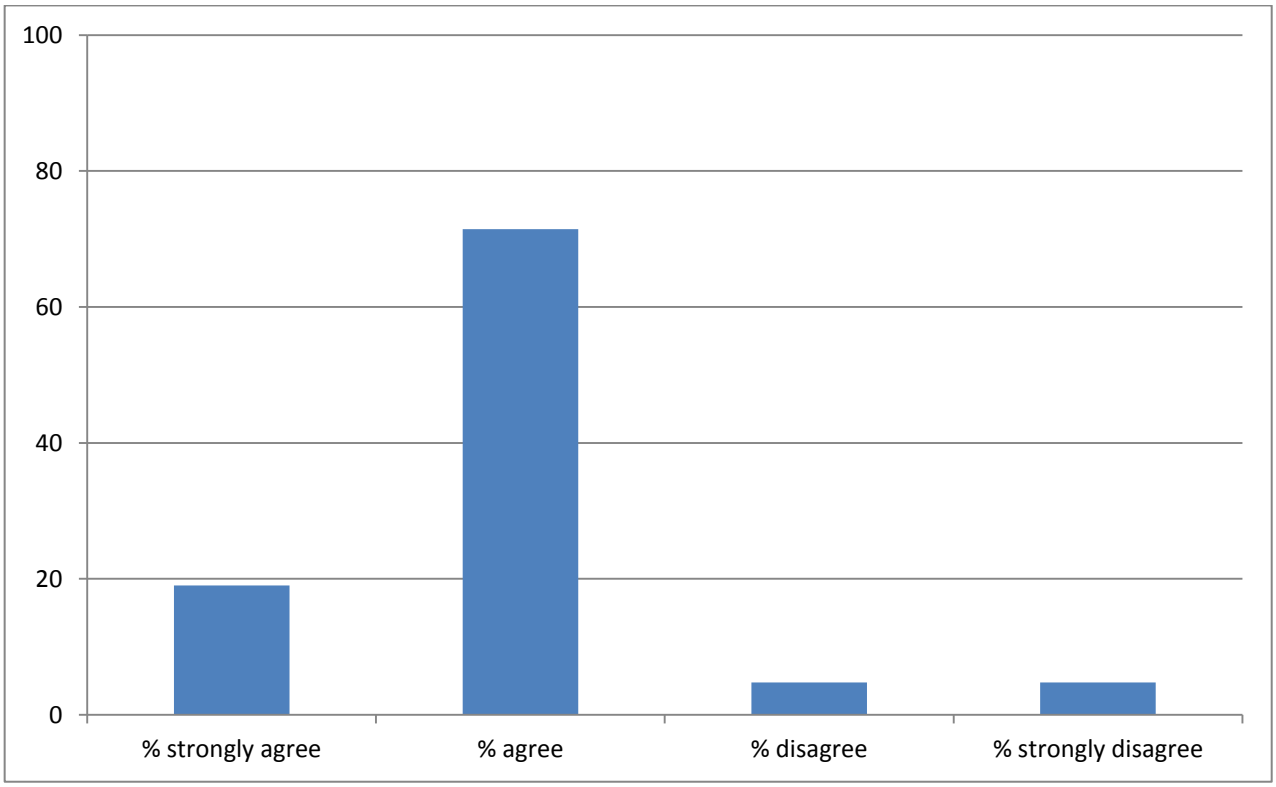


Figure 27: Response to Question 35. The unit outcomes describe clearly the expected learning for this unit (n=20)

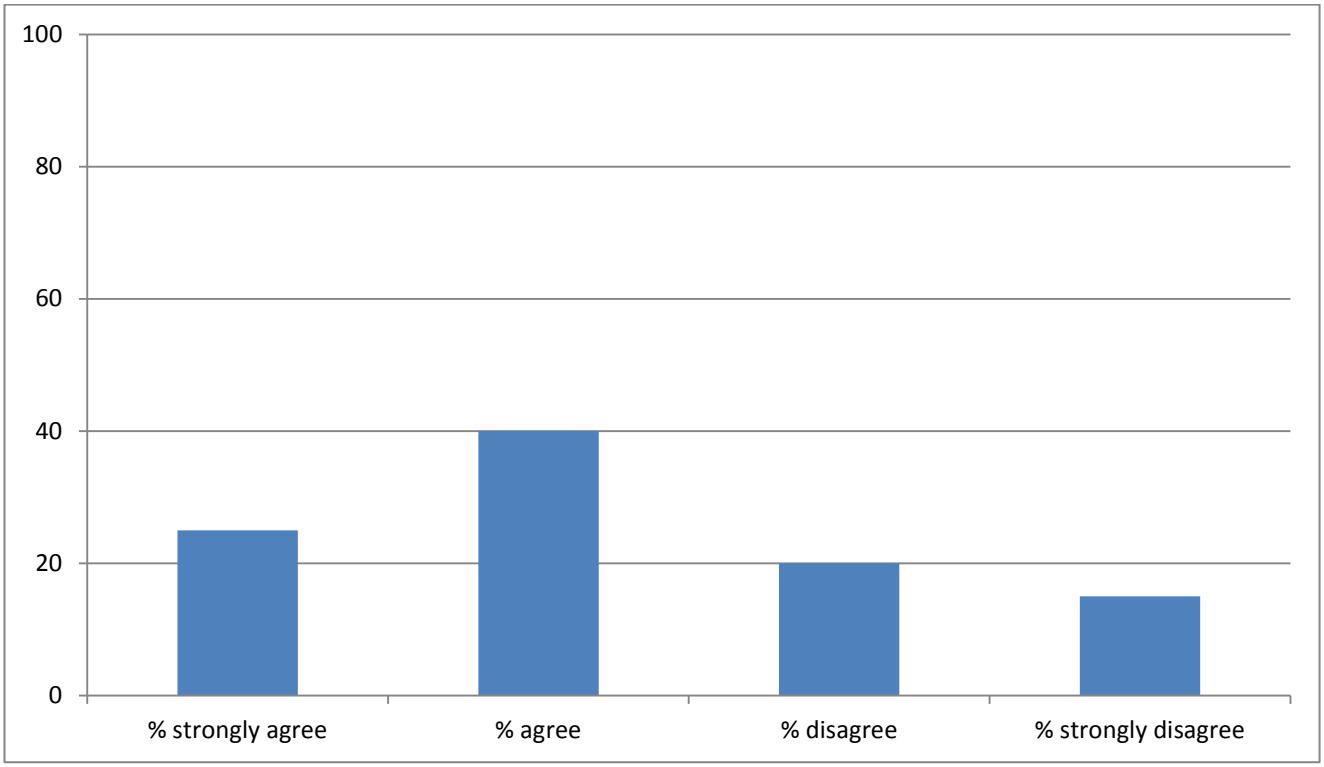



Figure 28: Response to Question 36. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=21)

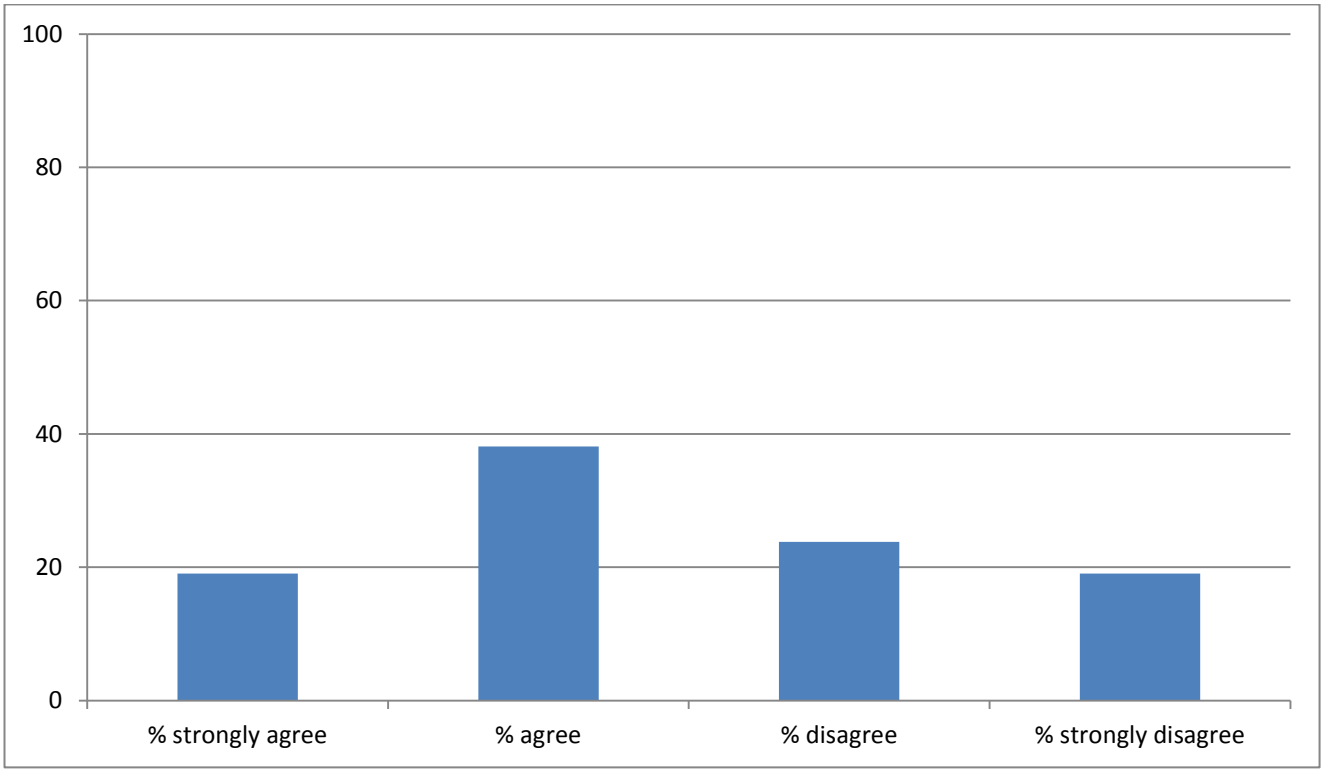


Figure 29: Response to Question 37. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=21)

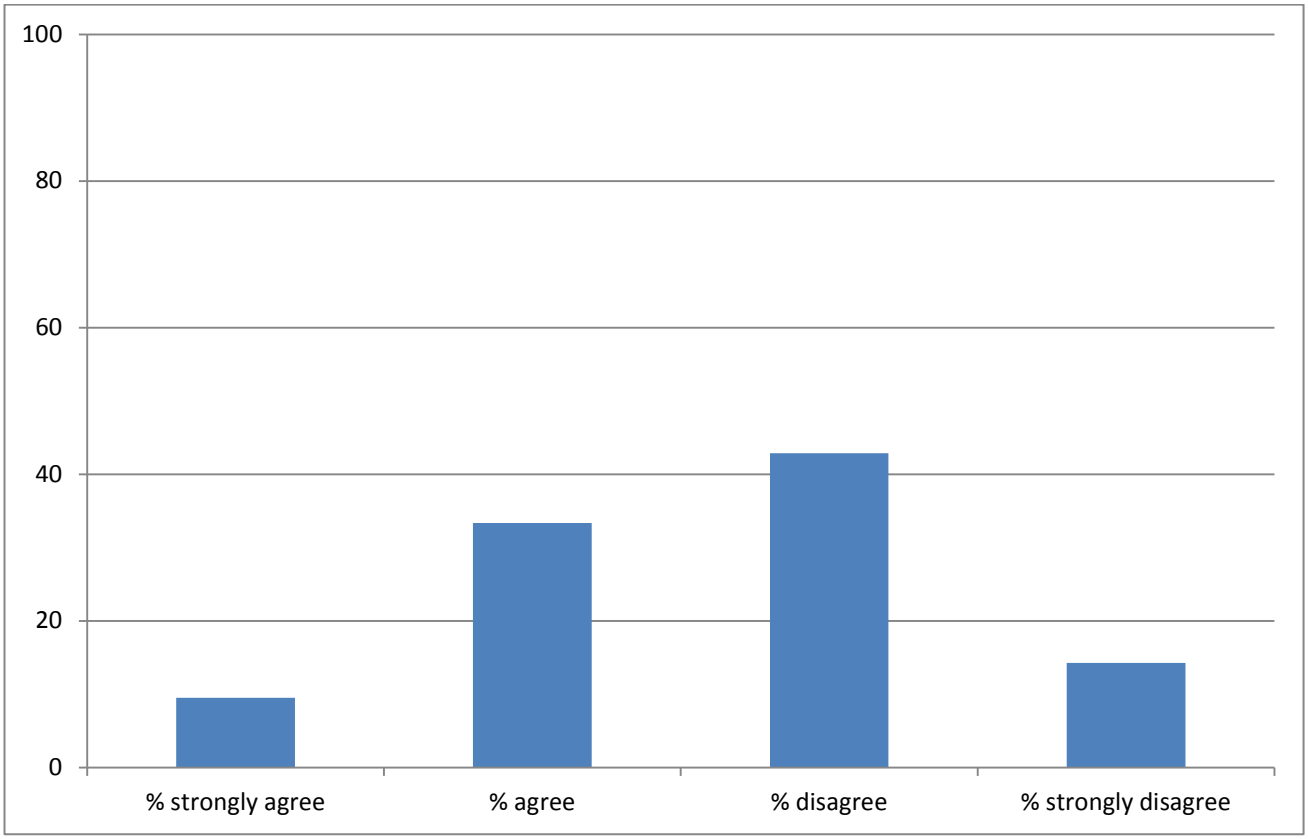
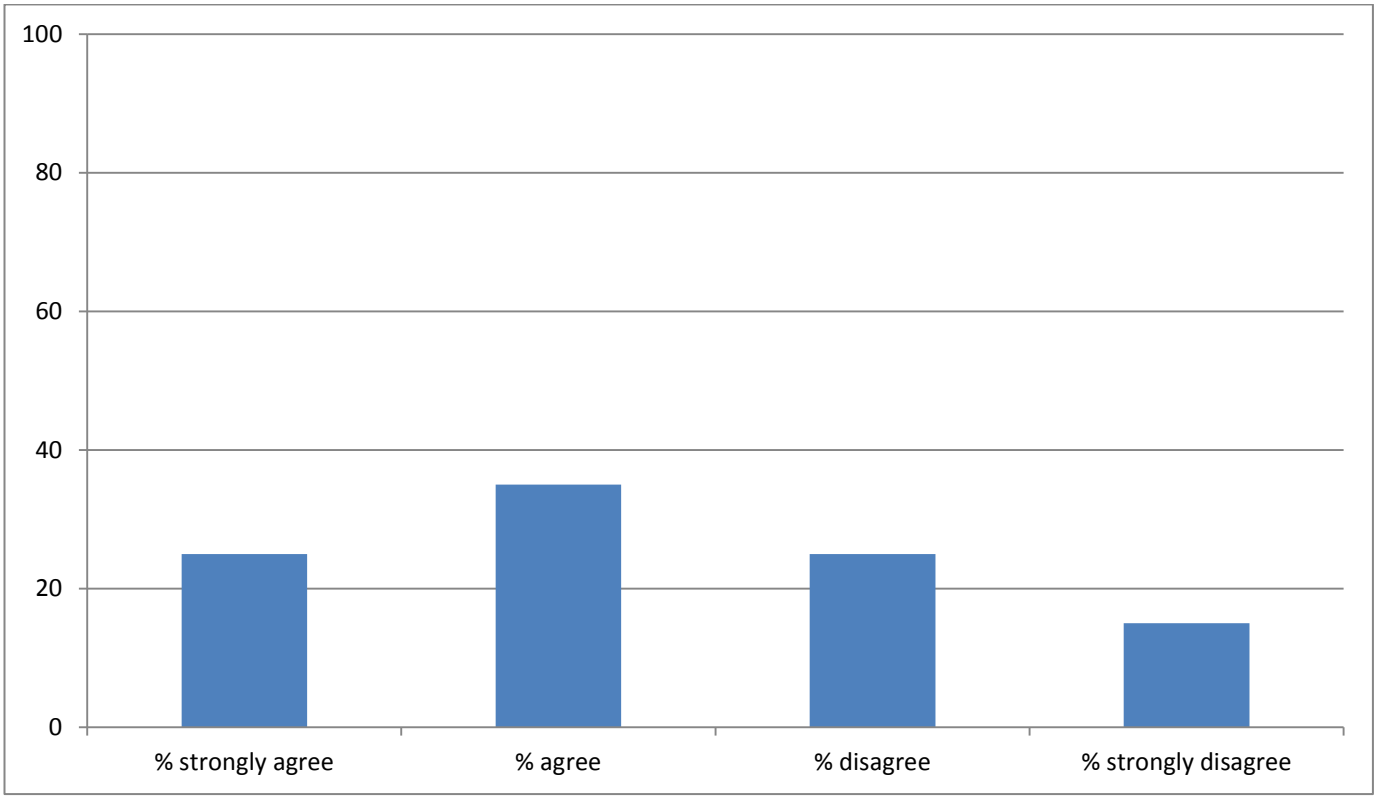



Figure 30: Response to Question 38. The content descriptions are specific about what is to be taught (n=20)



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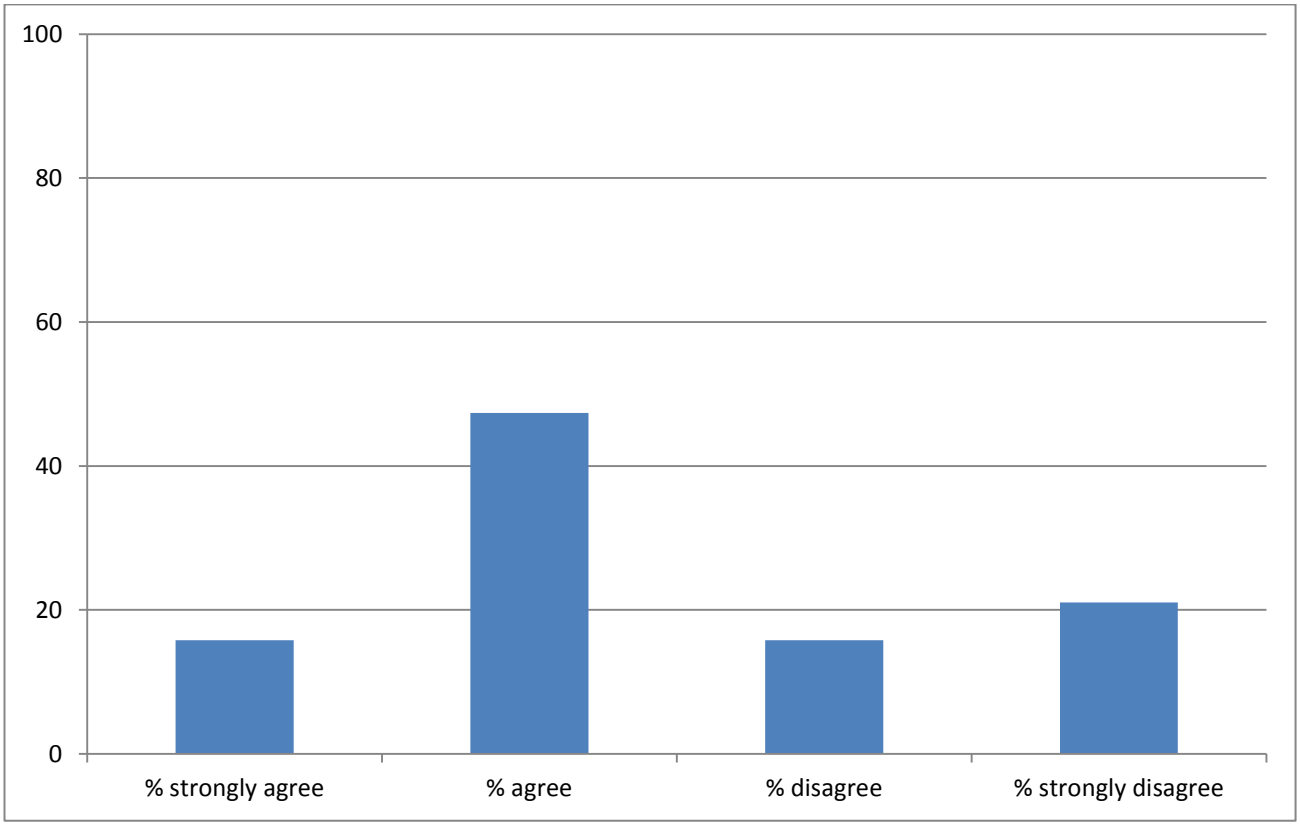


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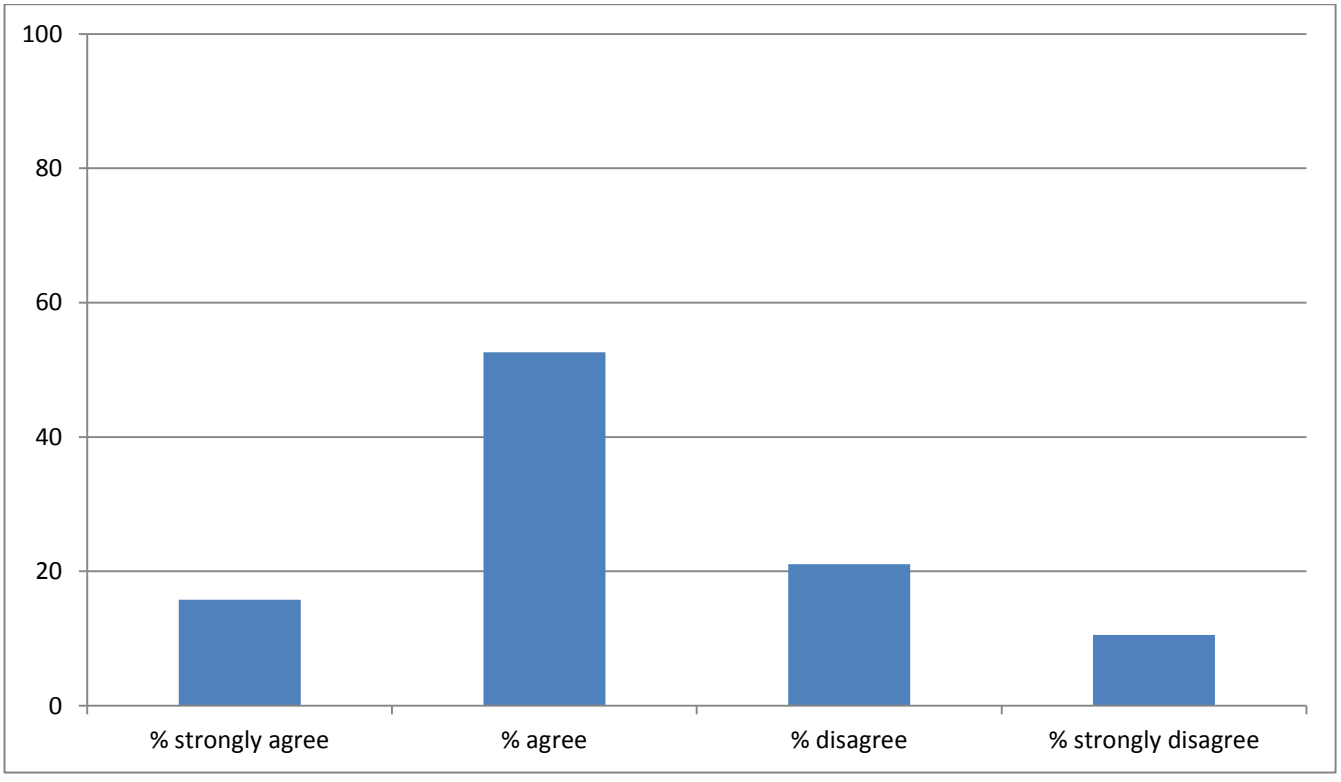

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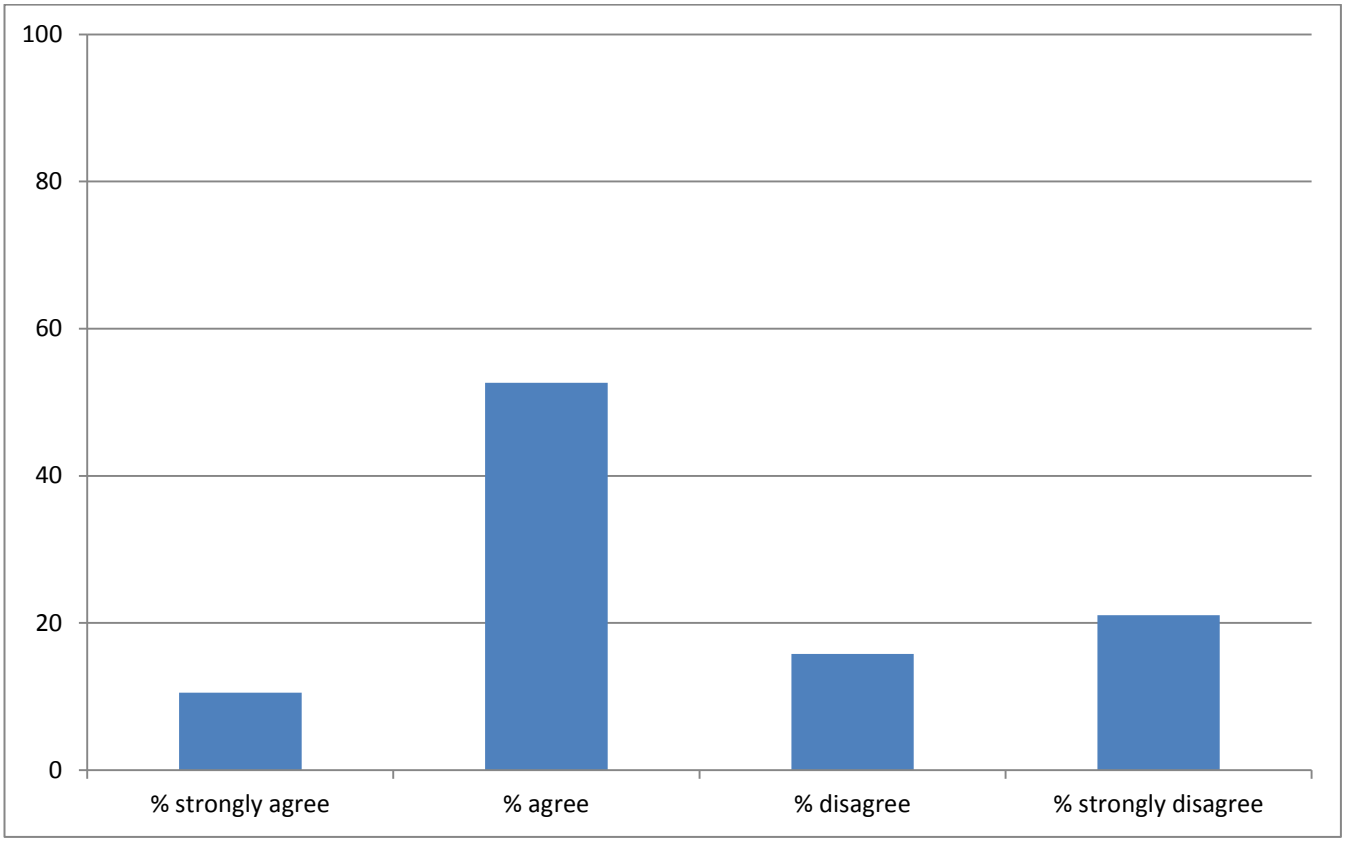


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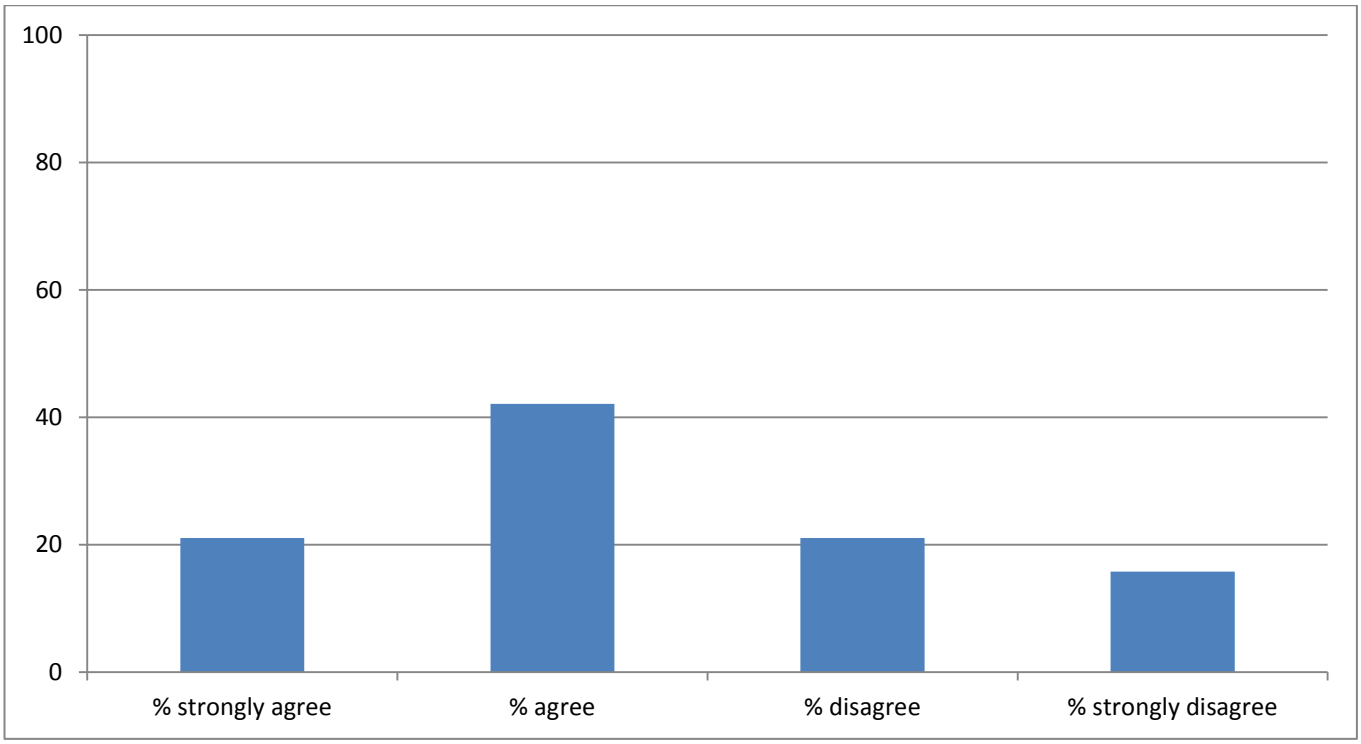

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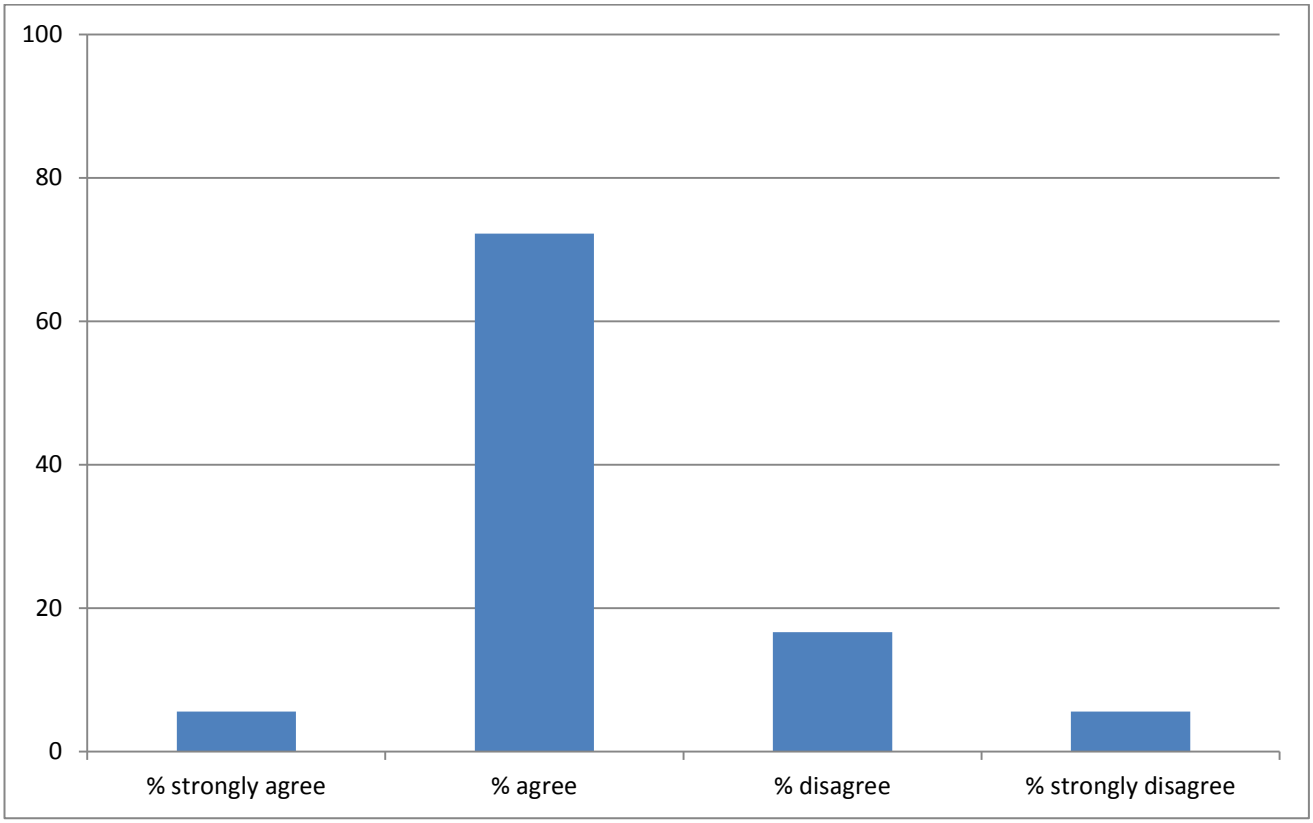


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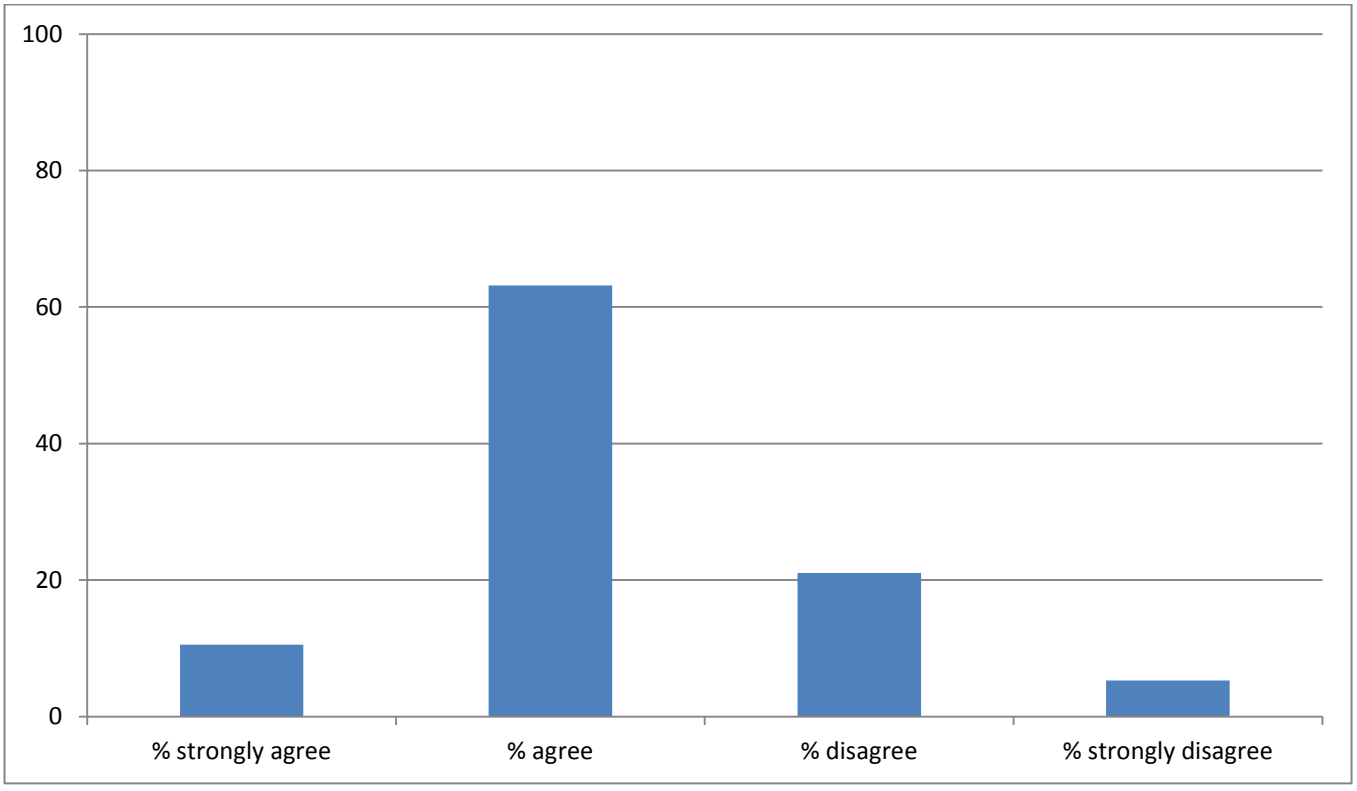

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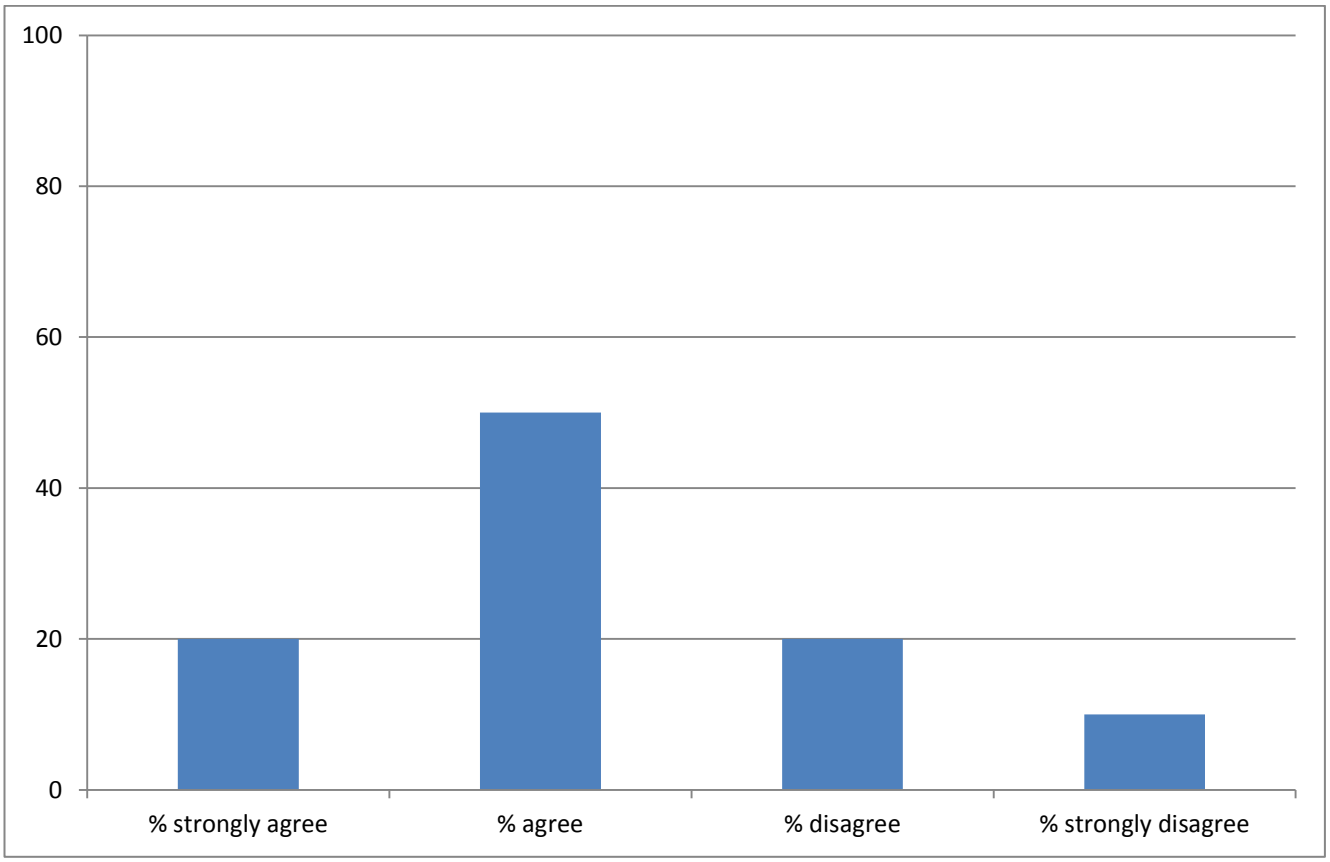


## Earth and Environmental Science

Figure 1: Response to Question 9. The rationale provides clarity about the subject's broad scope, distinctive nature and importance (n=4)

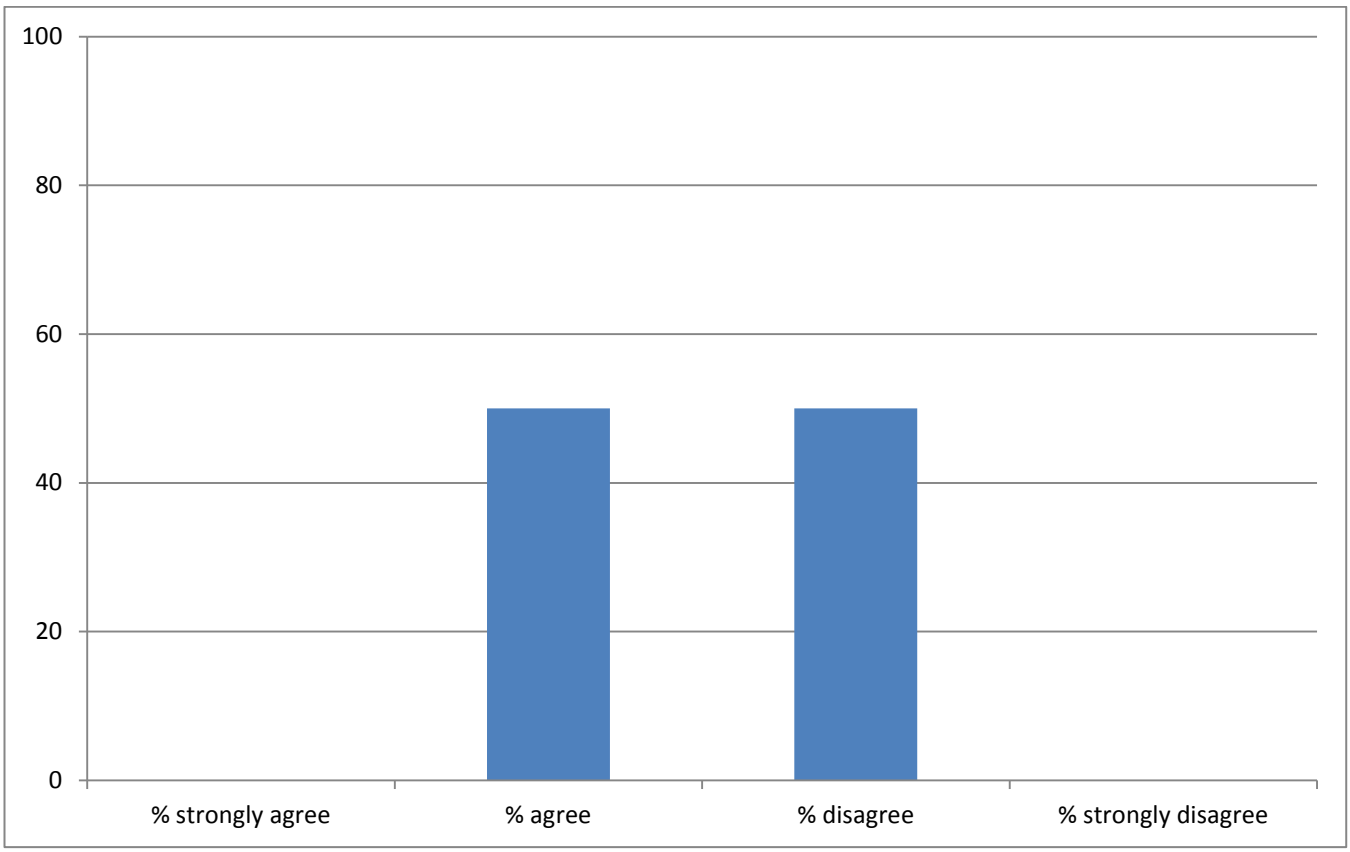
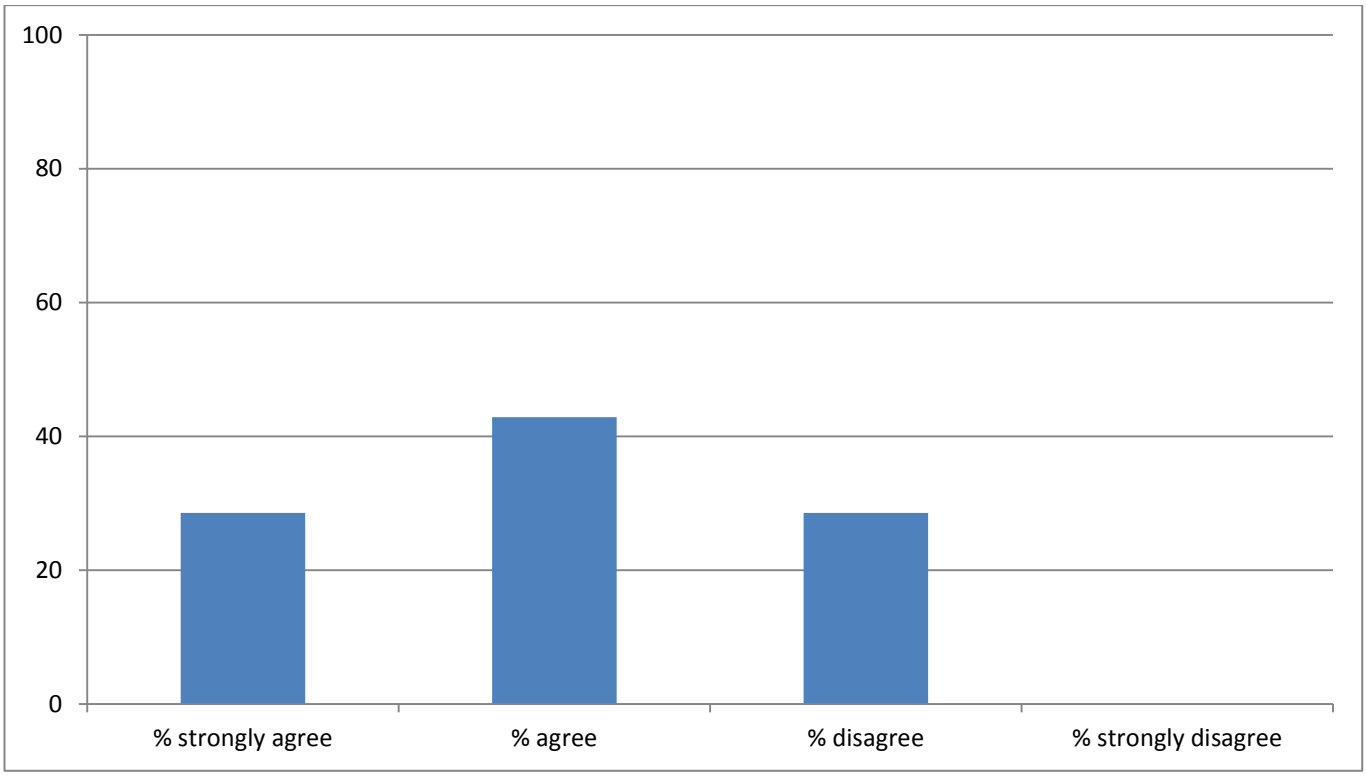



Figure 2: Response to Question 10. The aims comprehensively describe the intended learning as a result of studying the subject (n=7)



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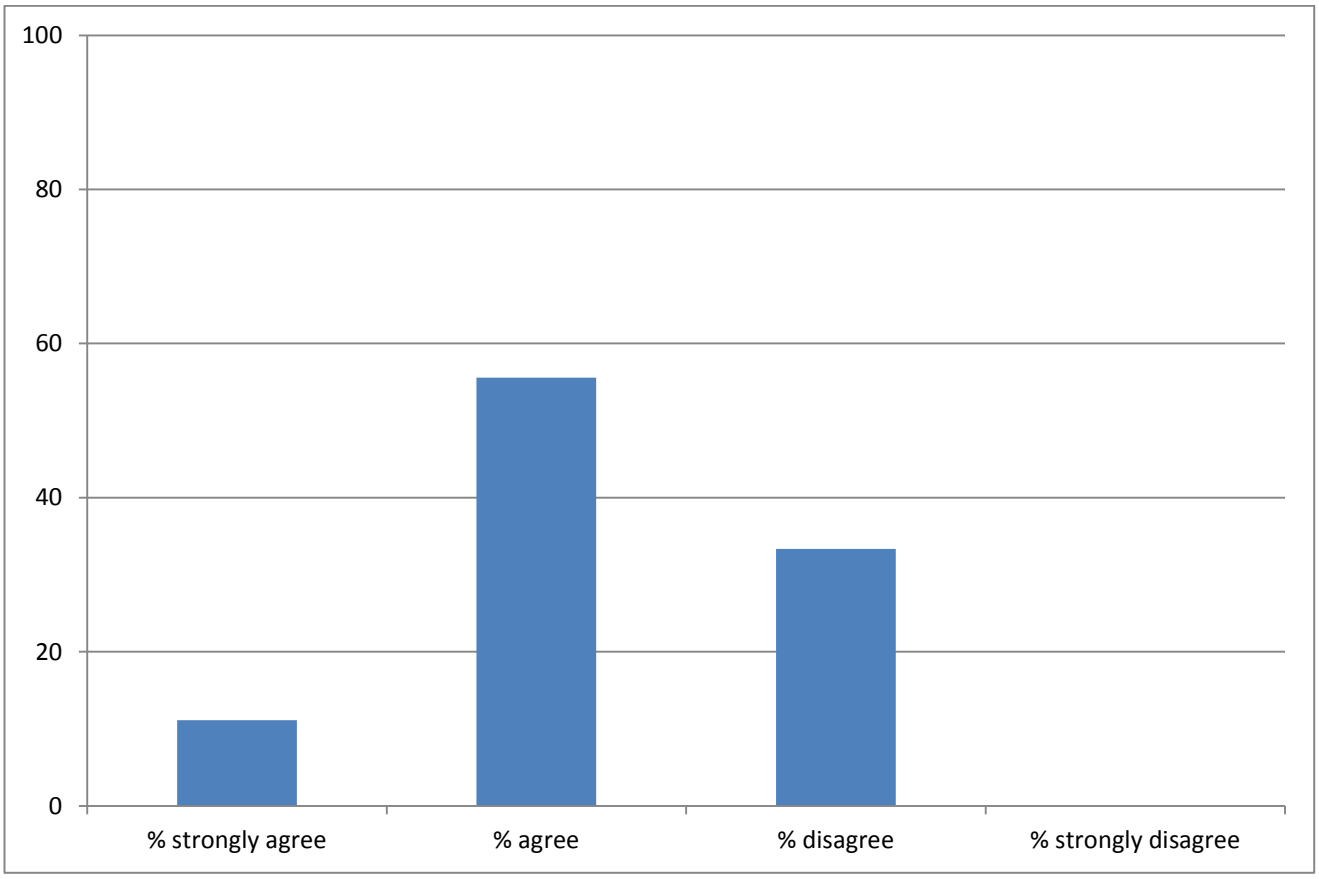



Figure 4: Response to Question 12. Units 3 and 4 are more cognitively demanding than Units 1 and 2 (n=9)

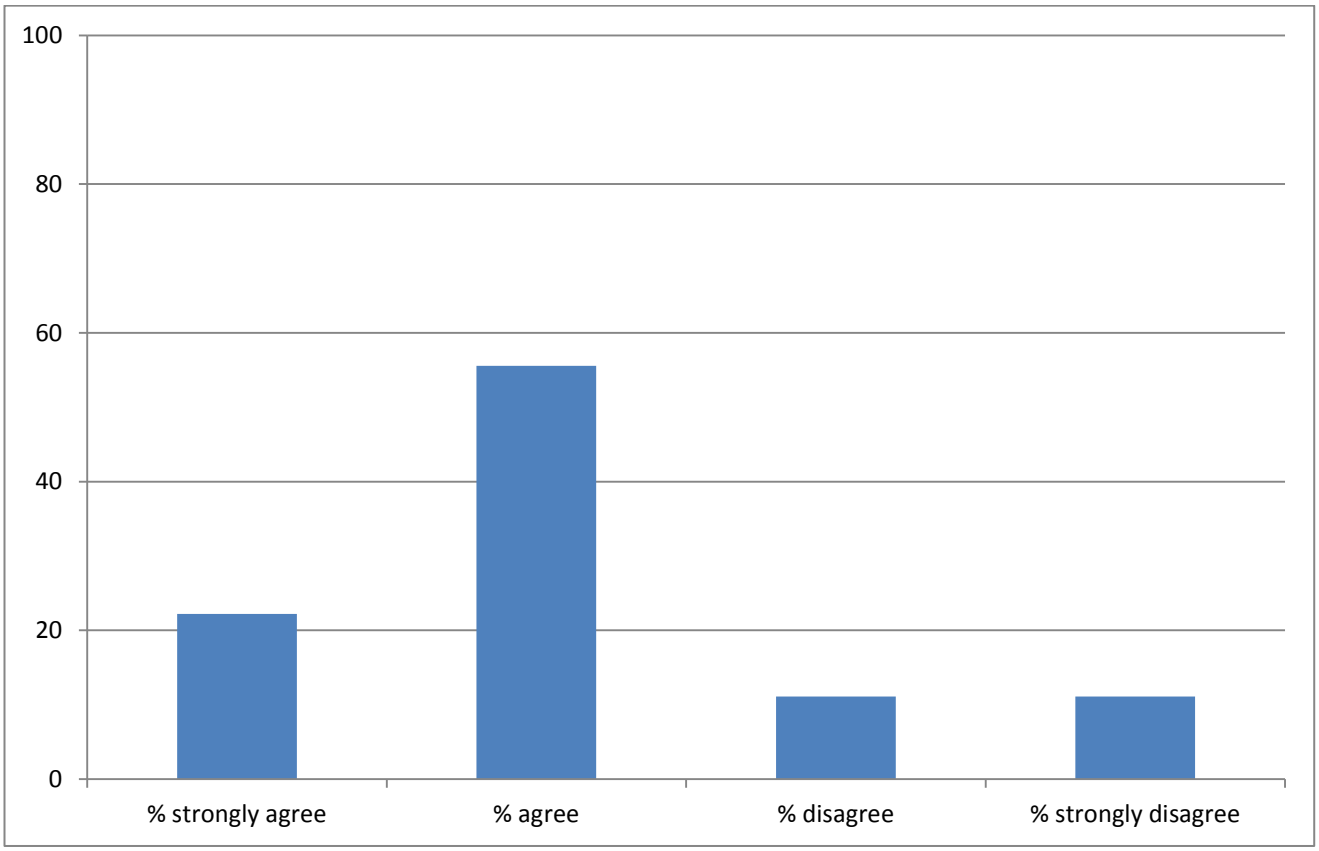


Figure 5: Response to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum (n=9)

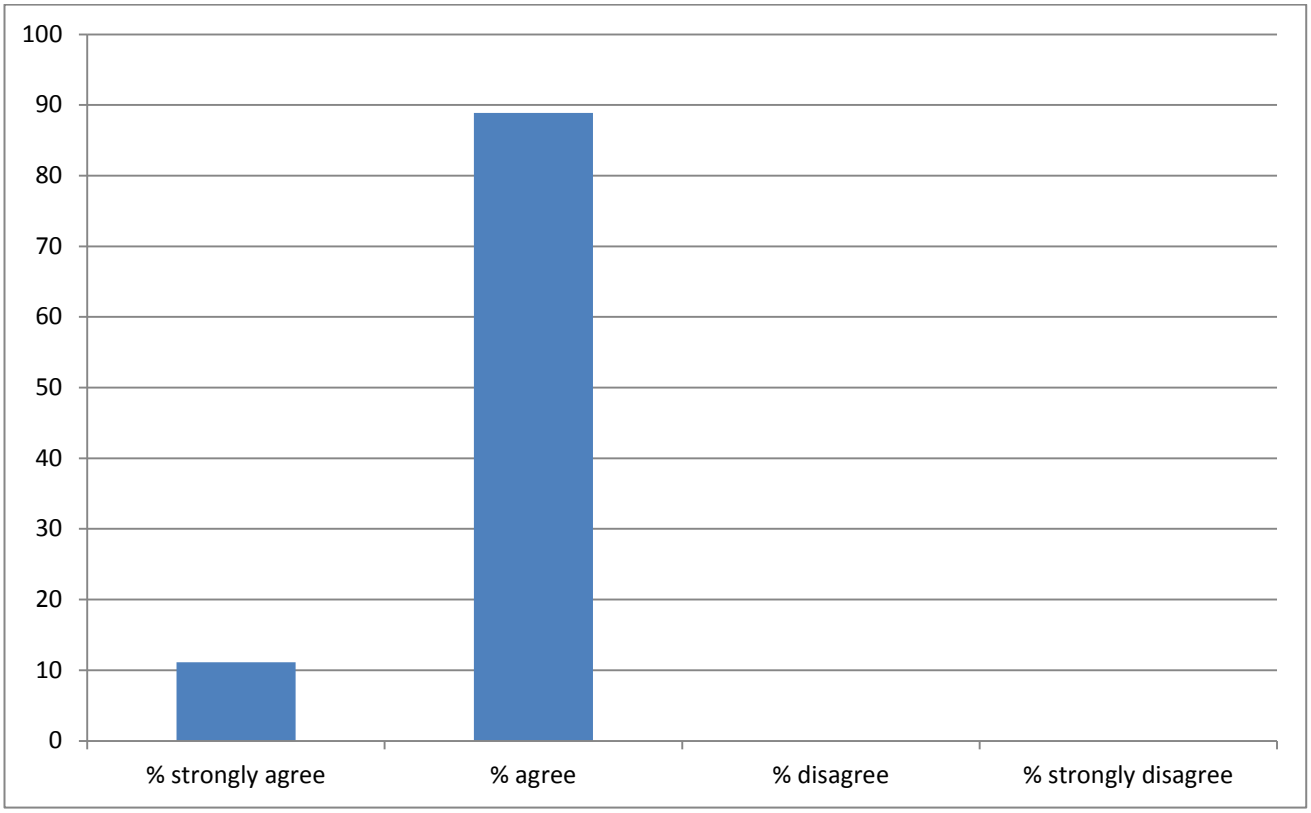



Figure 6: Response to Question 14. The achievement standards across Units 1 and 2 and Units 3 and 4 are organised in an order consistent with your experience (n=9)

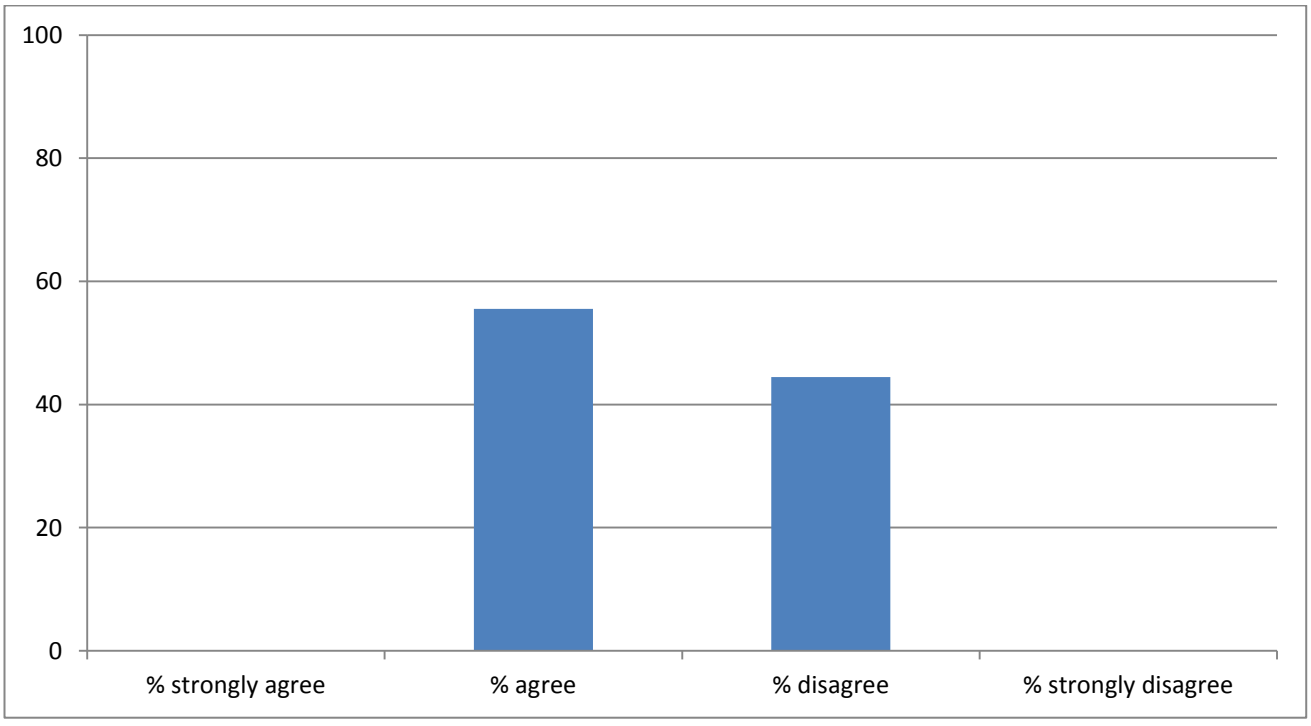


Figure 7: Response to Question 15. Unit 1: The unit description describes the focus and scope for this unit (n=7)

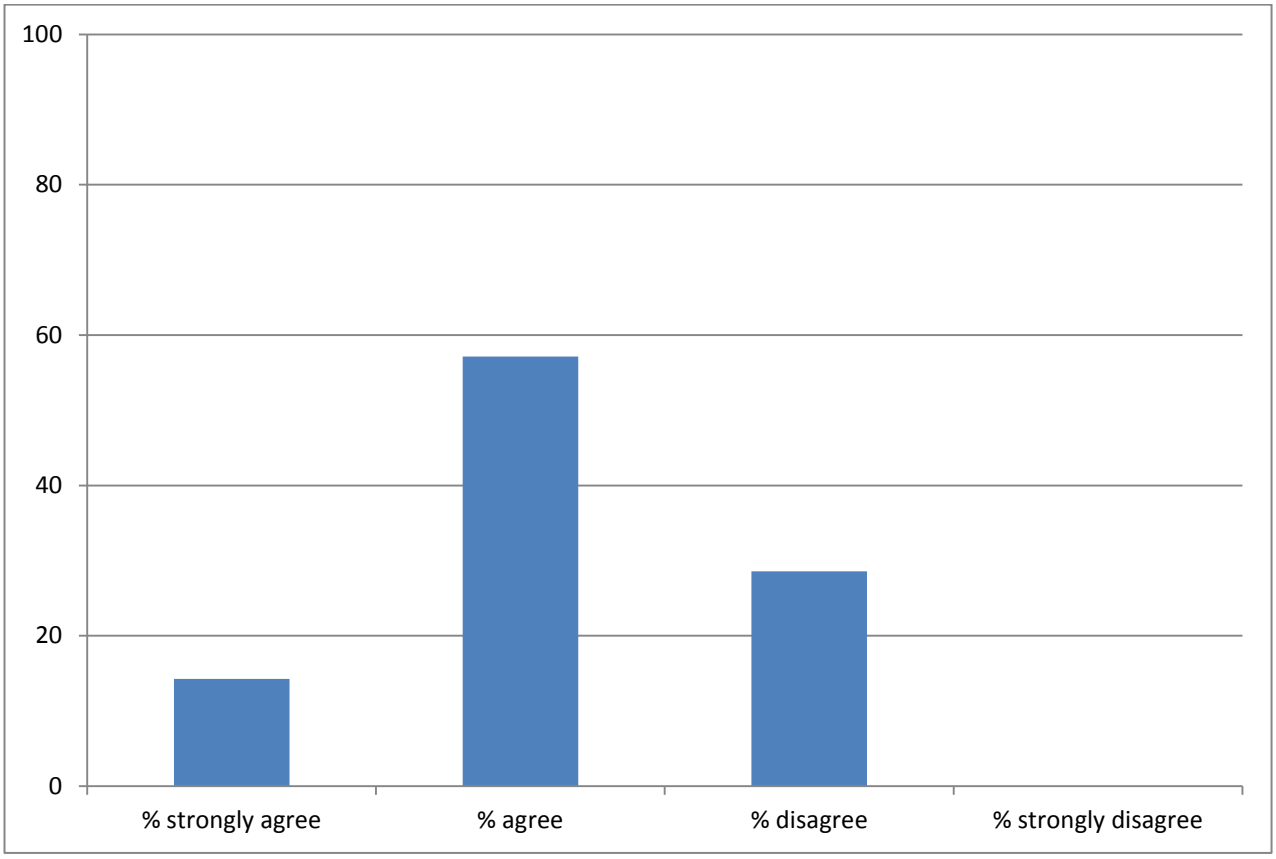



Figure 8: Response to Question 16. The outcomes describe clearly the expected learning for this unit (n=7)

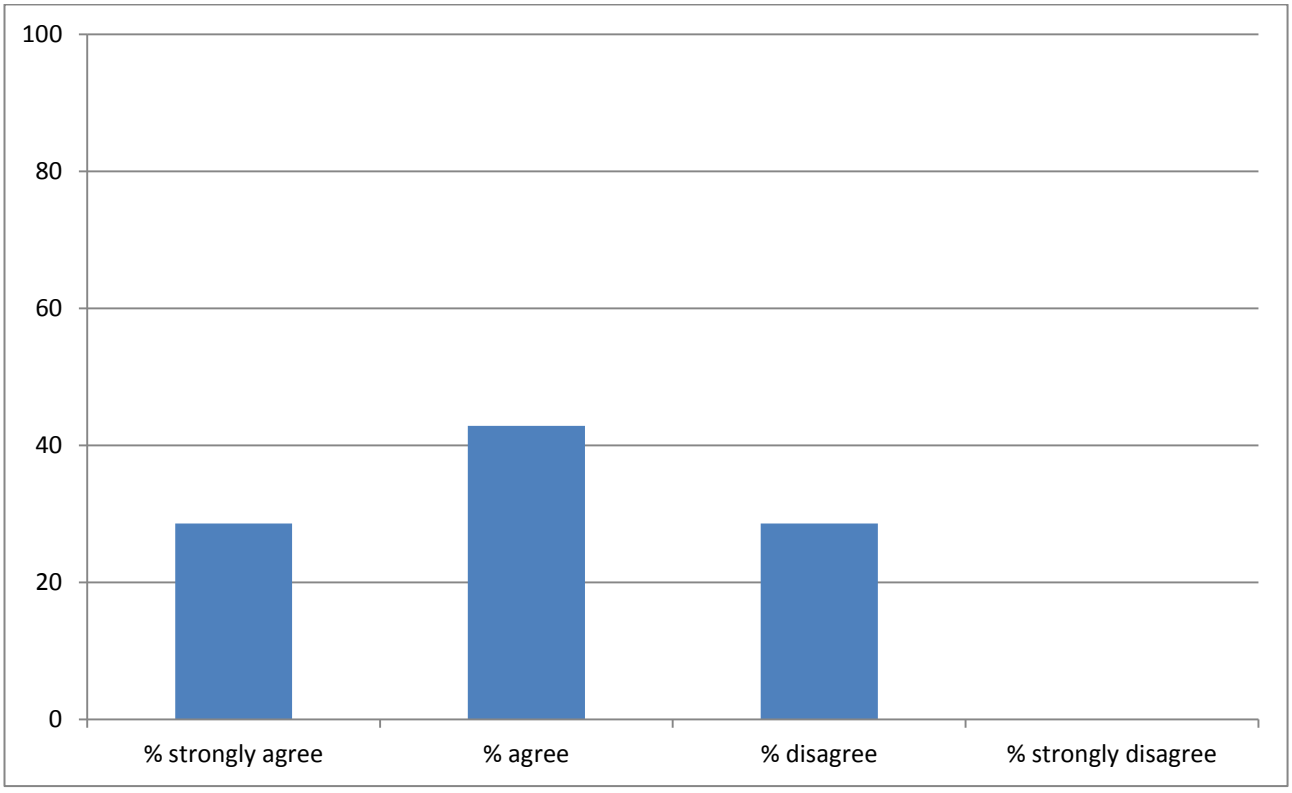


Figure 9: Response to Question 17. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=7)

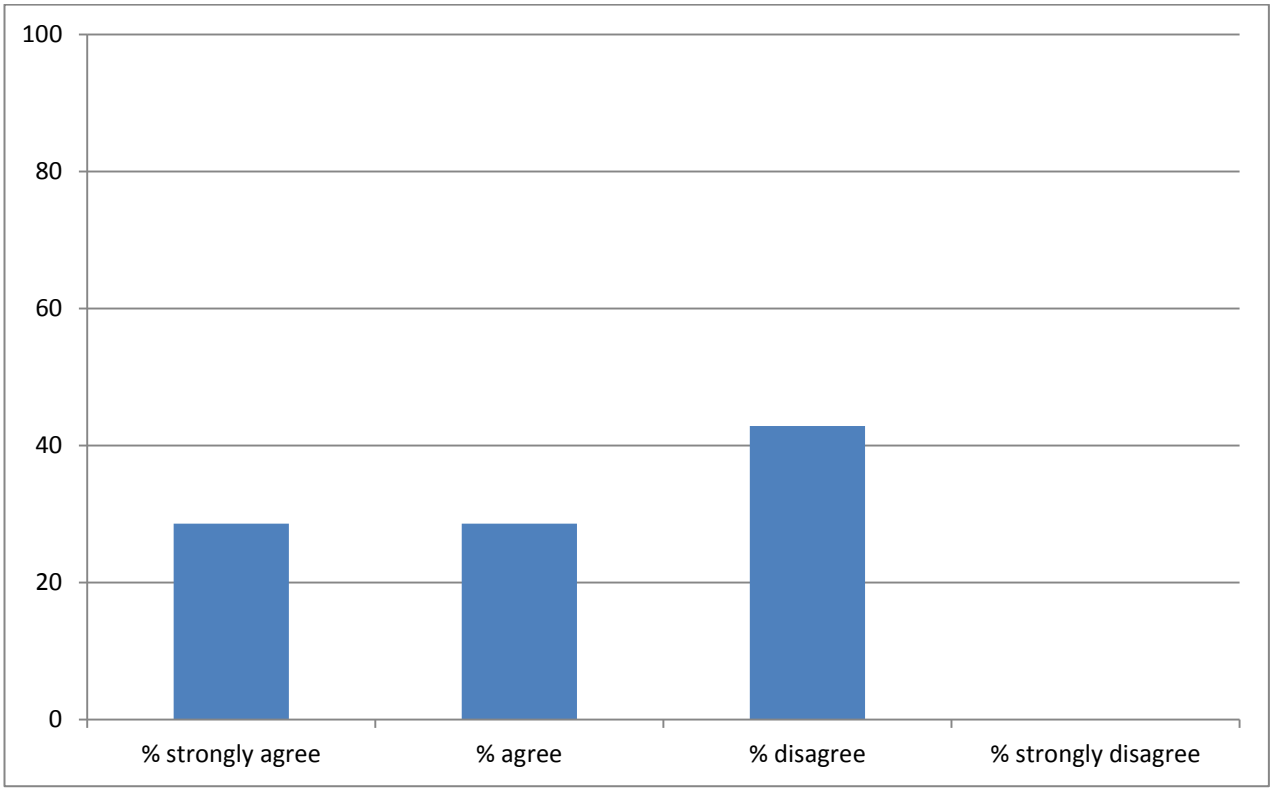



Figure 10: Response to Question 18. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=7)

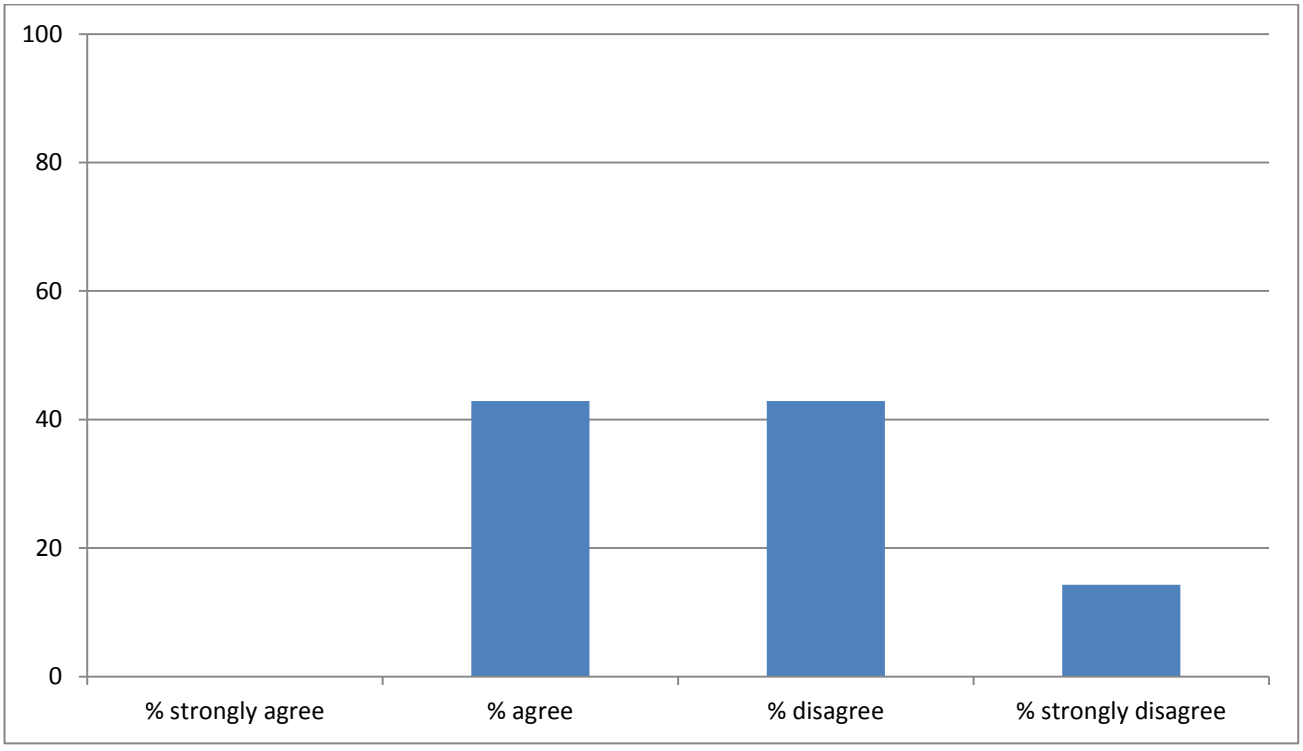


Figure 11: Response to Question 19. The content descriptions are specific about what is to be taught (n=7)

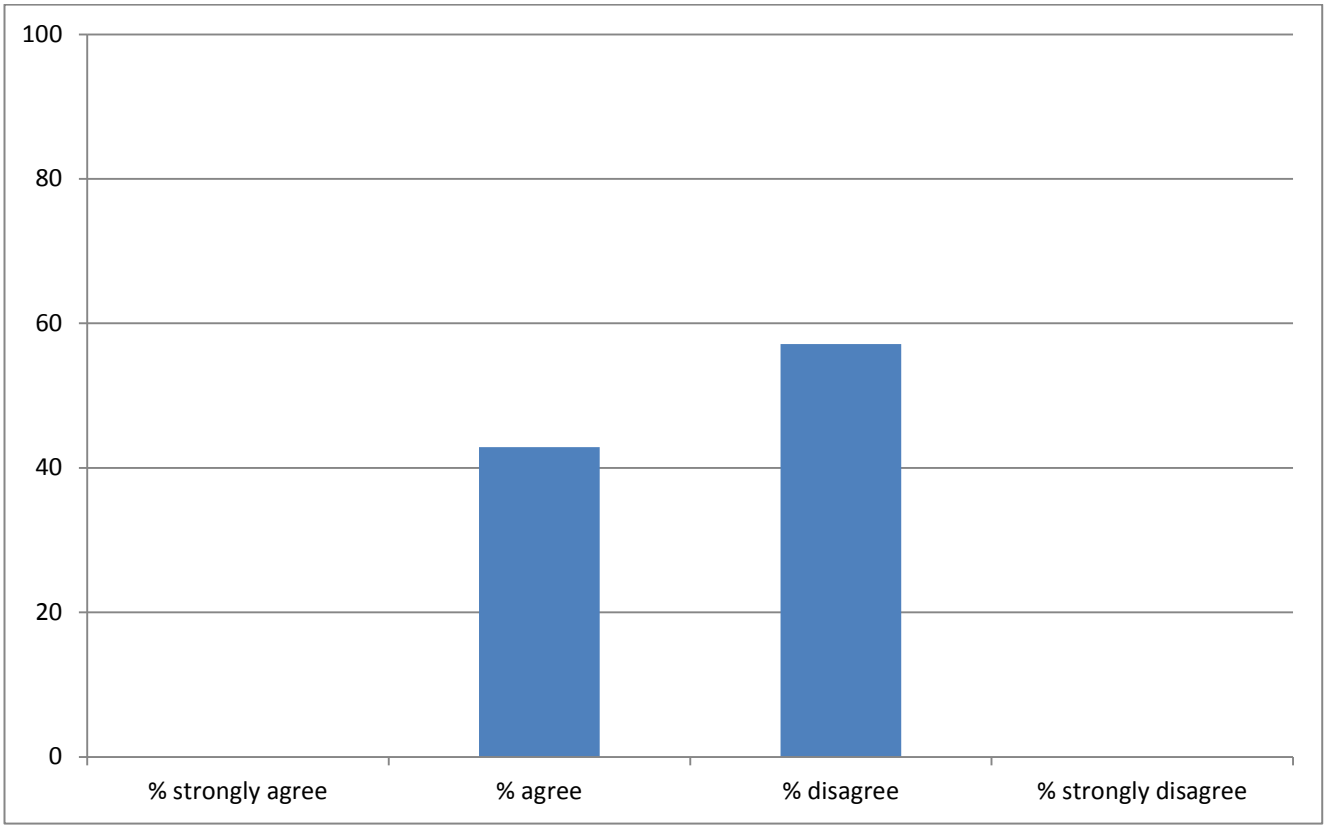



Figure 12: Response to Question 20. Unit 2: The unit description clearly describes the focus and scope for this unit (n=7)

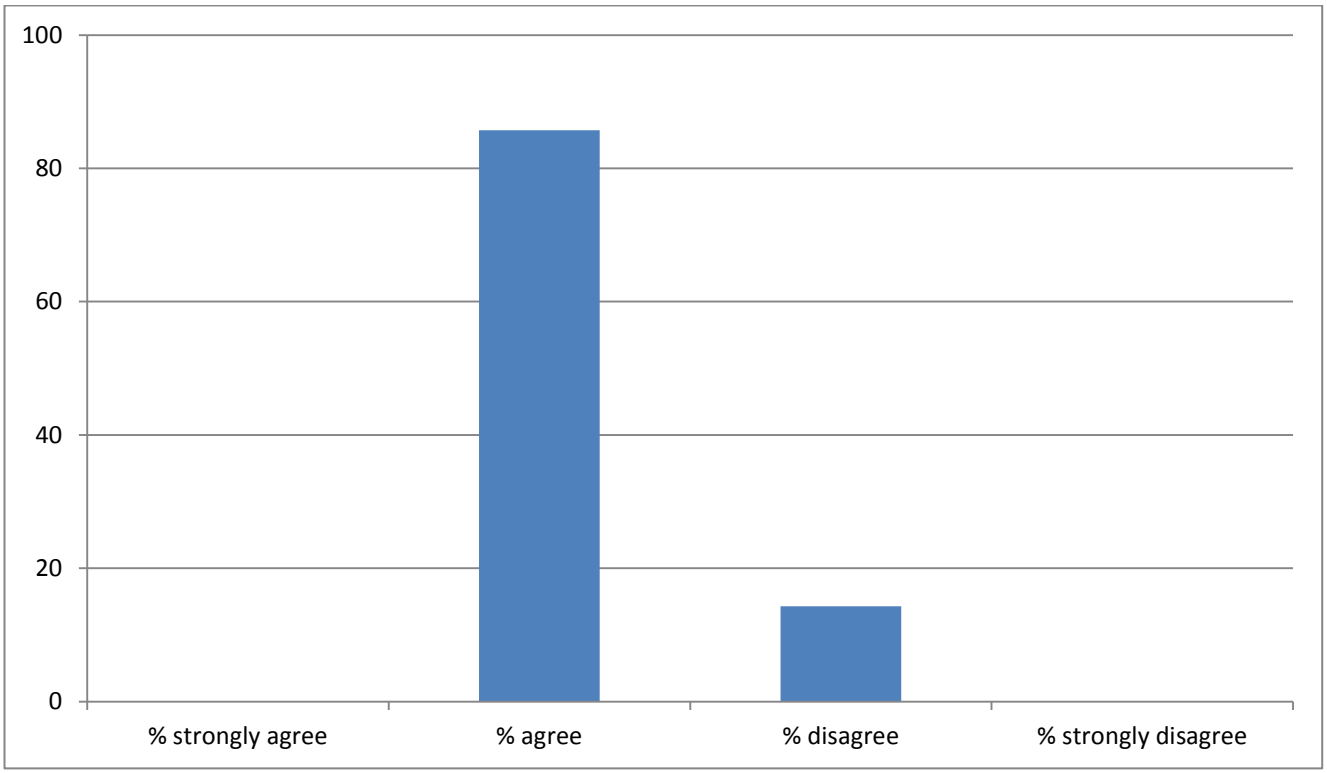


Figure 13: Response to Question 21. The unit outcomes describe clearly the expected learning for this unit (n=7)

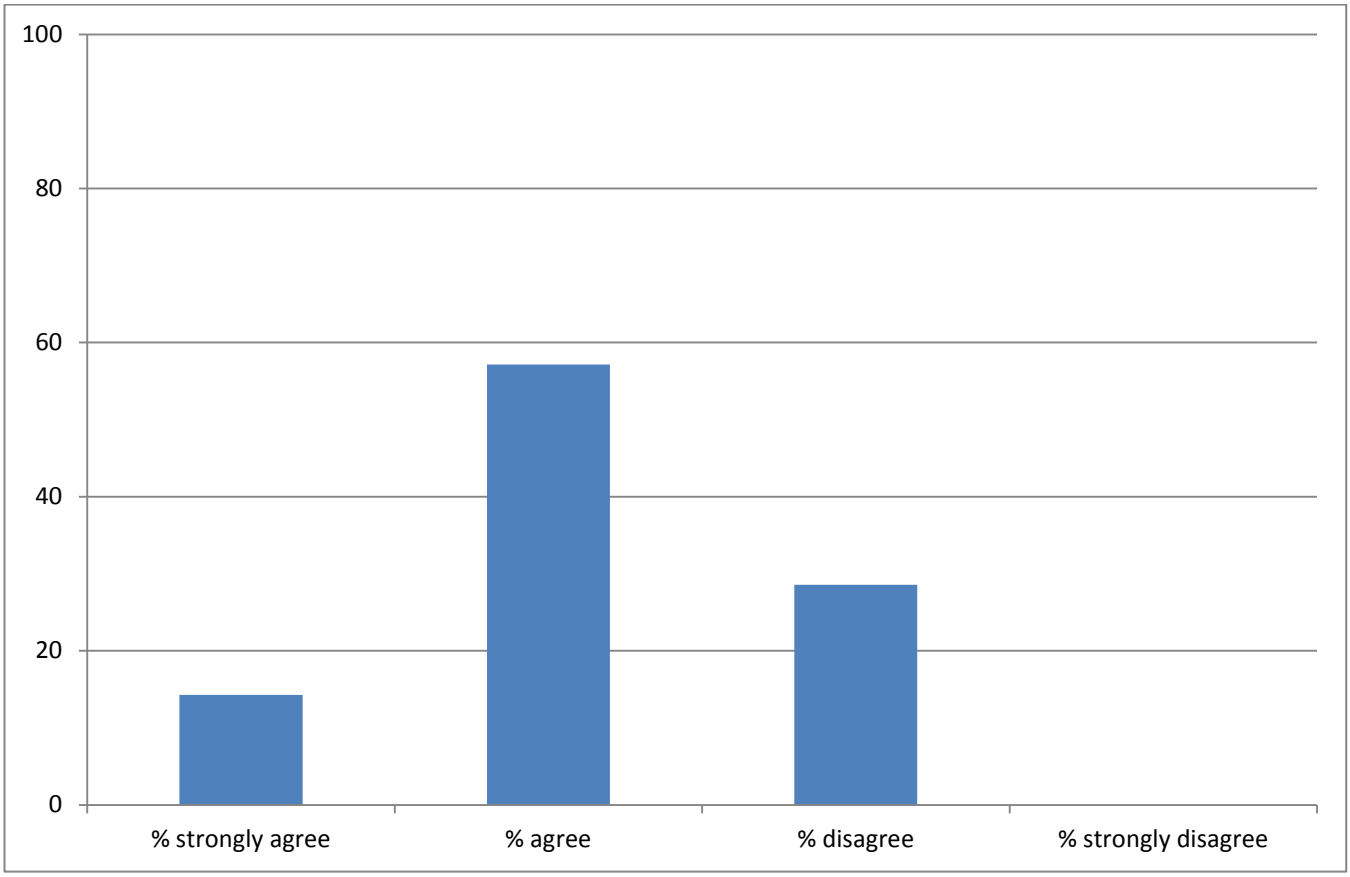



Figure 14: Response to Question 22. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=7)

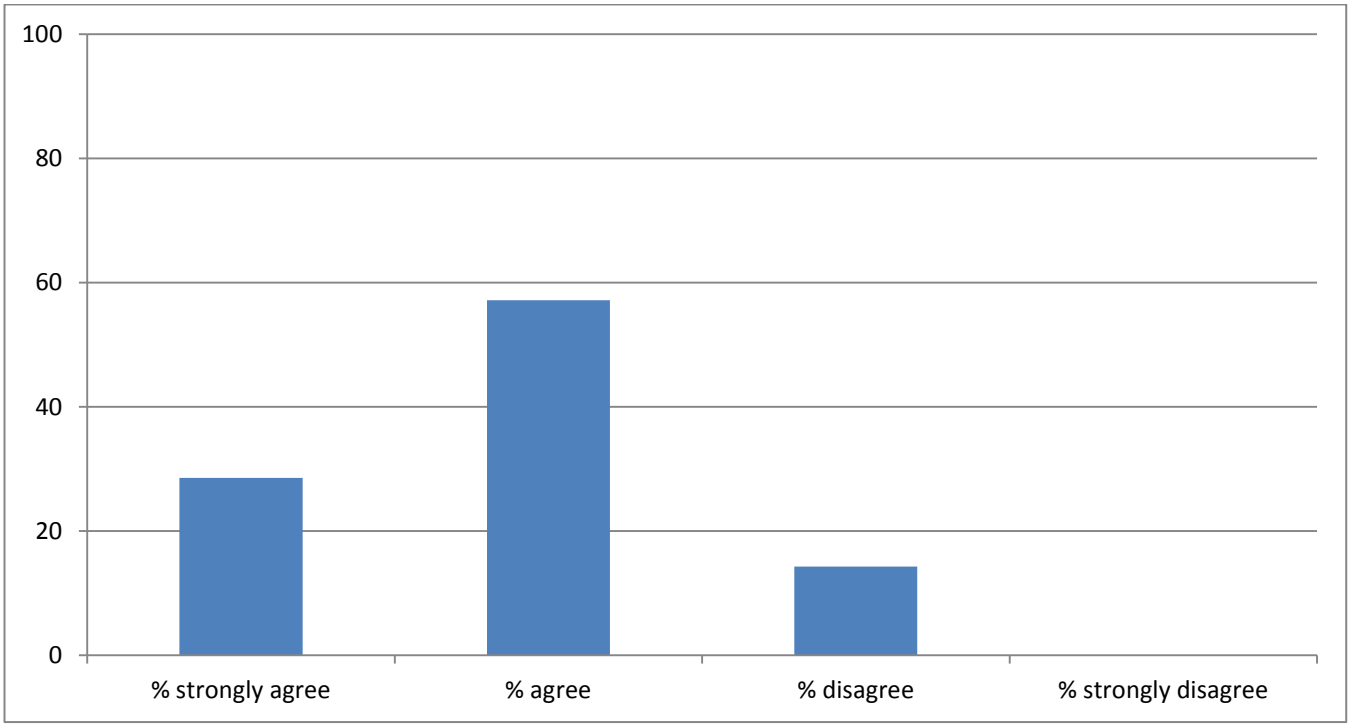


Figure 15: Response to Question 23. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=7)

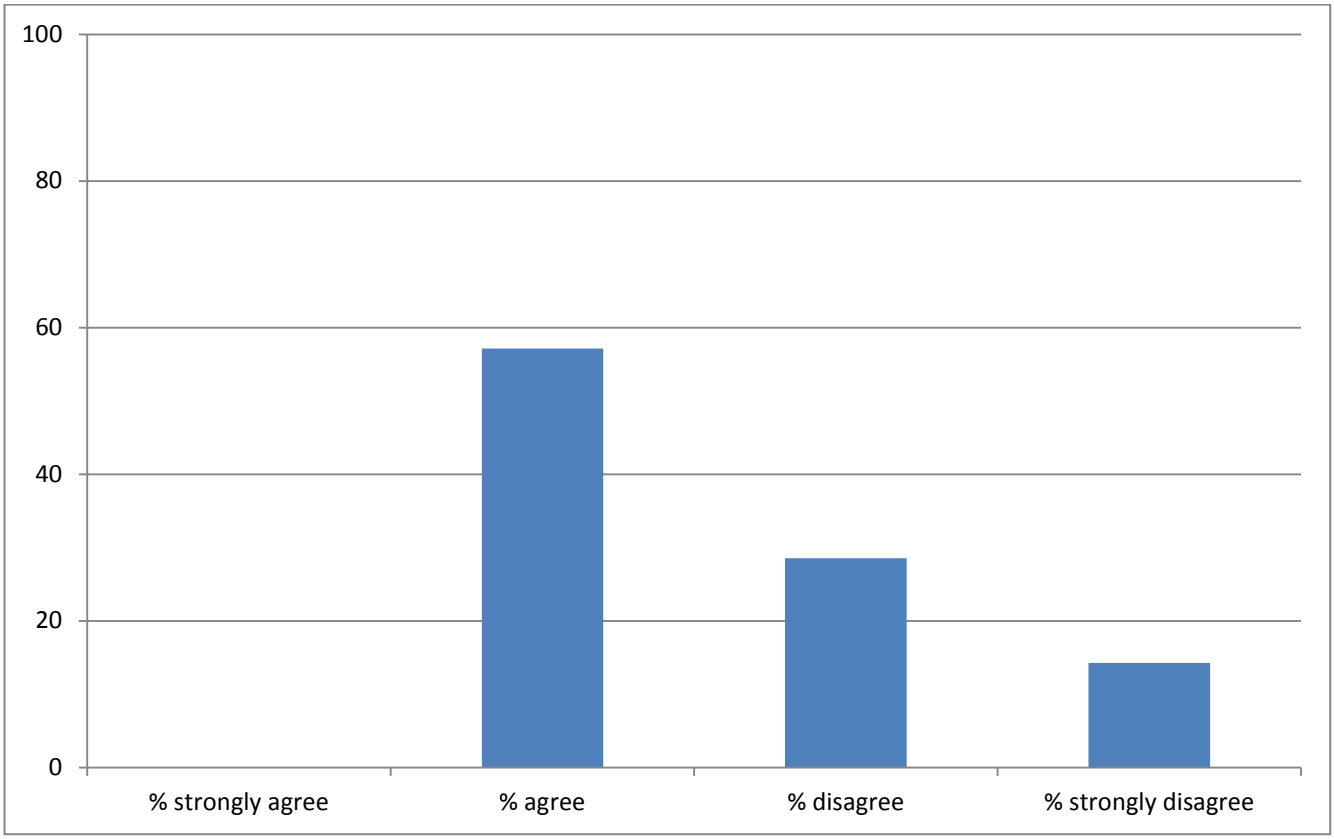



Figure 16: Response to Question 24. The content descriptions are specific about what is to be taught (n=7)

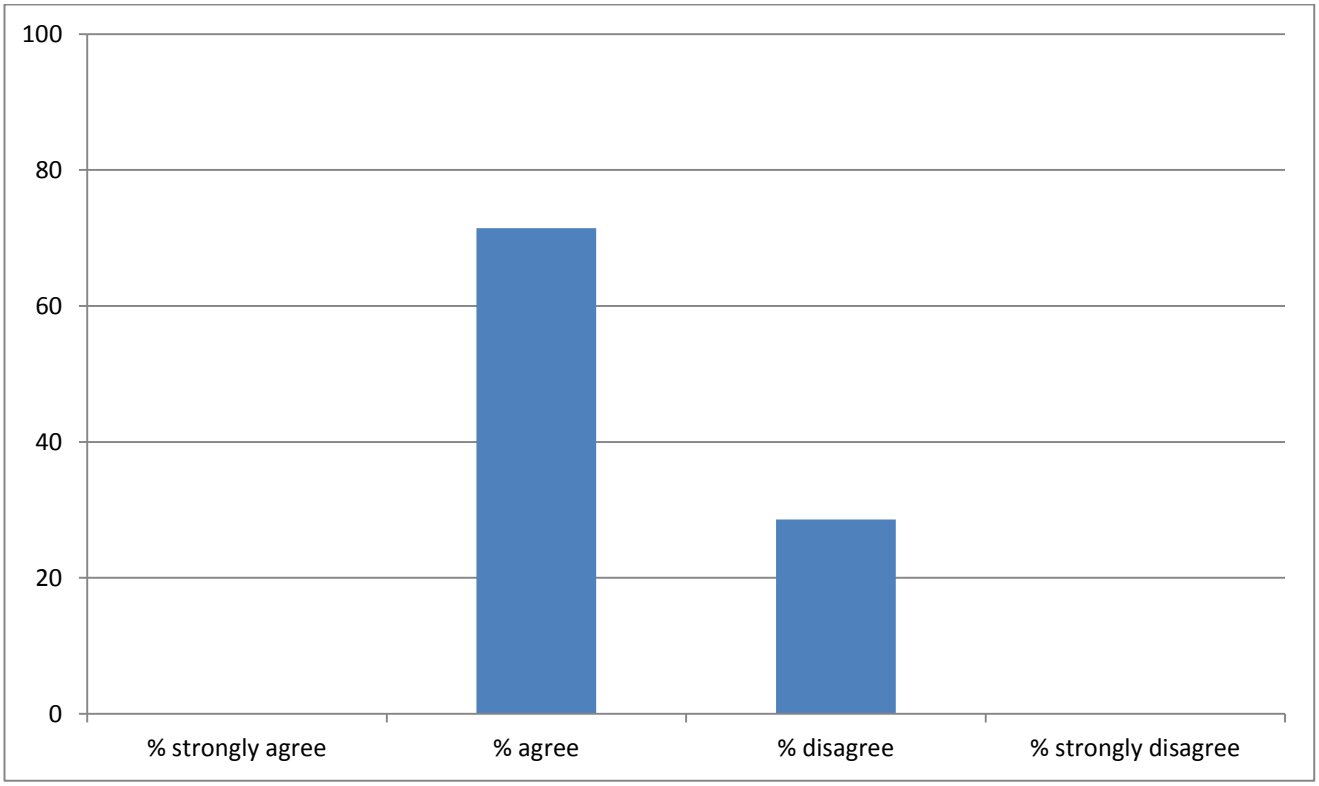


Figure 17: Response to Question 25. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=6)

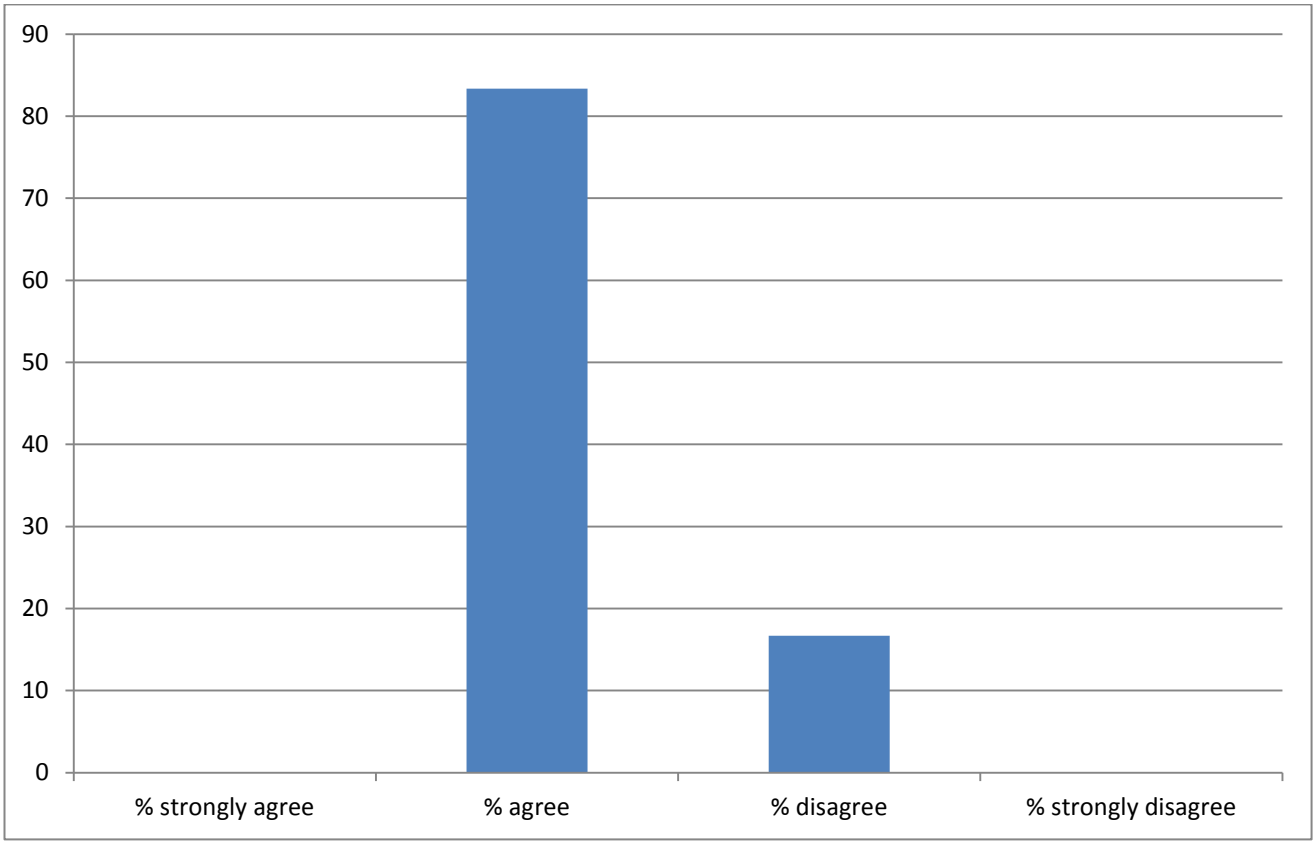



Figure 18: Response to Question 26. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=7)

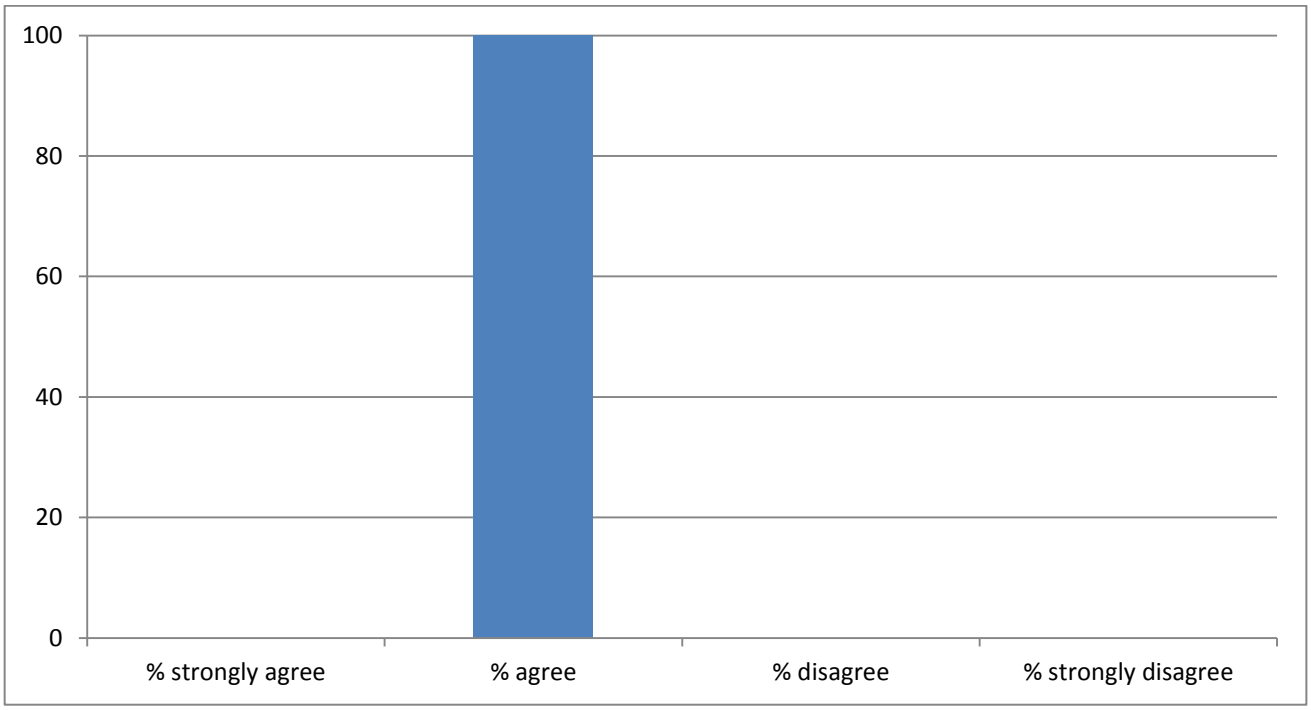


Figure 19: Response to Question 27. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=7)

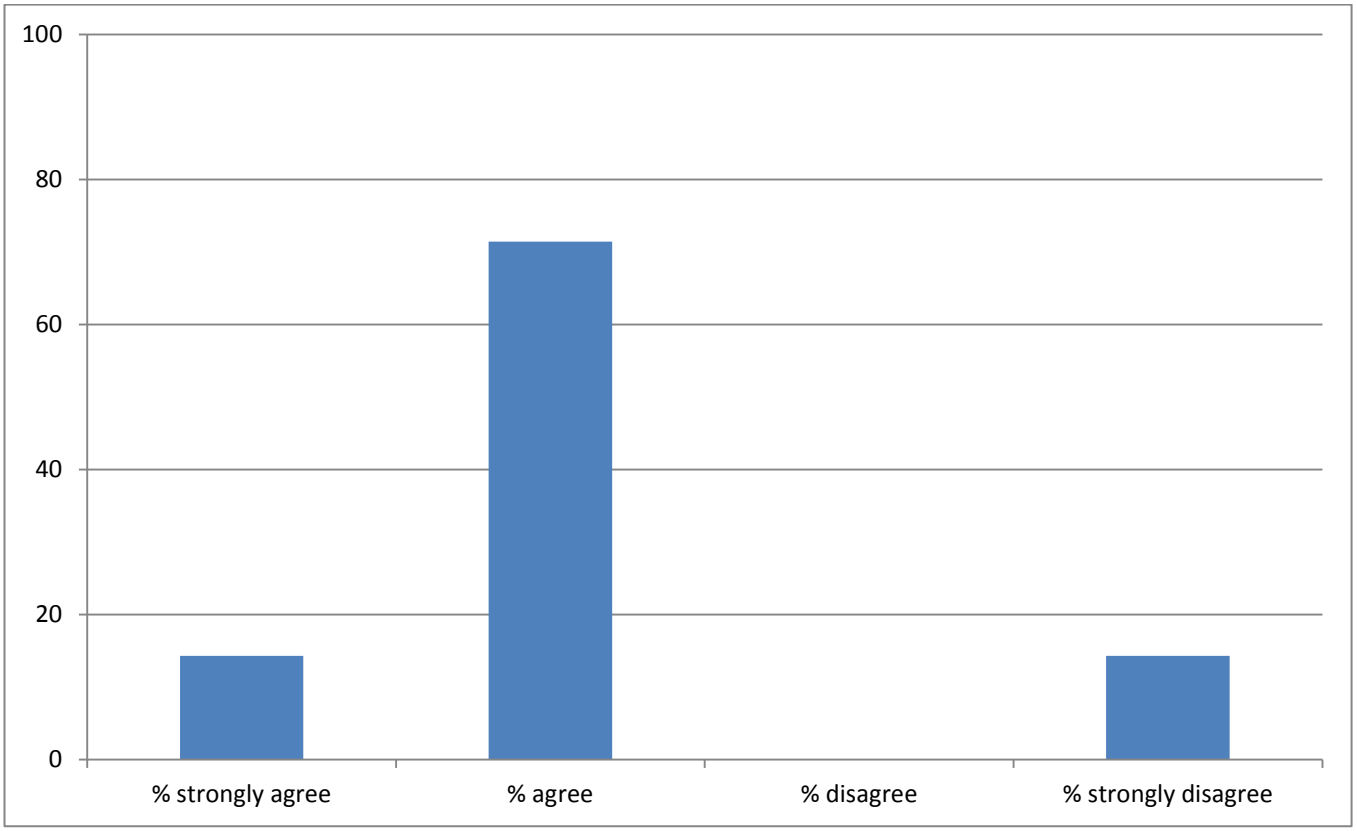



Figure 20: Response to Question 28. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=7)

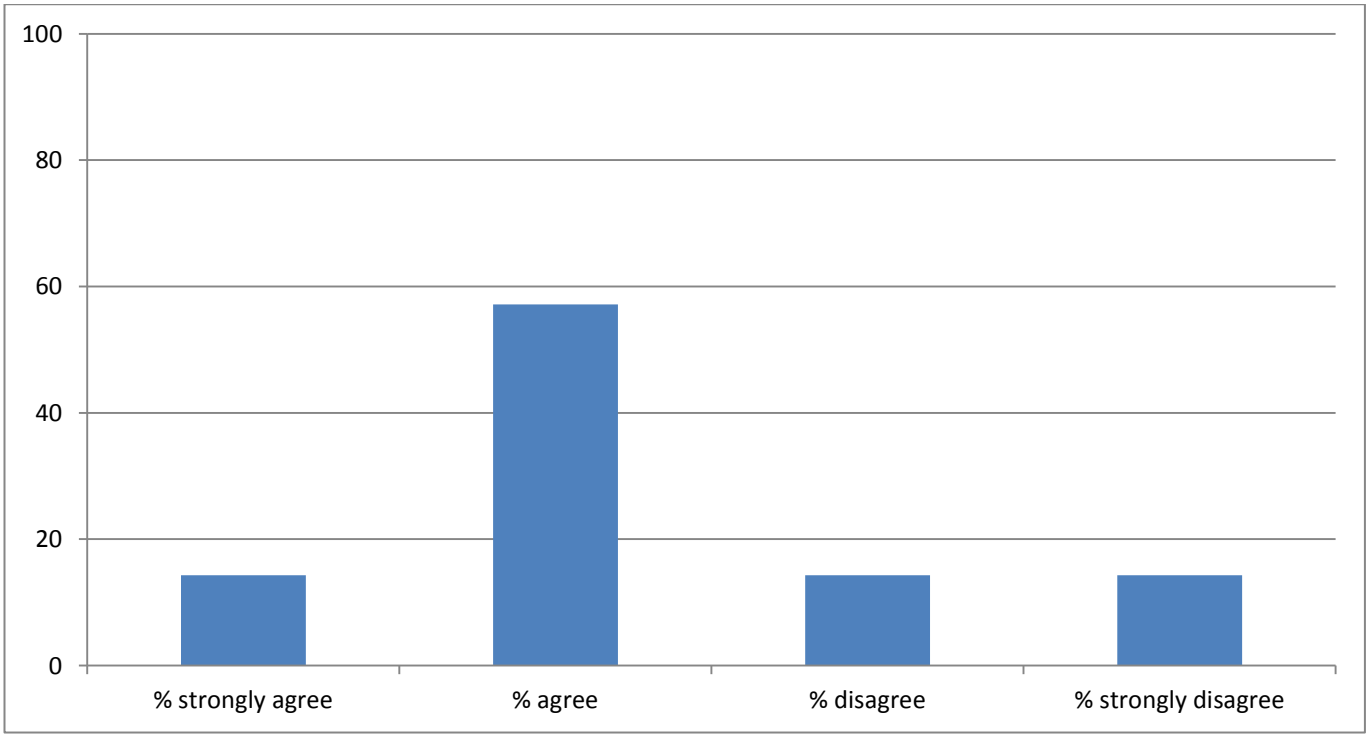


Figure 21: Response to Question 29. Unit 3: The unit description clearly describes the focus and scope for this unit (n=7)

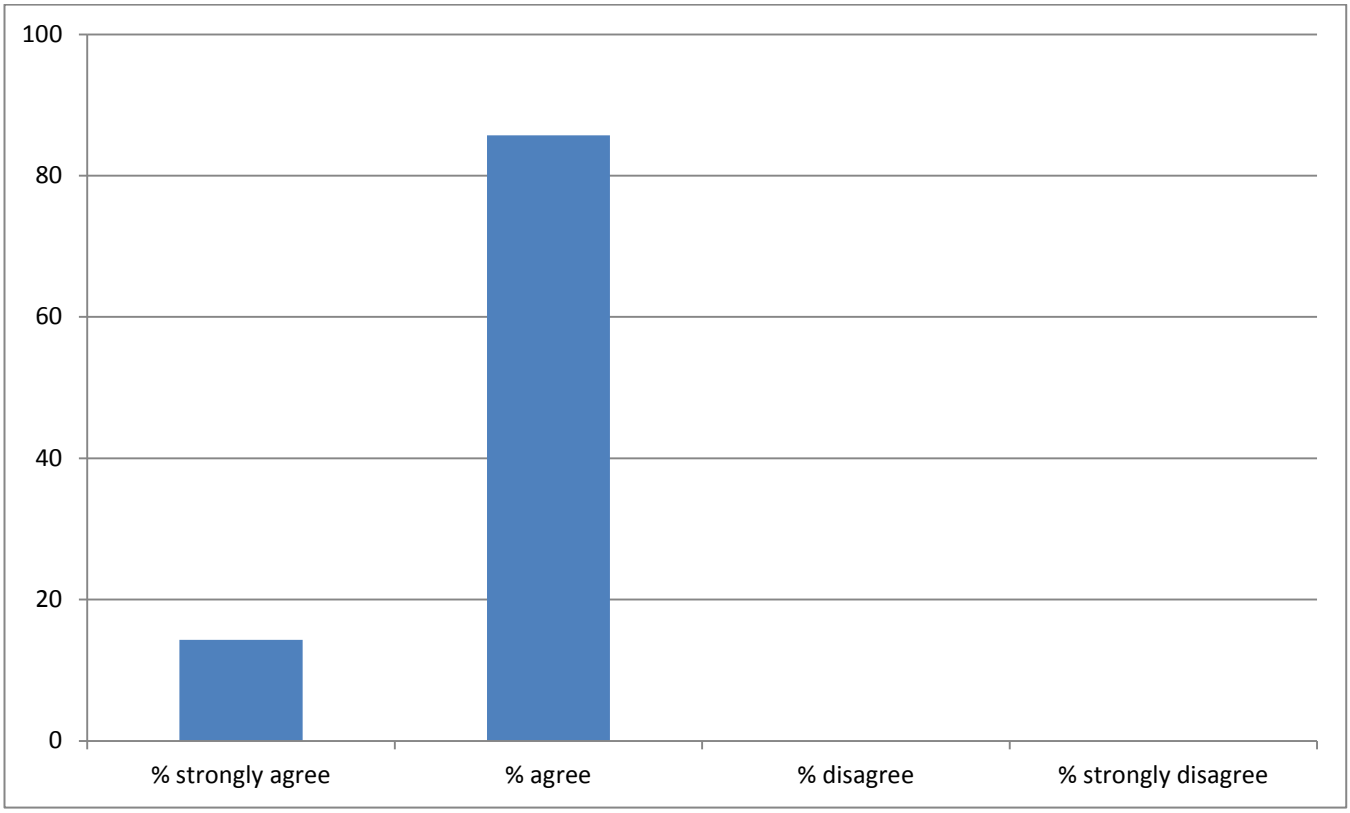



Figure 22: Response to Question 30. Unit 3: The unit outcomes describe clearly the expected learning for this unit (n=7)

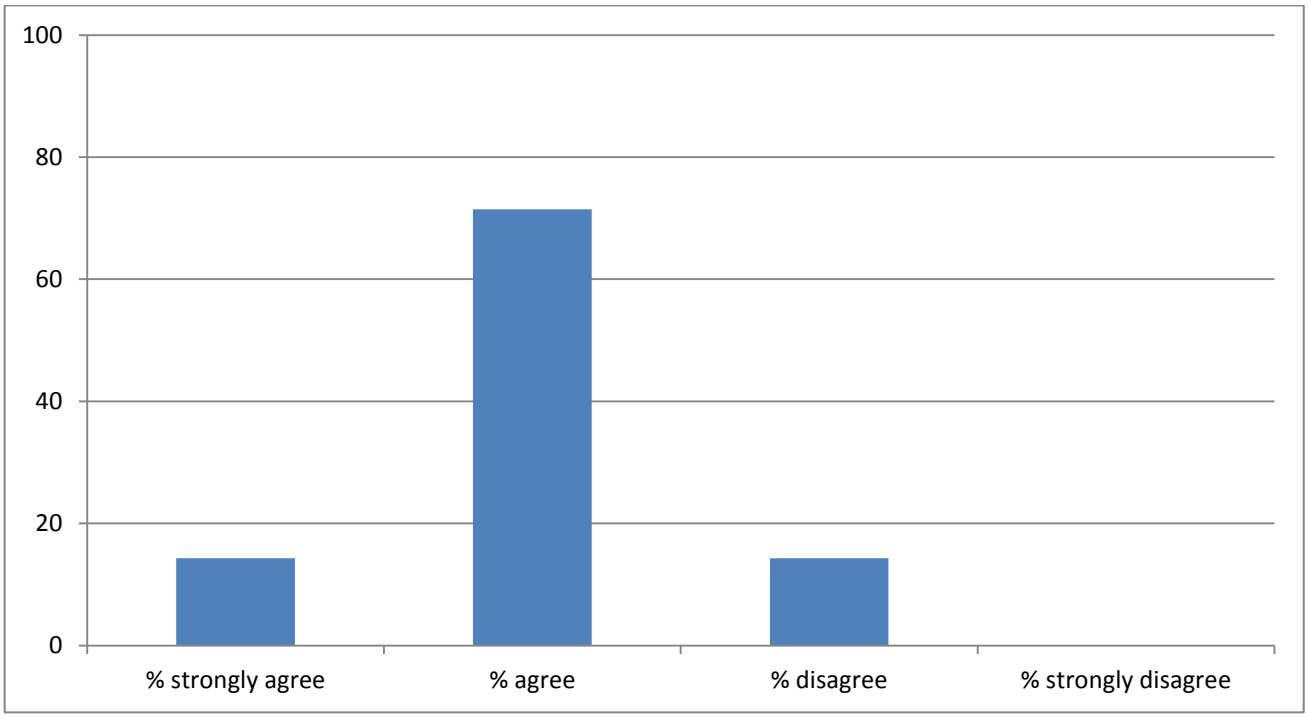


Figure 23: Response to Question 31. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=7)

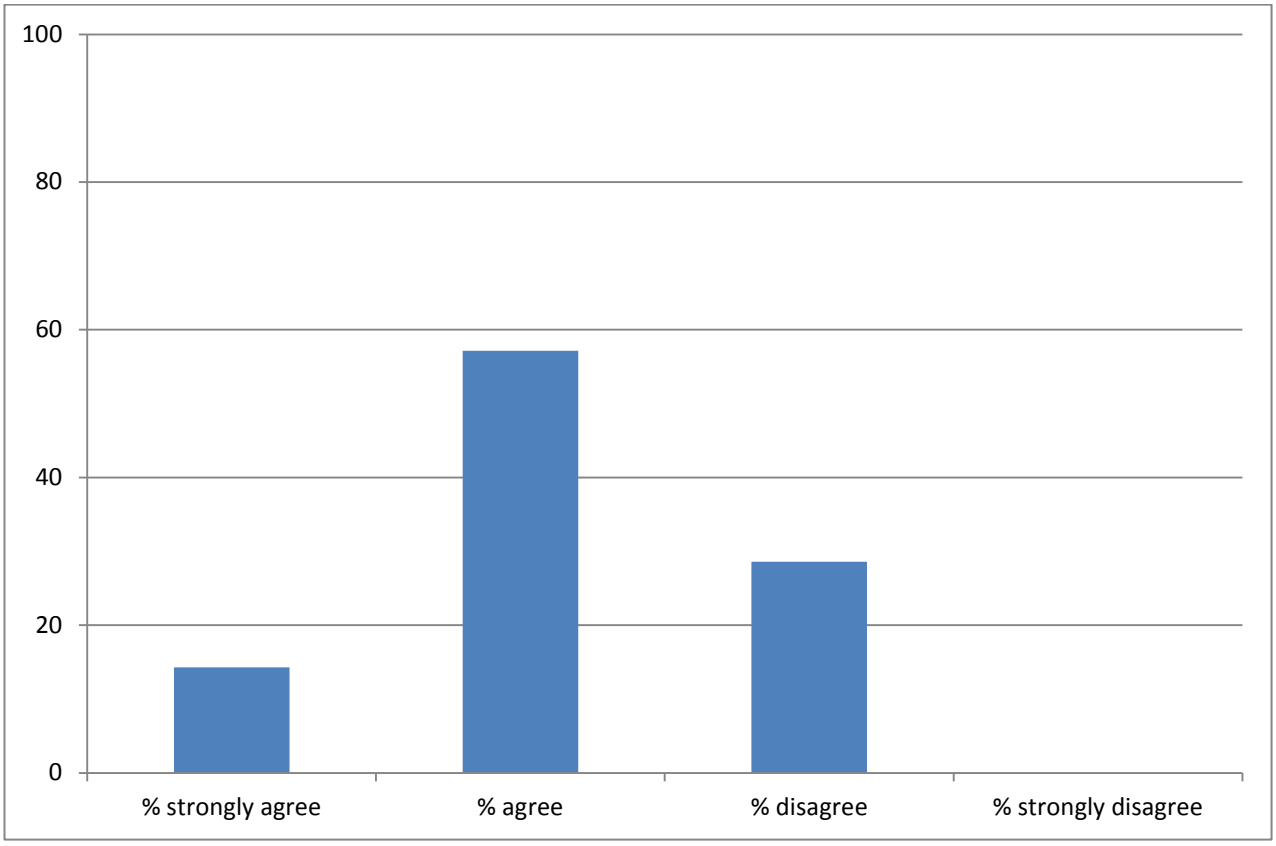



Figure 24: Response to Question 32. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=7)

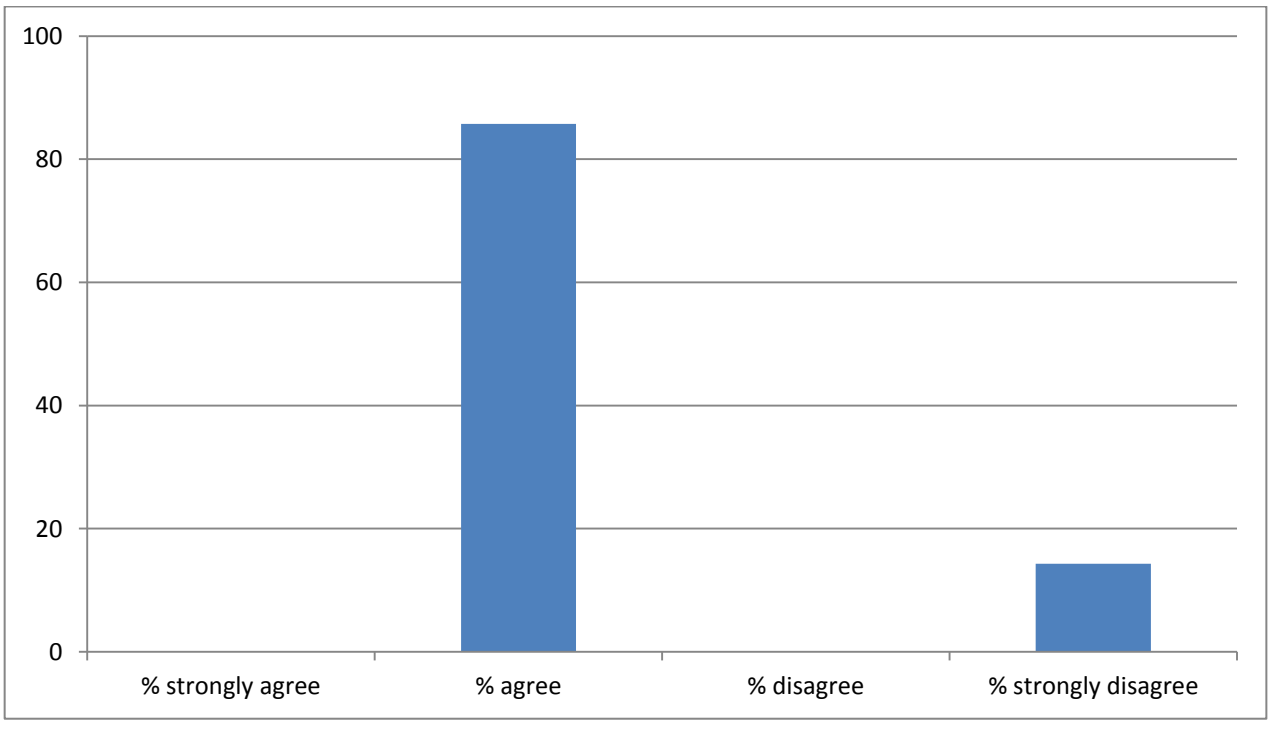


Figure 25: Response to Question 33. The content descriptions are specific about what is to be taught (n=7)

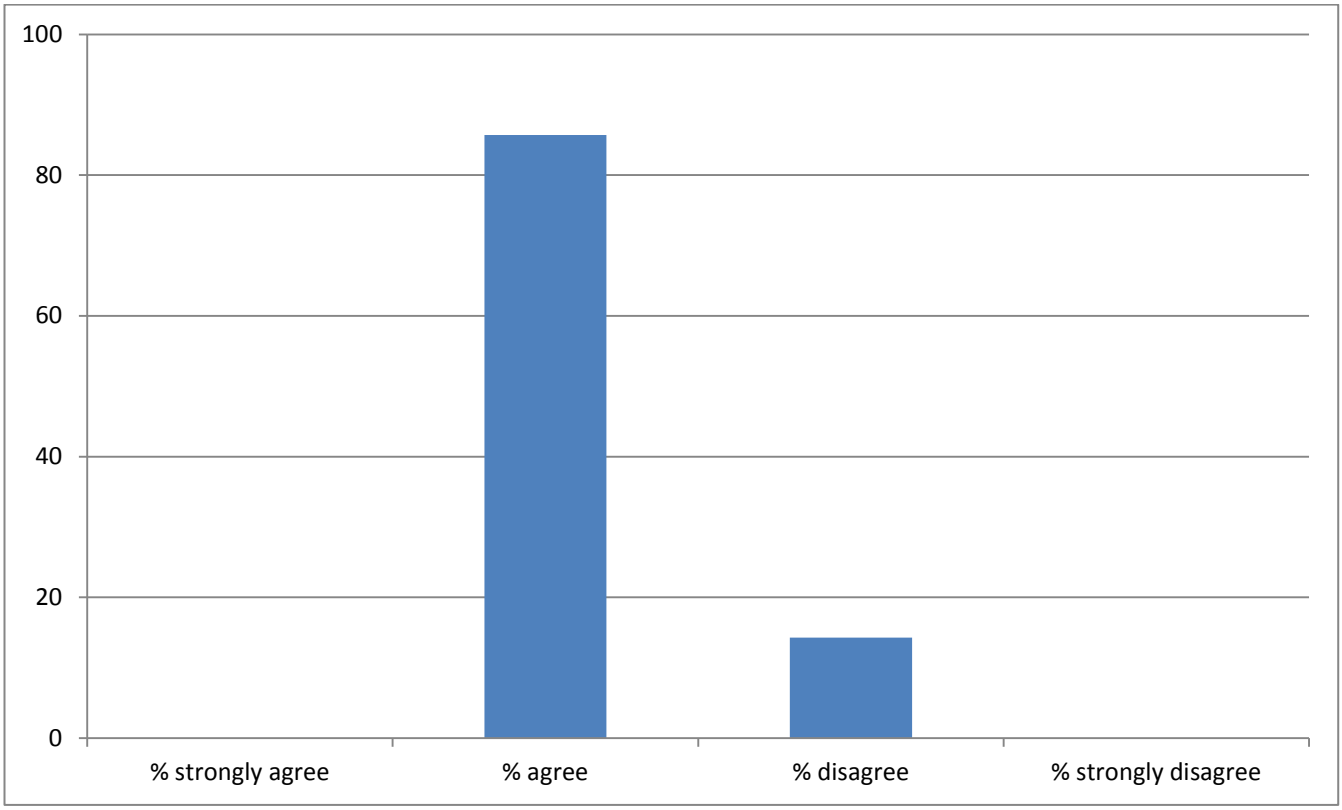



Figure 26: Response to Question 34. Unit 4: The unit description clearly describes the focus and scope for this unit (n=7)

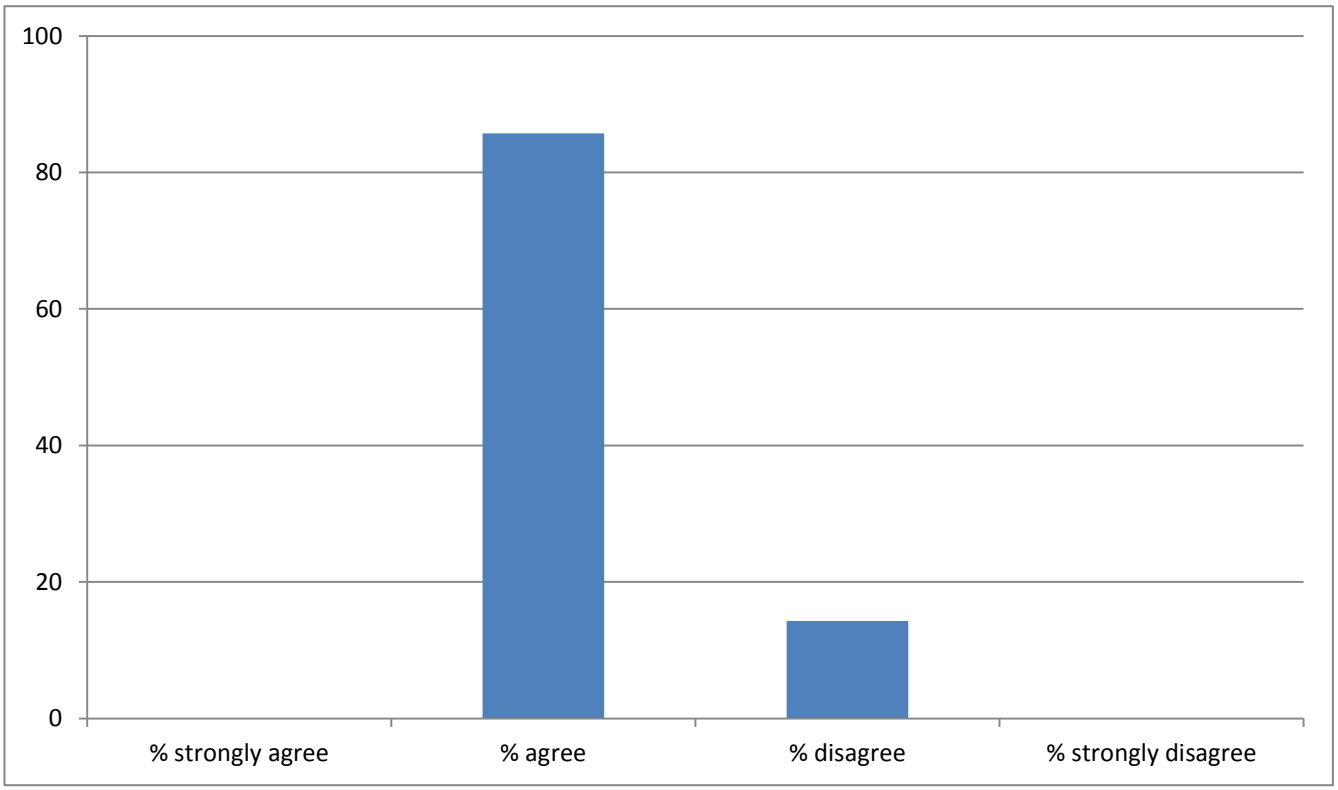


Figure 27: Response to Question 35. The unit outcomes describe clearly the expected learning for this unit (n=7)

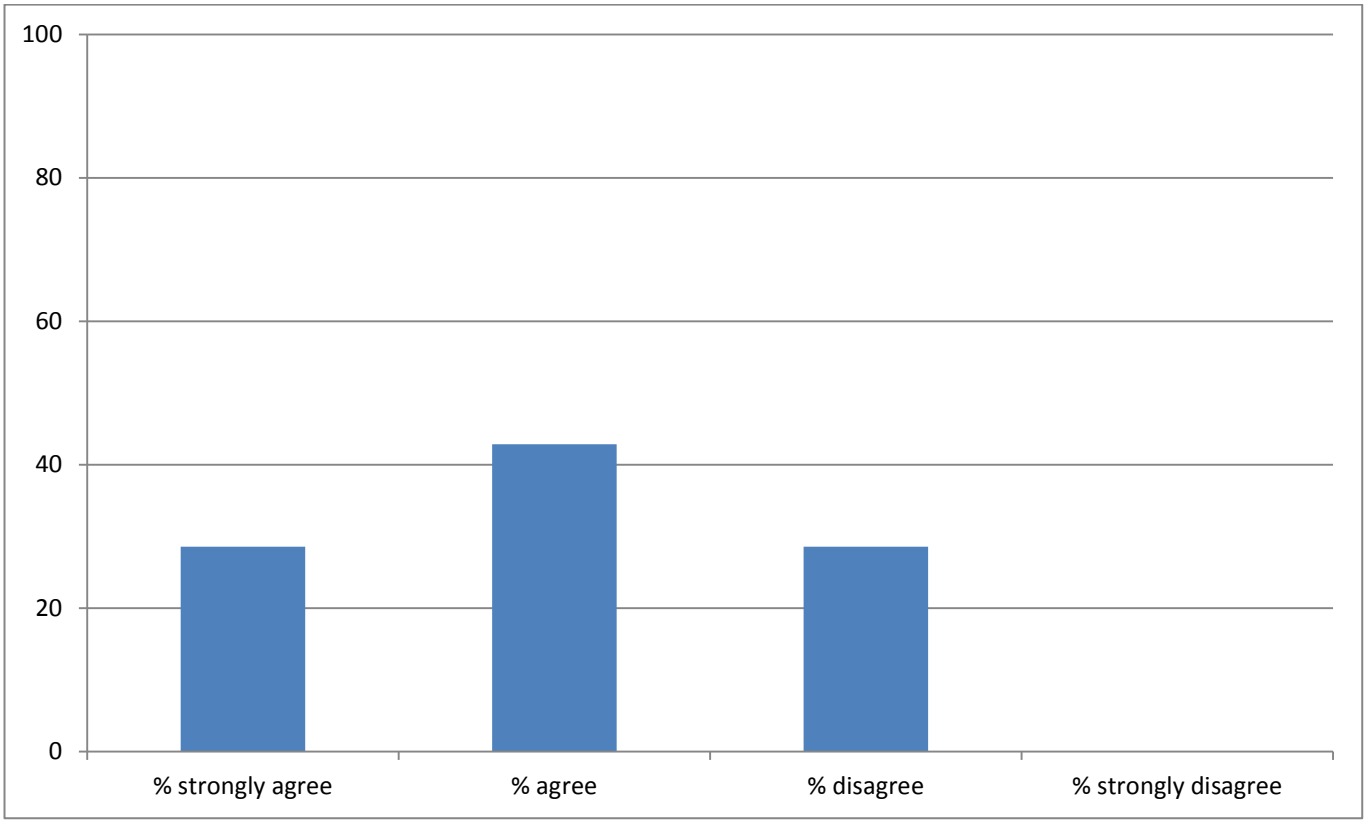



Figure 28: Response to Question 36. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=7)

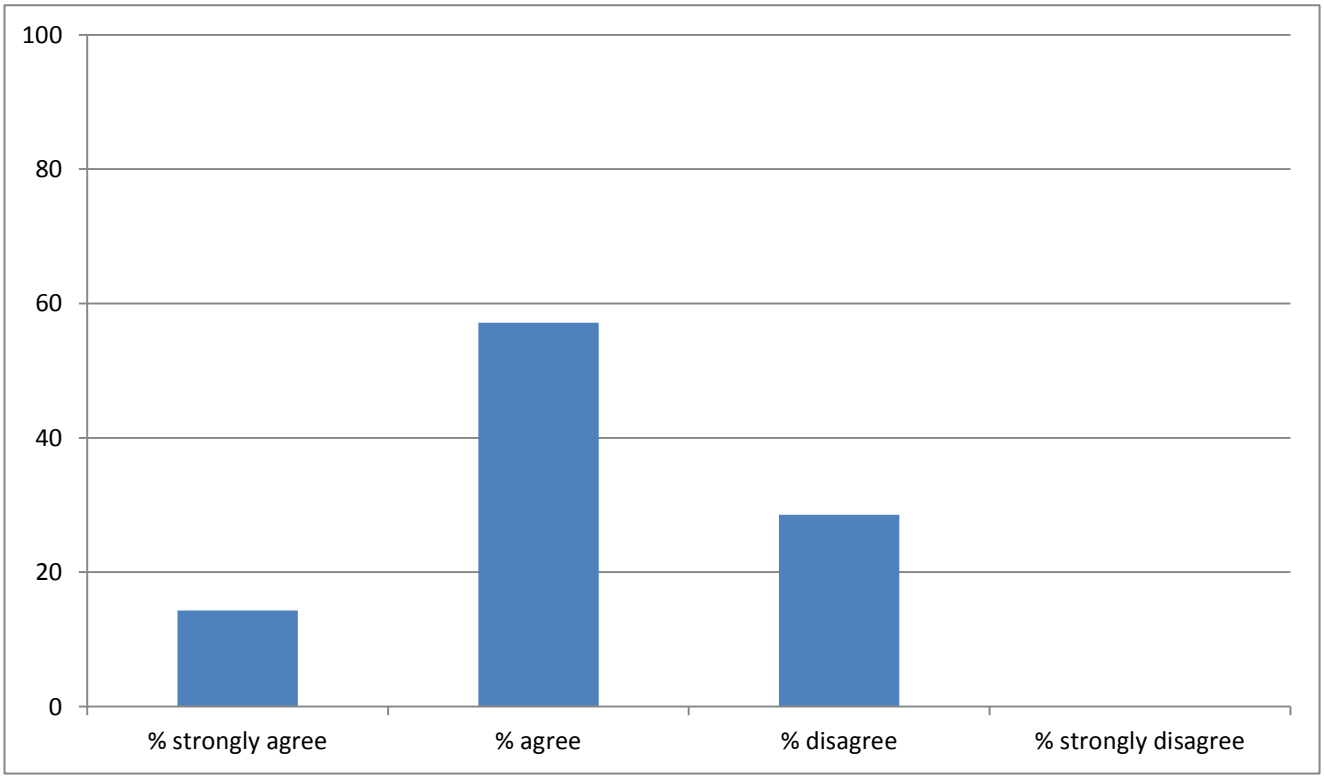


Figure 29: Response to Question 37. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=7)

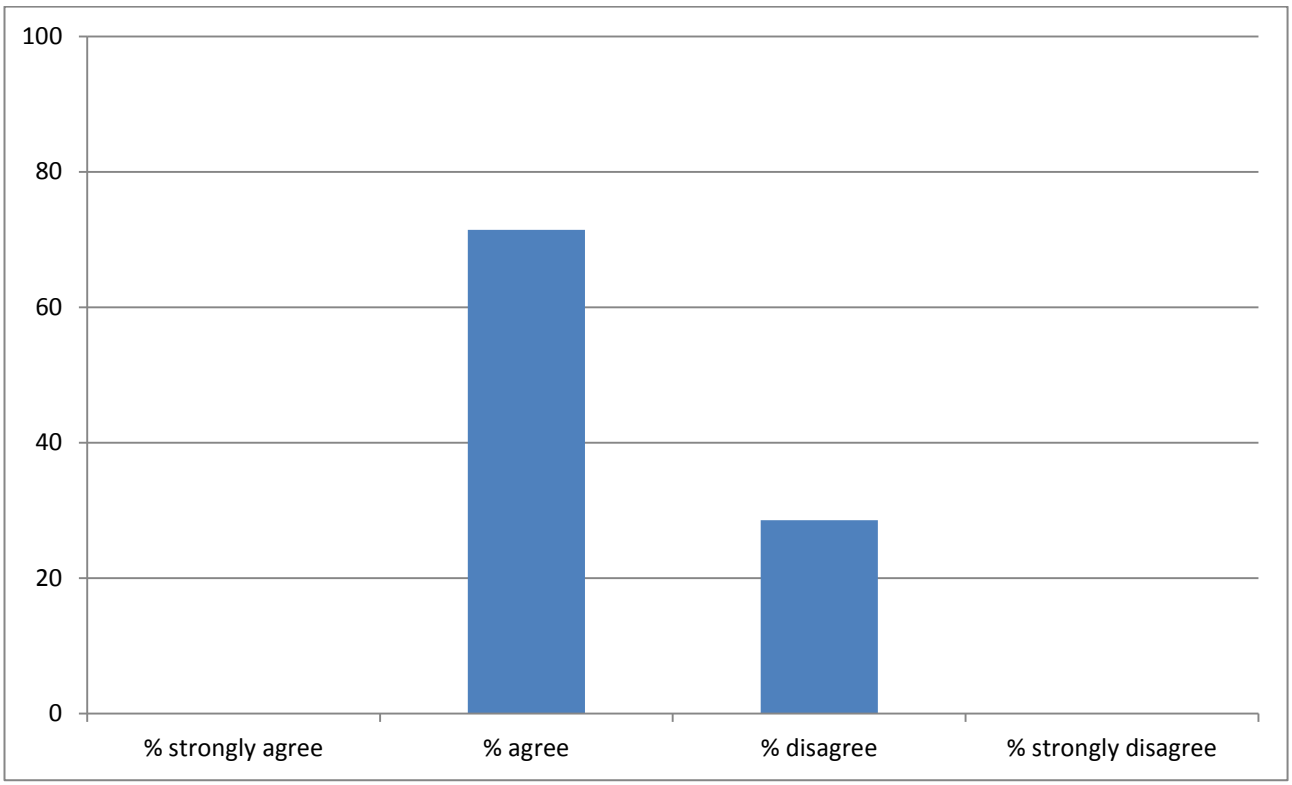



Figure 30: Response to Question 38. The content descriptions are specific about what is to be taught (n=6)

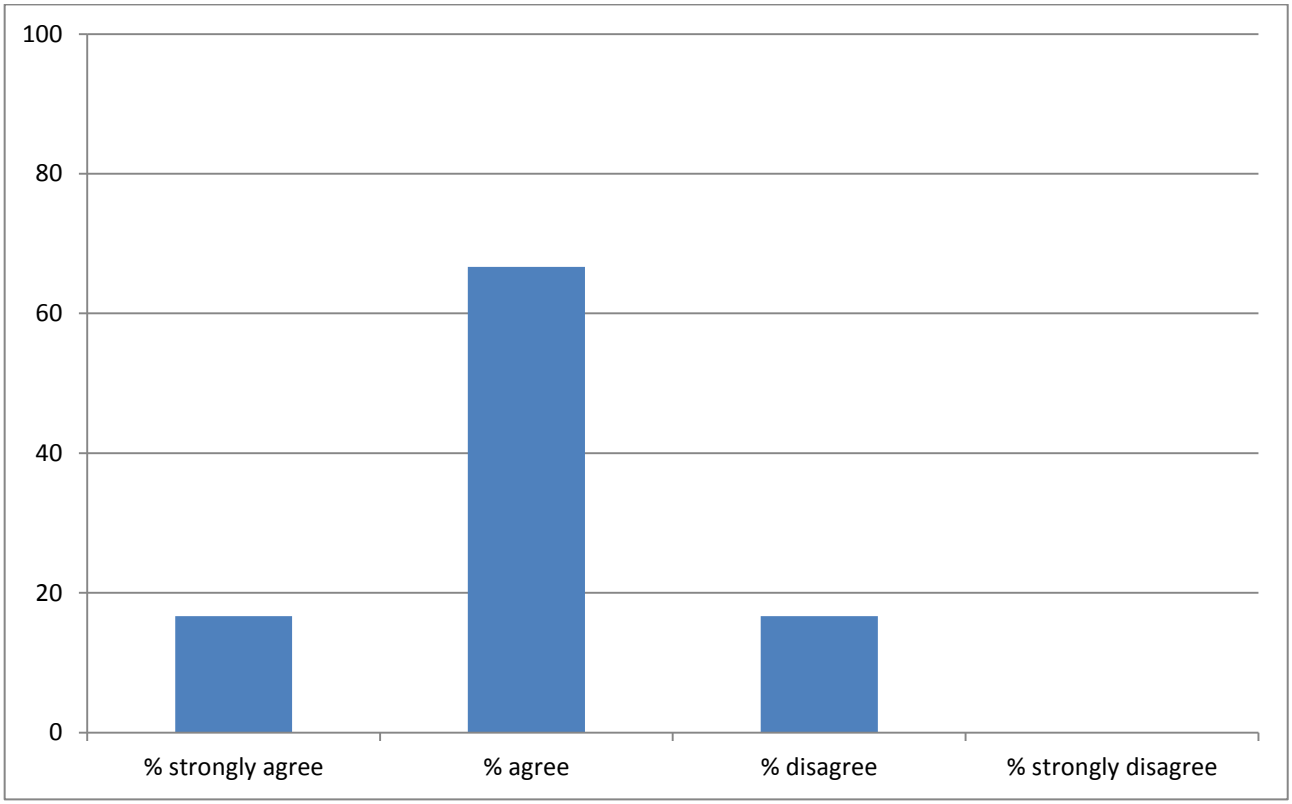


Figure 31: Response to Question 39. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=6)

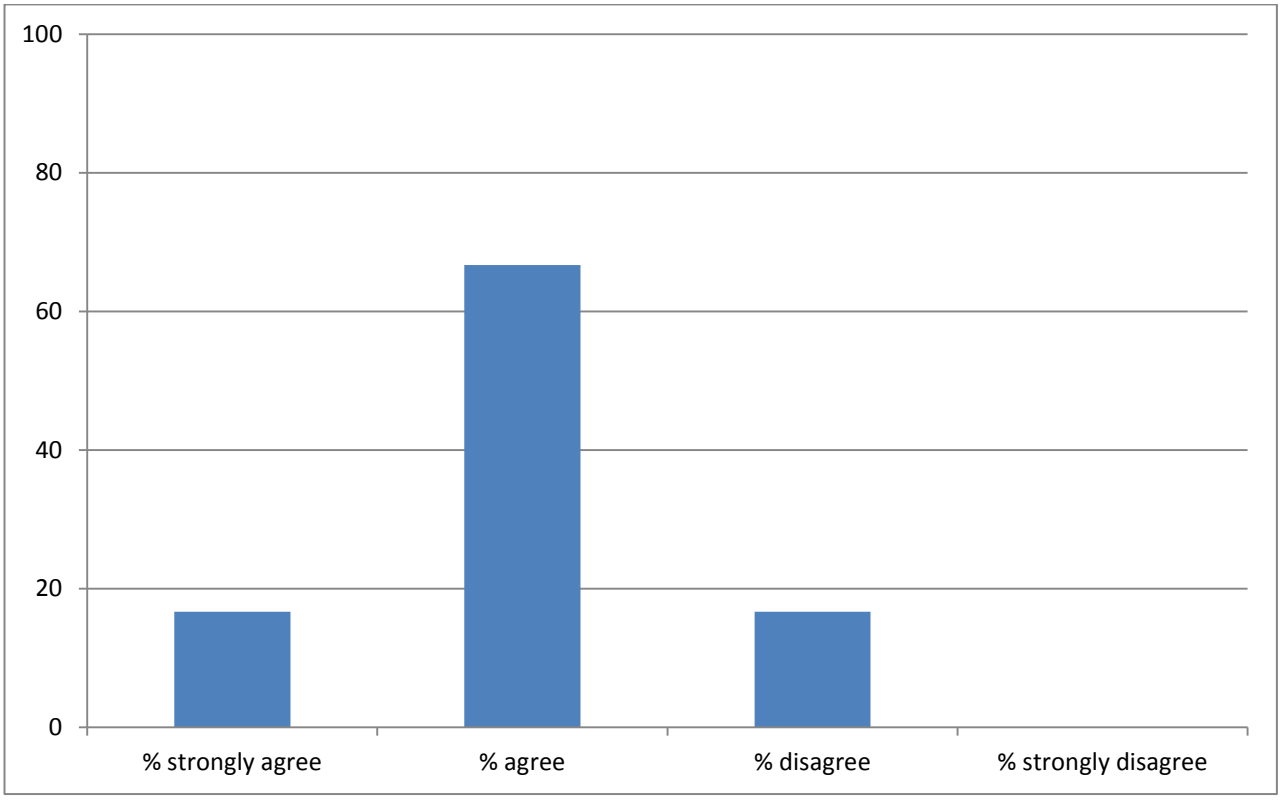



Figure 32: Response to Question 40. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=6)

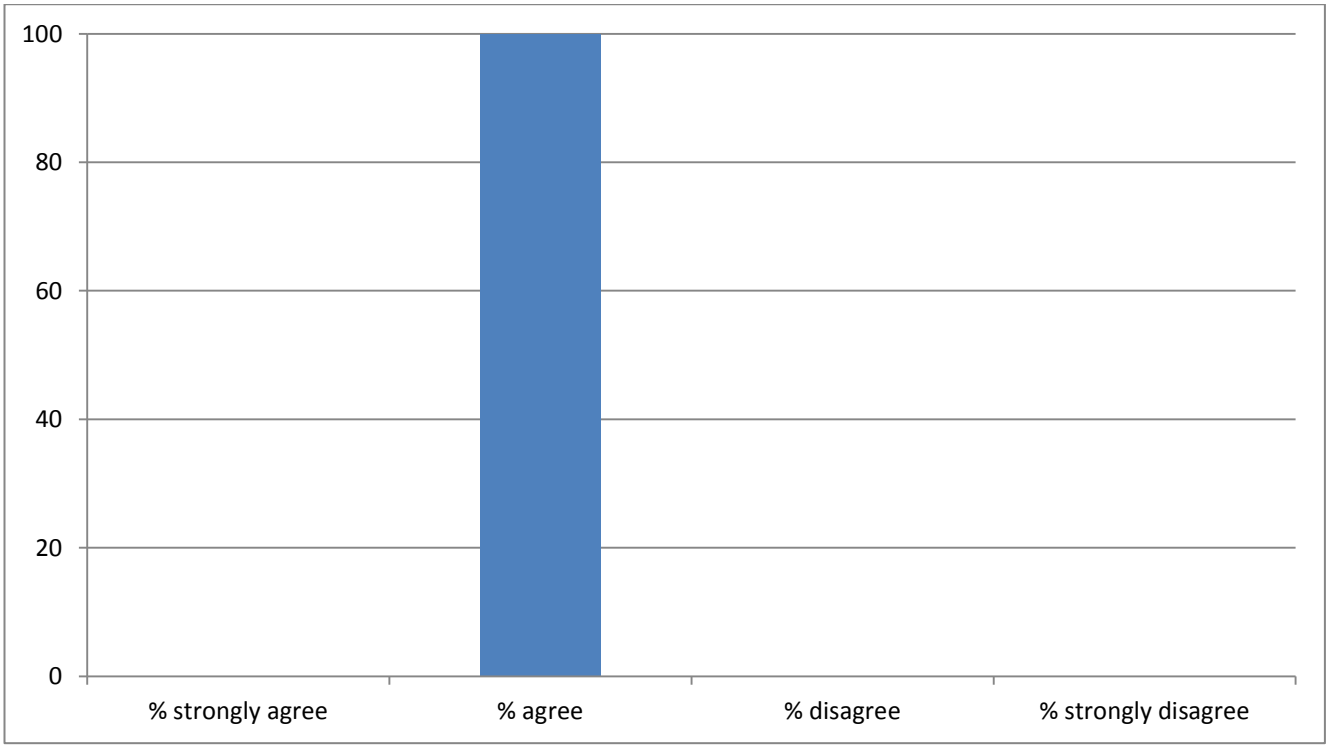


Figure 33: Response to Question 41. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=6)

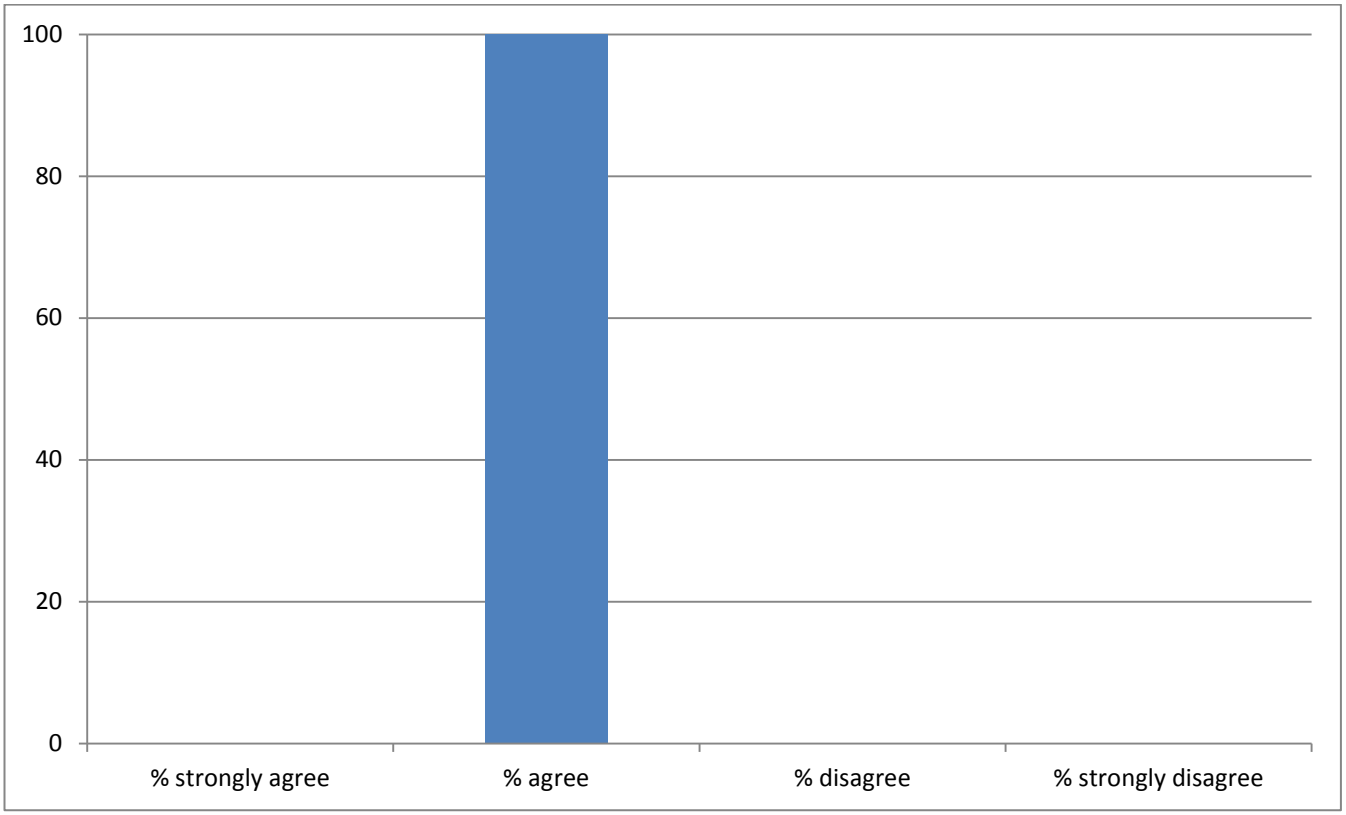



Figure 34: Response to Question 42. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=6)

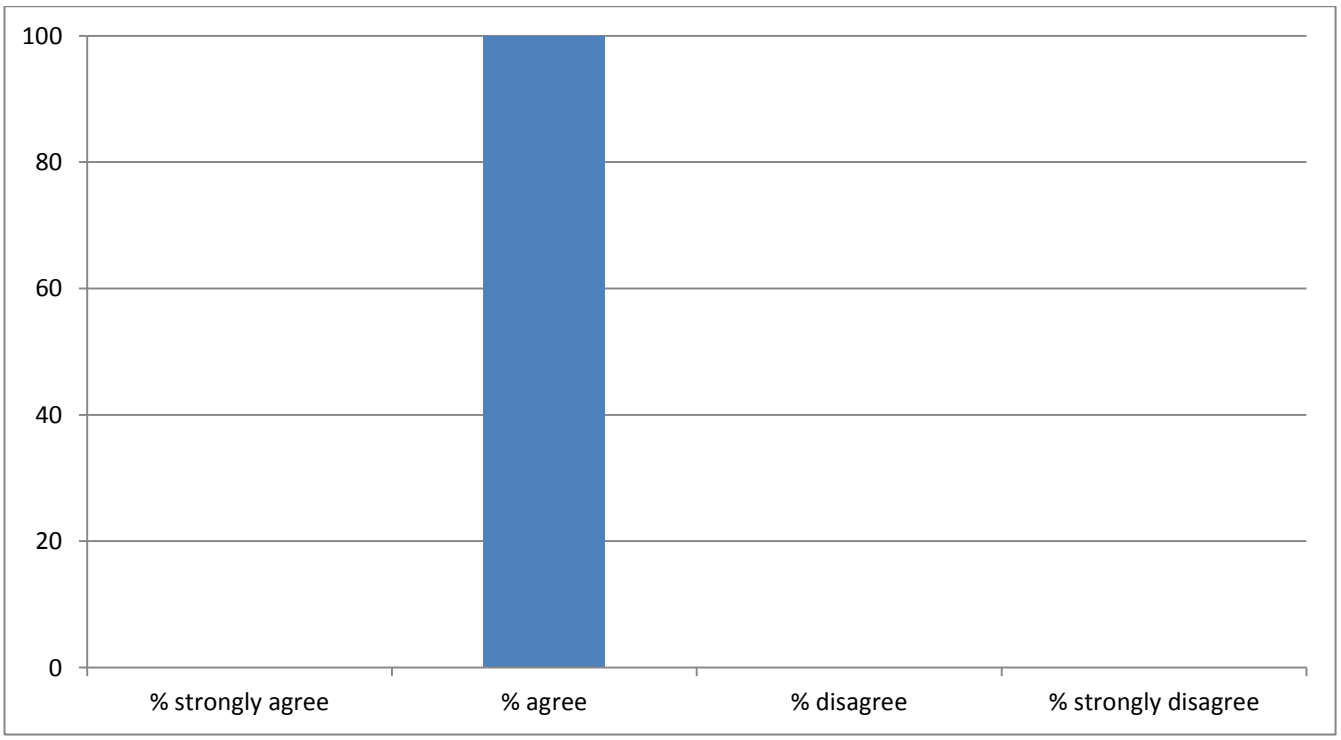


Figure 35: Response to Question 43. The general capabilities that naturally fit with this subject are appropriately represented (n=6)

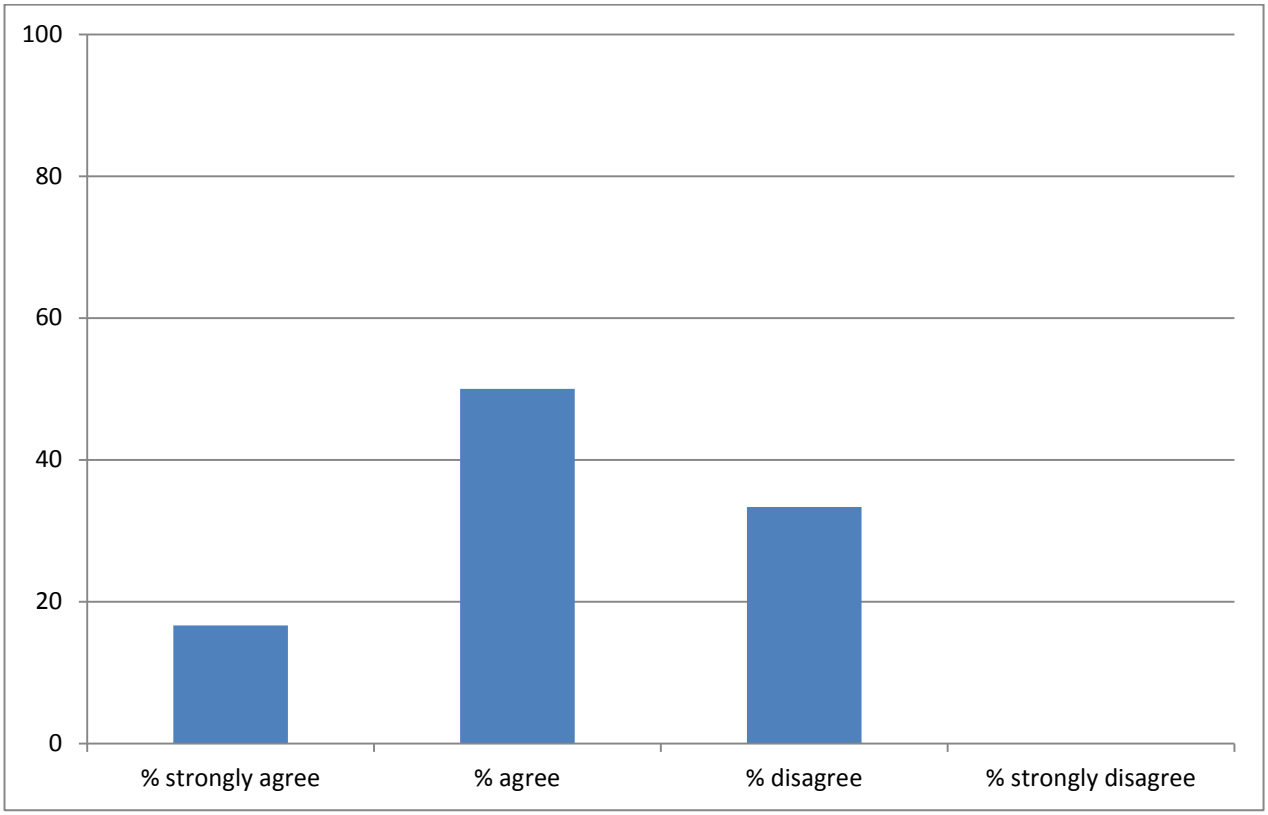



Figure 36: Response to Question 44. The cross-curriculum priorities that naturally fit with this subject are appropriately represented (n=7)

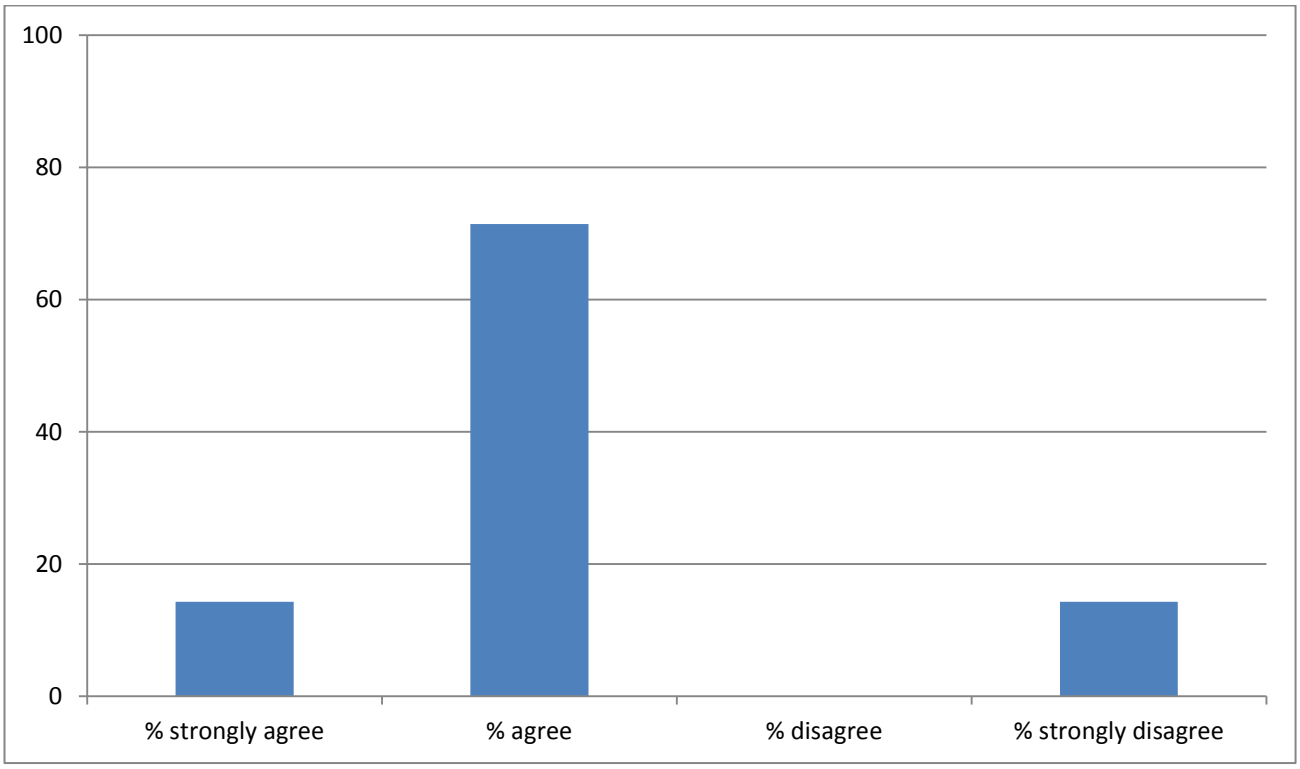
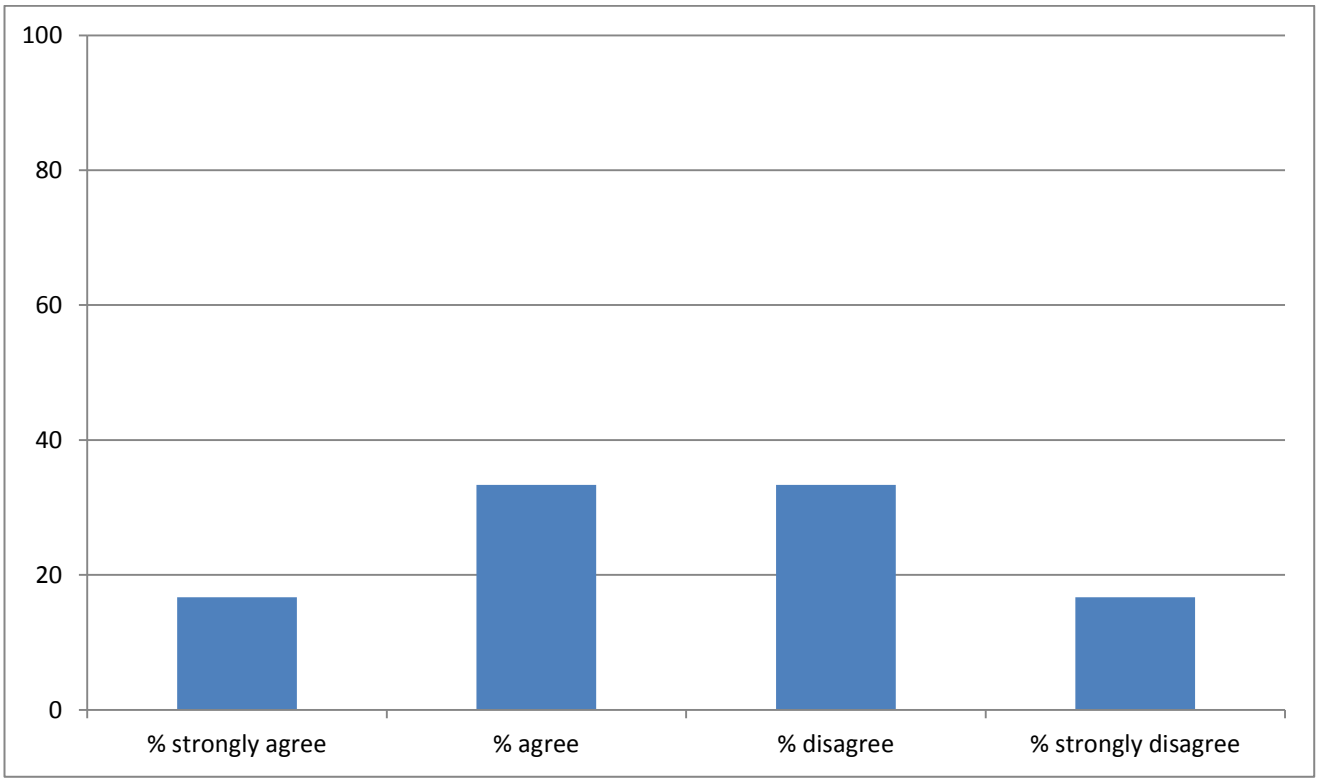


Figure 37: Response to Question 45. The glossary is comprehensive (n=6)



## Physics

Figure 1: Response to Question 9. The rationale provides clarity about the subject's broad scope, distinctive nature and importance (n=22)

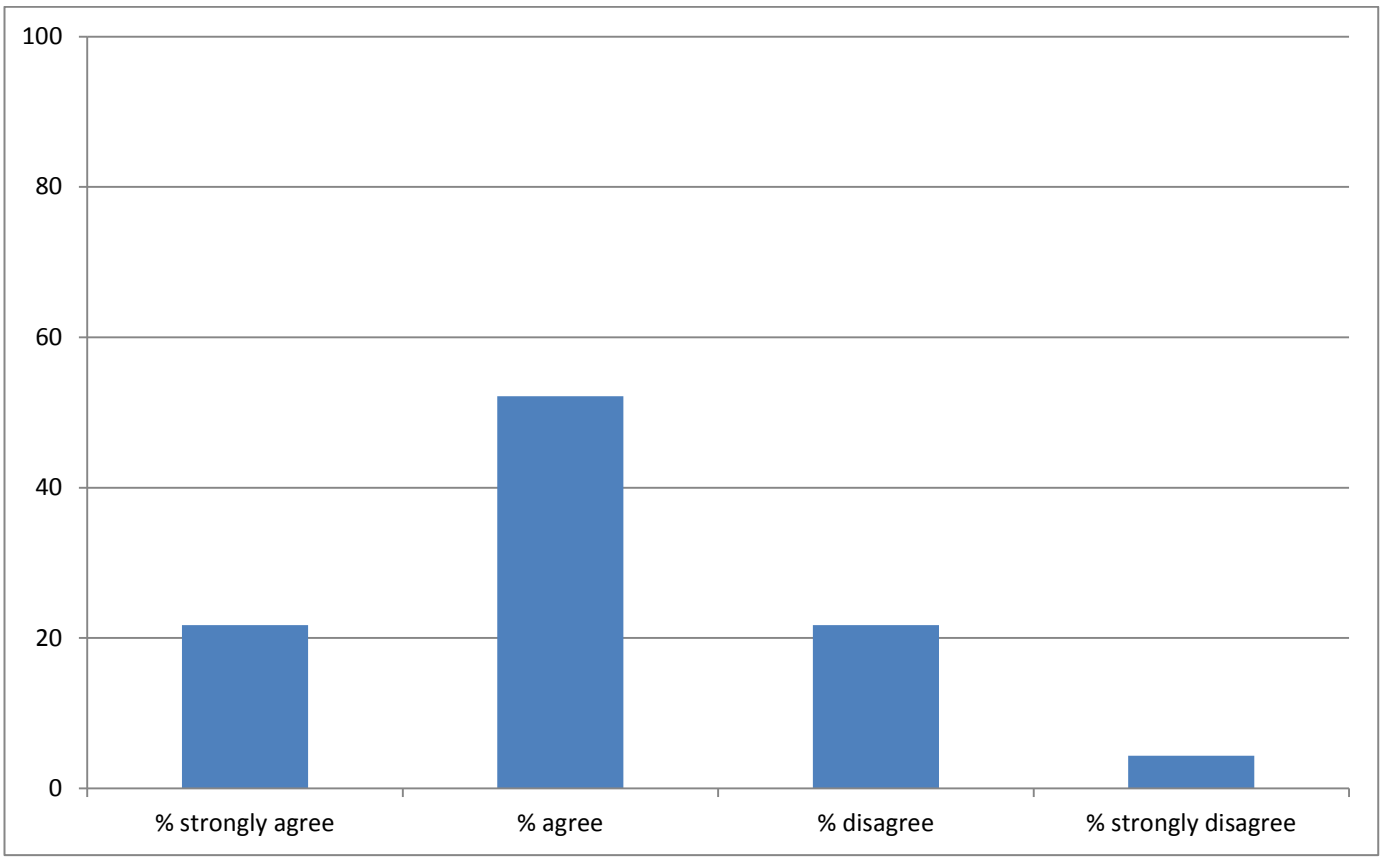



Figure 2: Response to Question 10. The aims comprehensively describe the intended learning as a result of studying the subject (n=20)

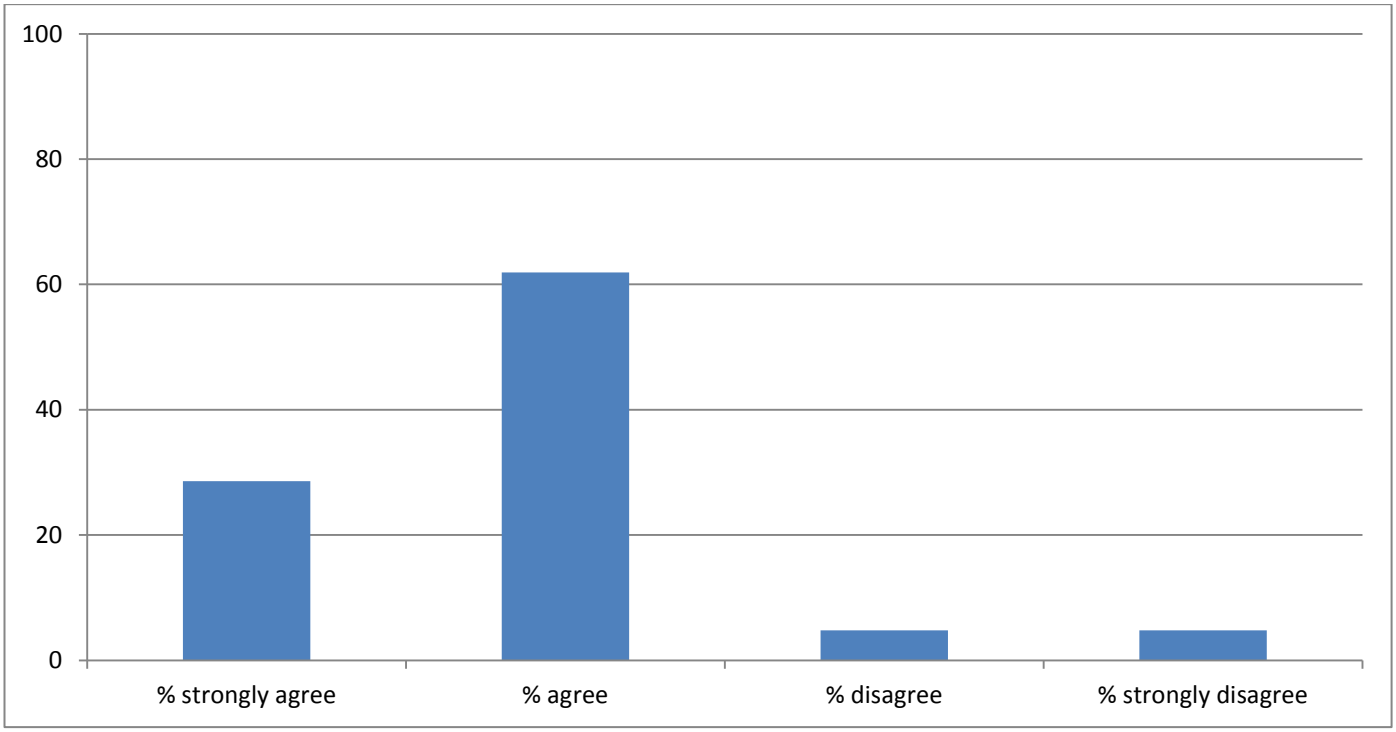


Figure 3: Response to Question 11. The four-unit structure has internal logic and coherence (n=33)

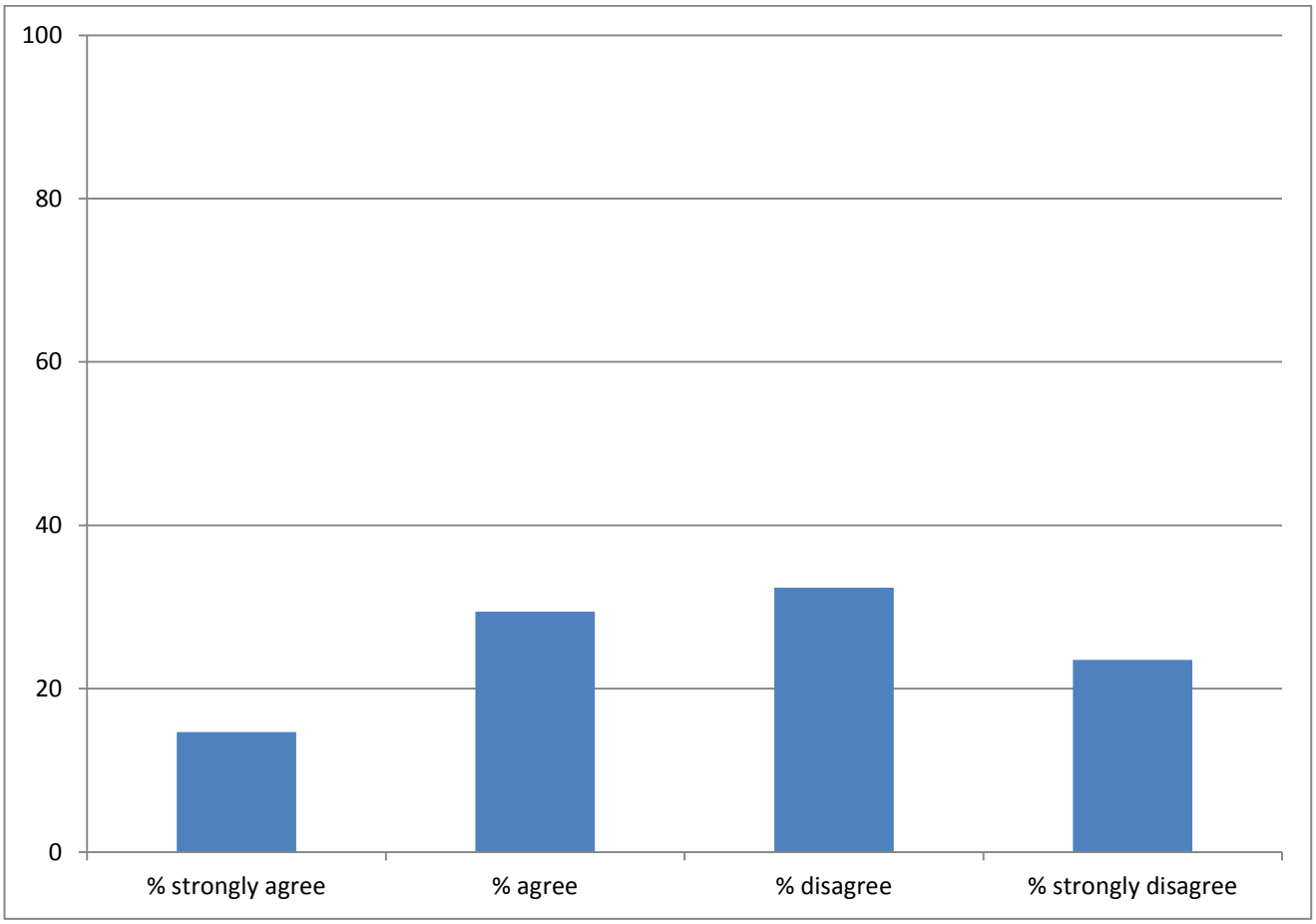



Figure 4: Response to Question 12. Units 3 and 4 are more cognitively demanding than Units 1 and 2 (n=33)

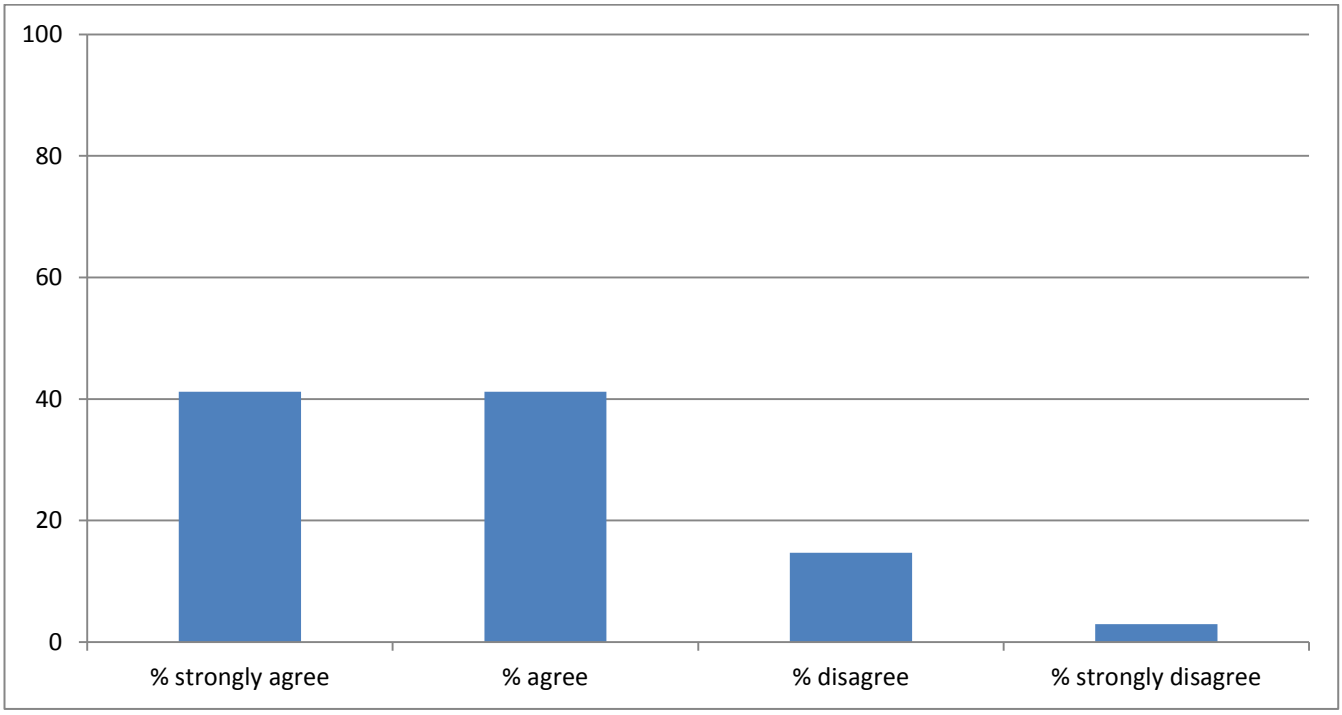


Figure 5: Response to Question 13. There is a clear link between this senior secondary curriculum and the relevant F–10 Australian Curriculum (n=31)

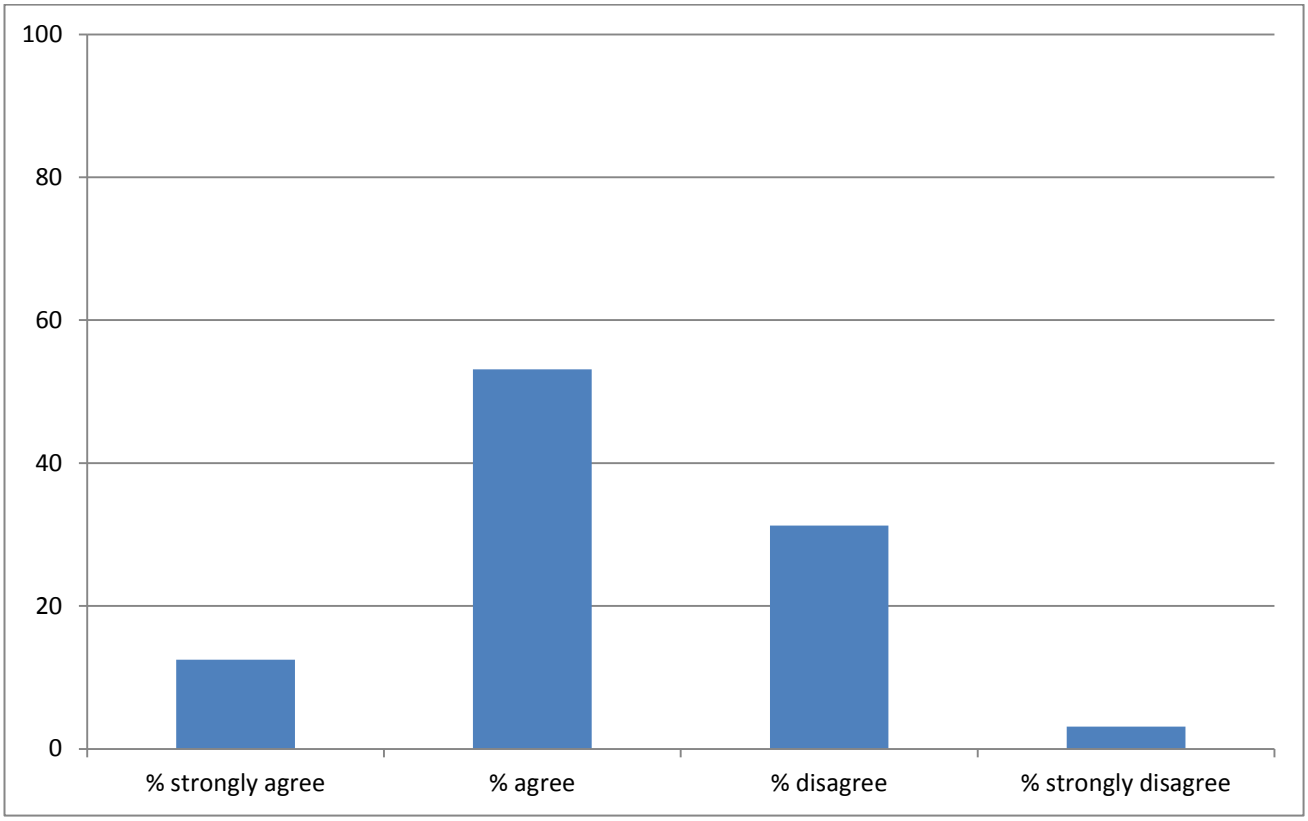



Figure 6: Response to Question 14. The achievement standards across Units 1 and 2 and Units 3 and 4 are organised in an order consistent with your experience (n=32)

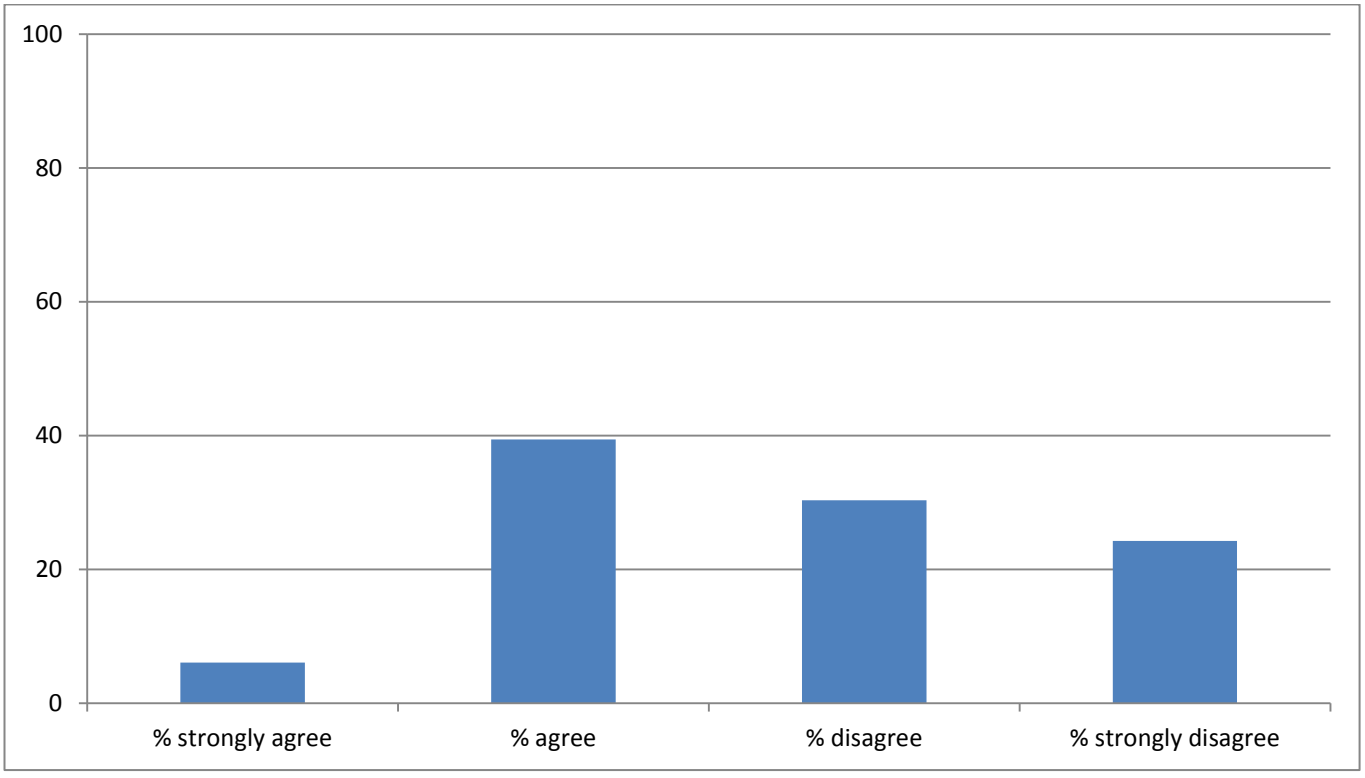


Figure 7: Response to Question 15. Unit 1: The unit description describes the focus and scope for this unit (n=28)

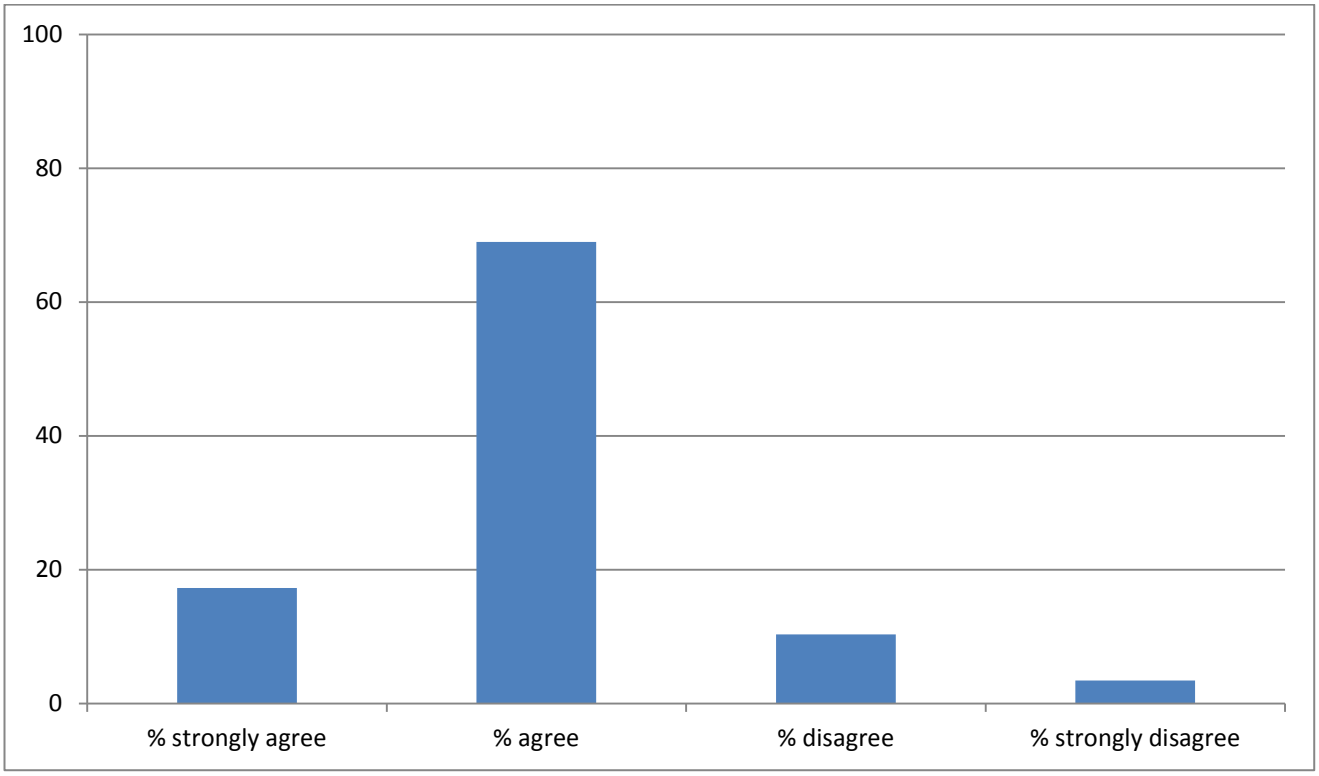



Figure 8: Response to Question 16. The outcomes describe clearly the expected learning for this unit (n=27)

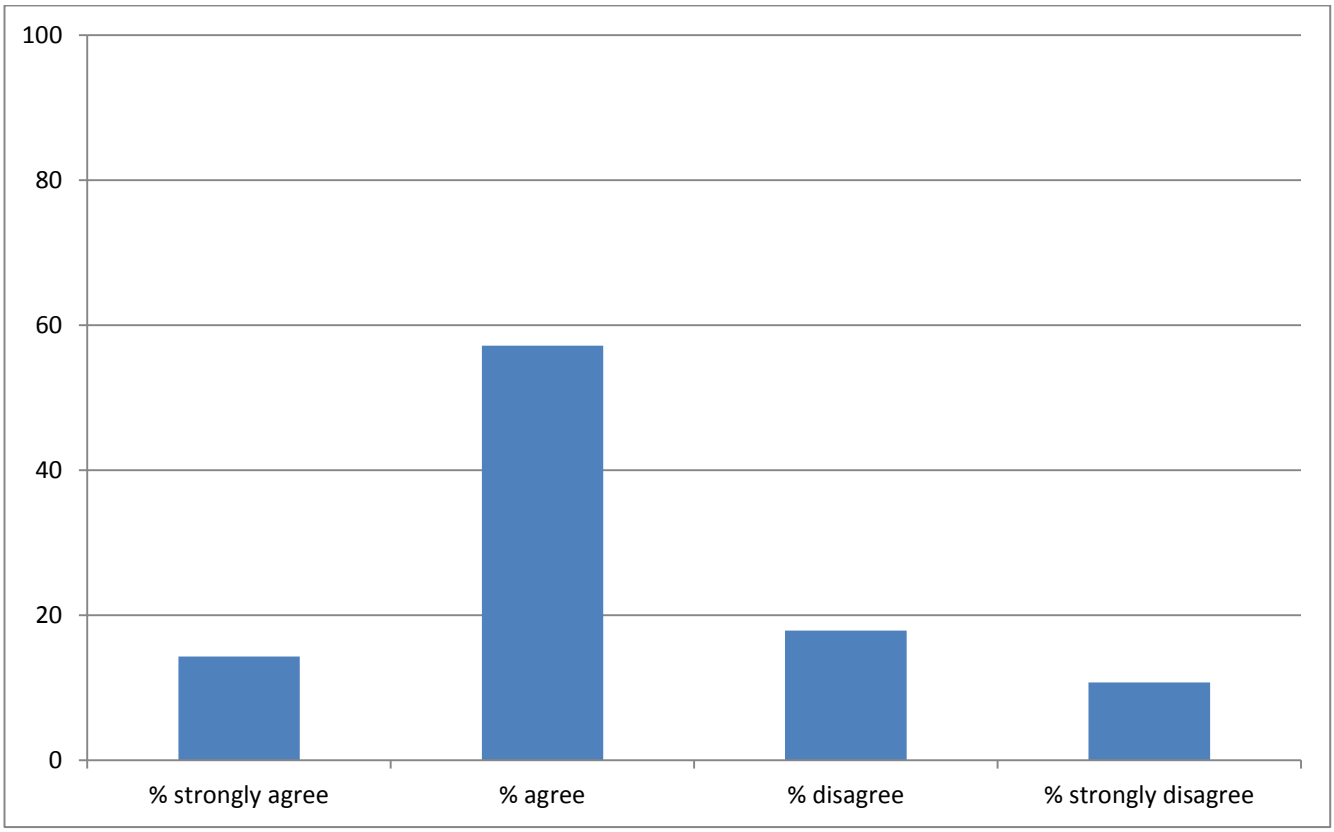


Figure 9: Response to Question 17. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=29)

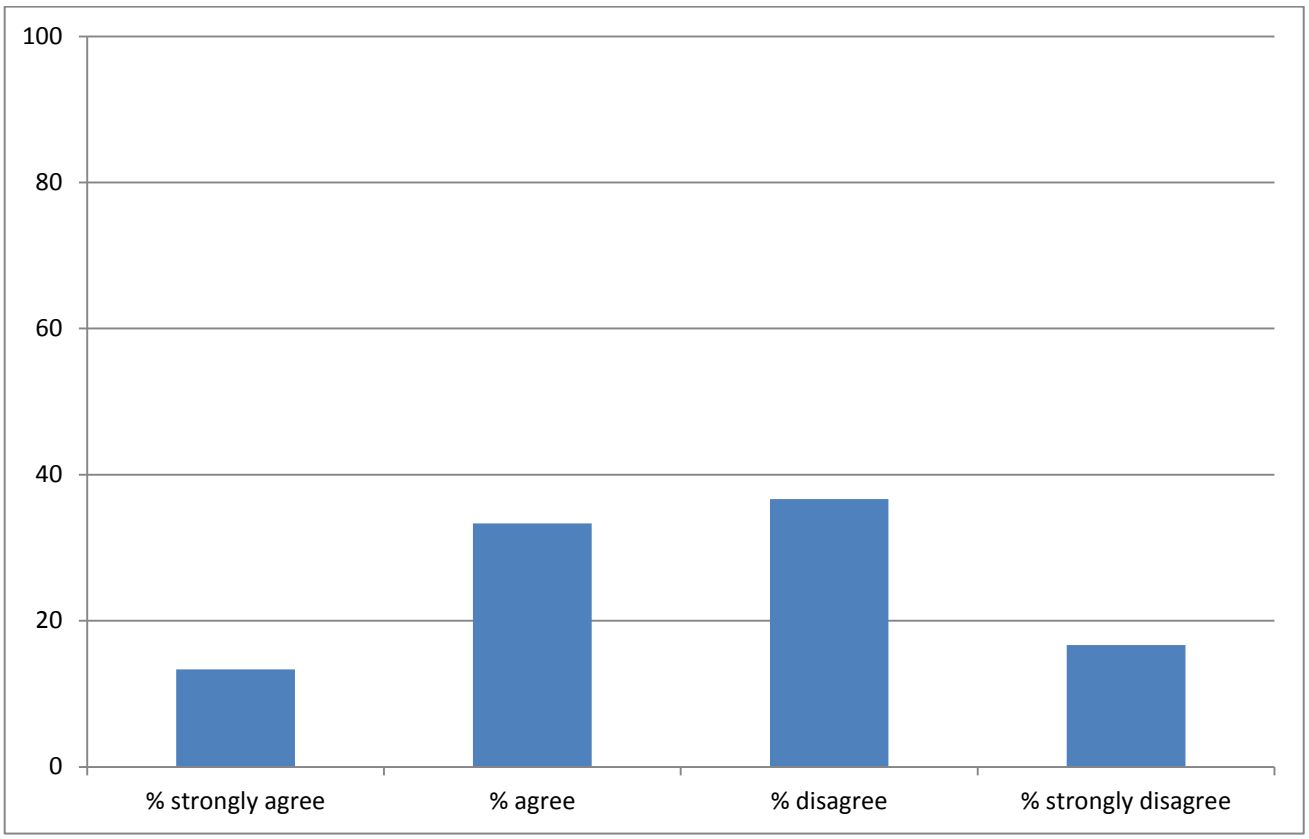



Figure 10: Response to Question 18. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=30)

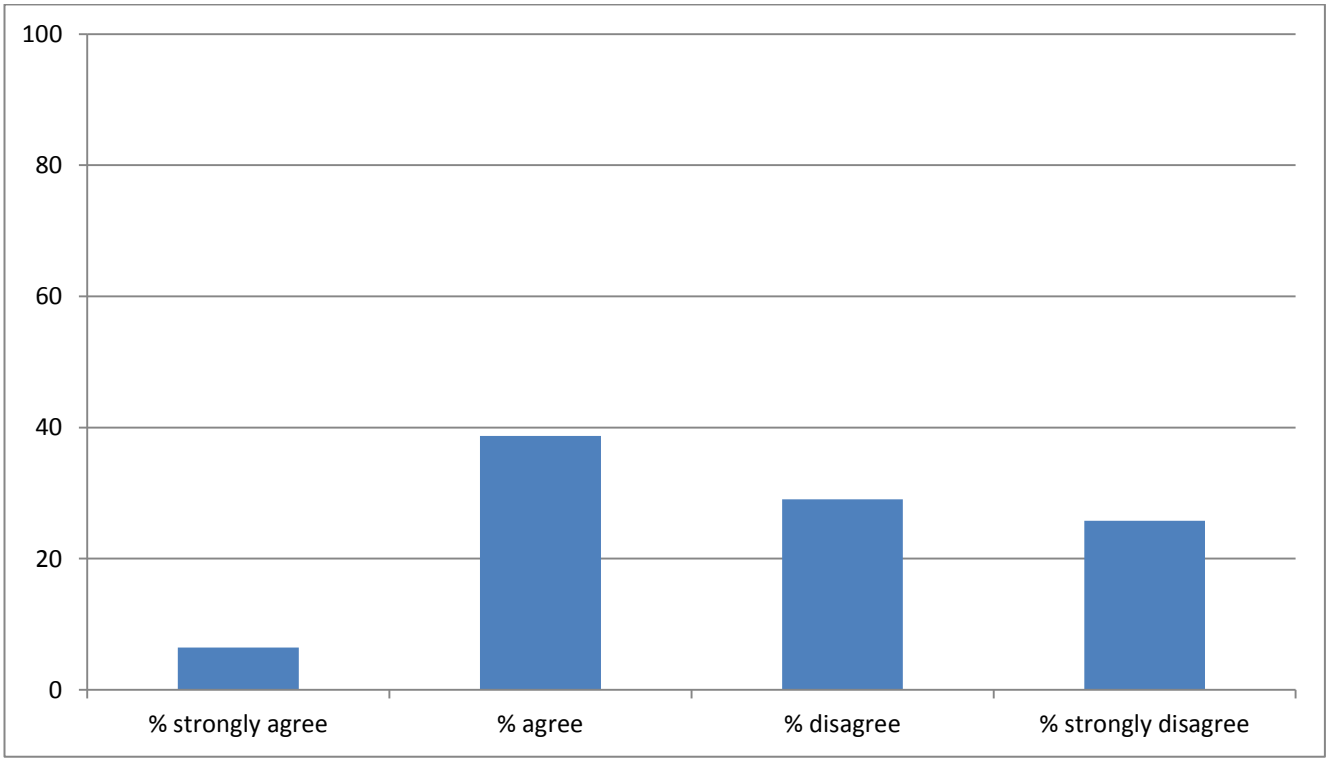


Figure 11: Response to Question 19. The content descriptions are specific about what is to be taught (n=28)

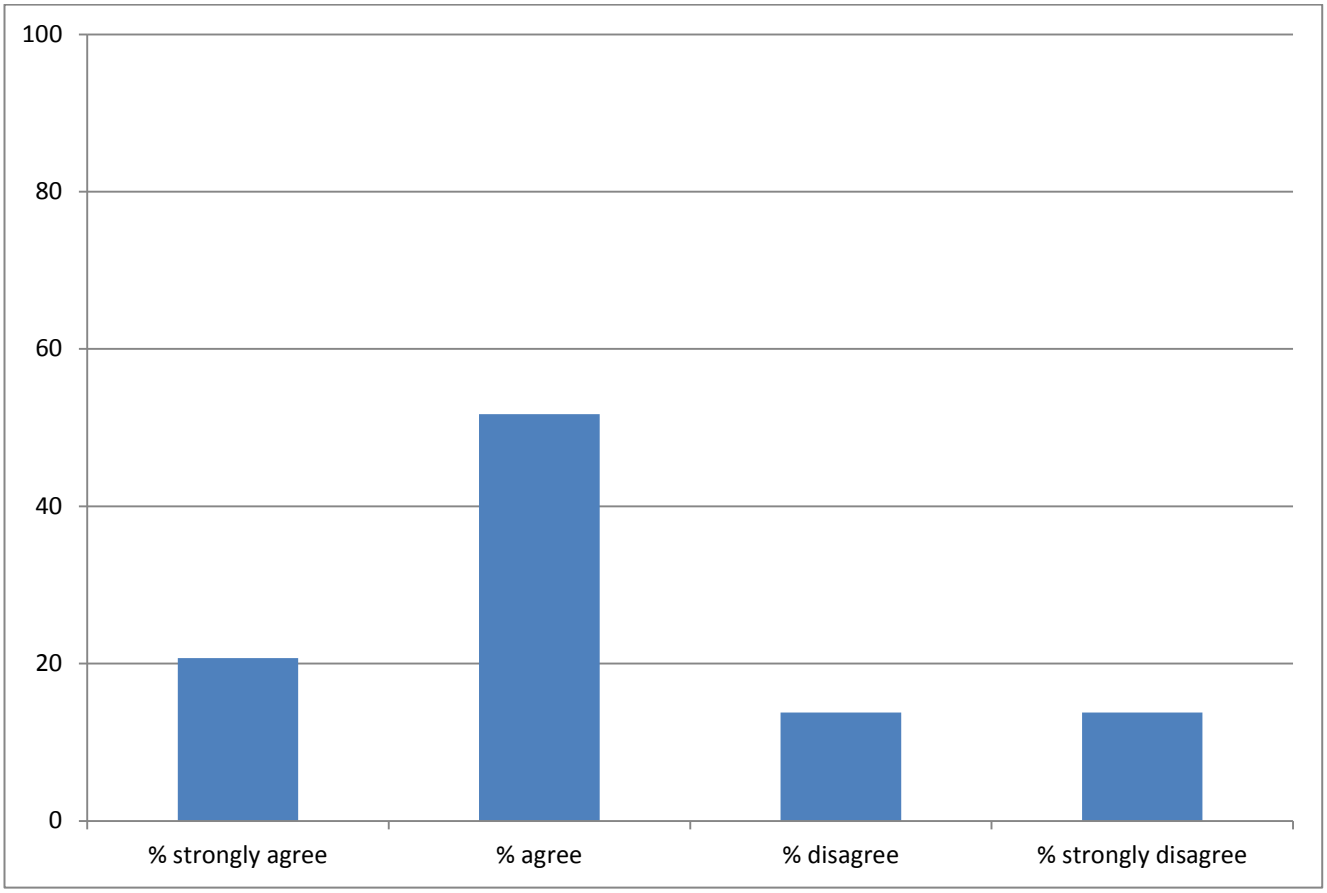



Figure 12: Response to Question 20. Unit 2: The unit description clearly describes the focus and scope for this unit (n=28)

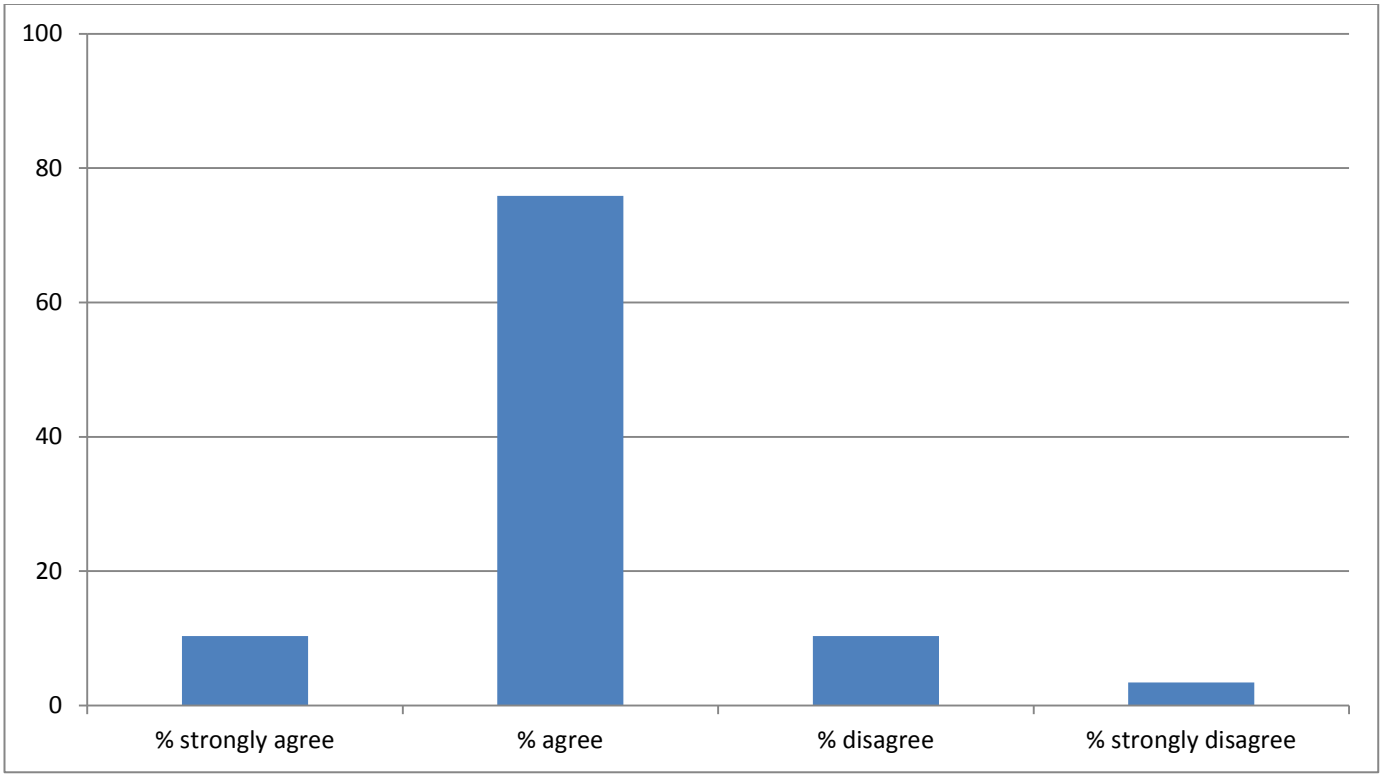


Figure 13: Response to Question 21. The unit outcomes describe clearly the expected learning for this unit (n=27)

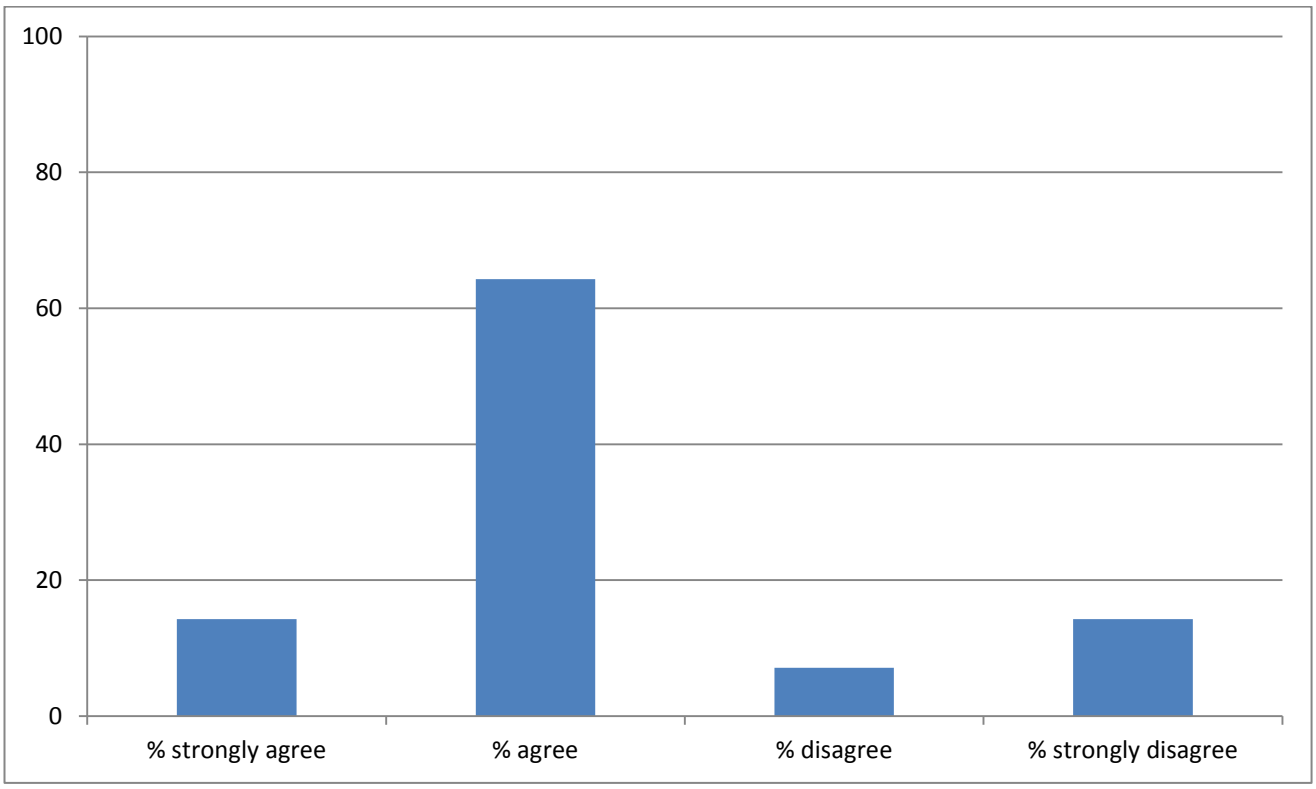



Figure 14: Response to Question 22. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=28)

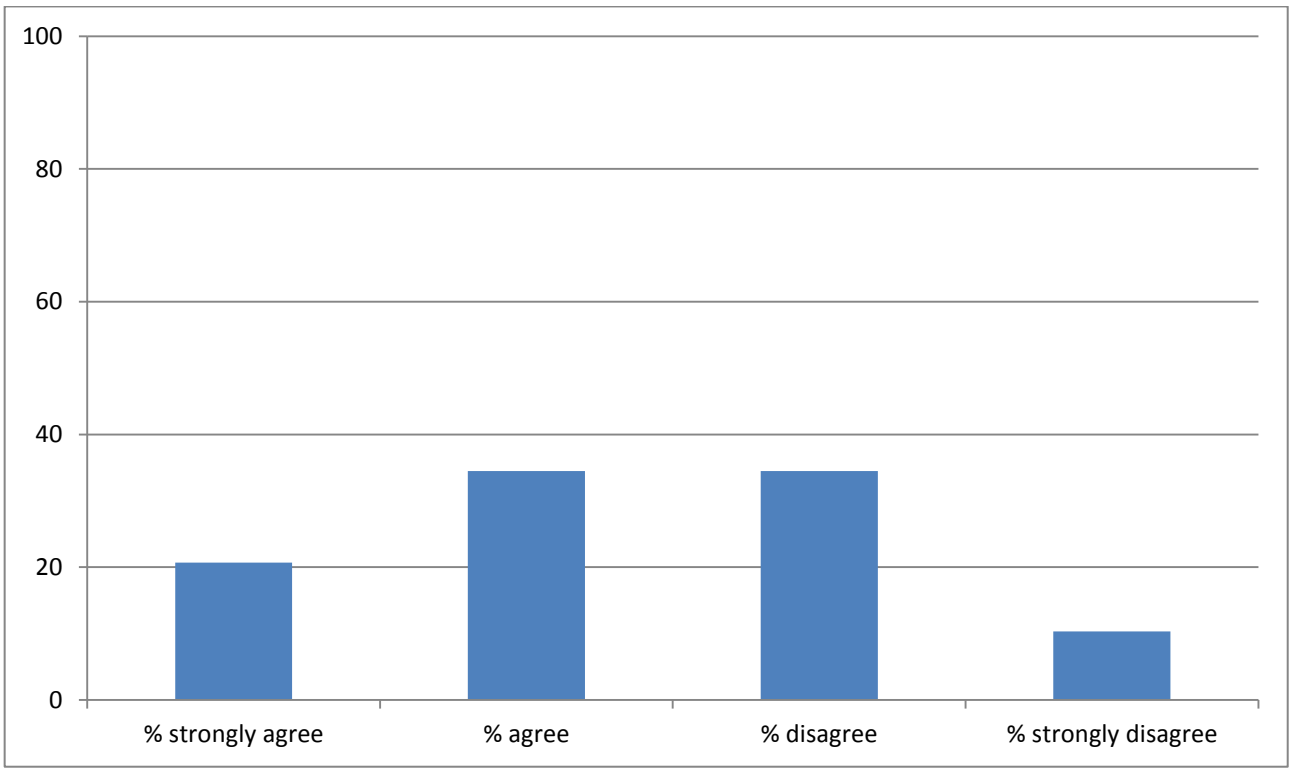


Figure 15: Response to Question 23. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=28)

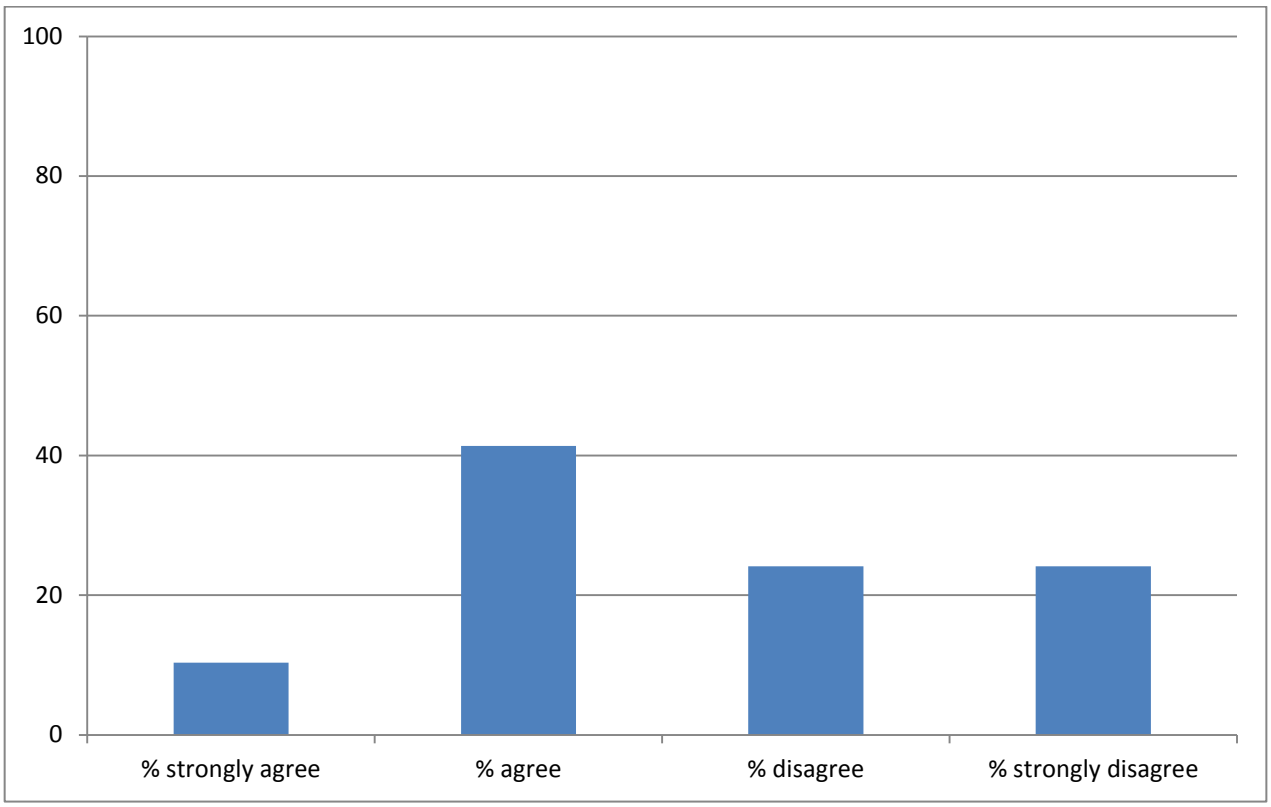



Figure 16: Response to Question 24. The content descriptions are specific about what is to be taught (n=26)

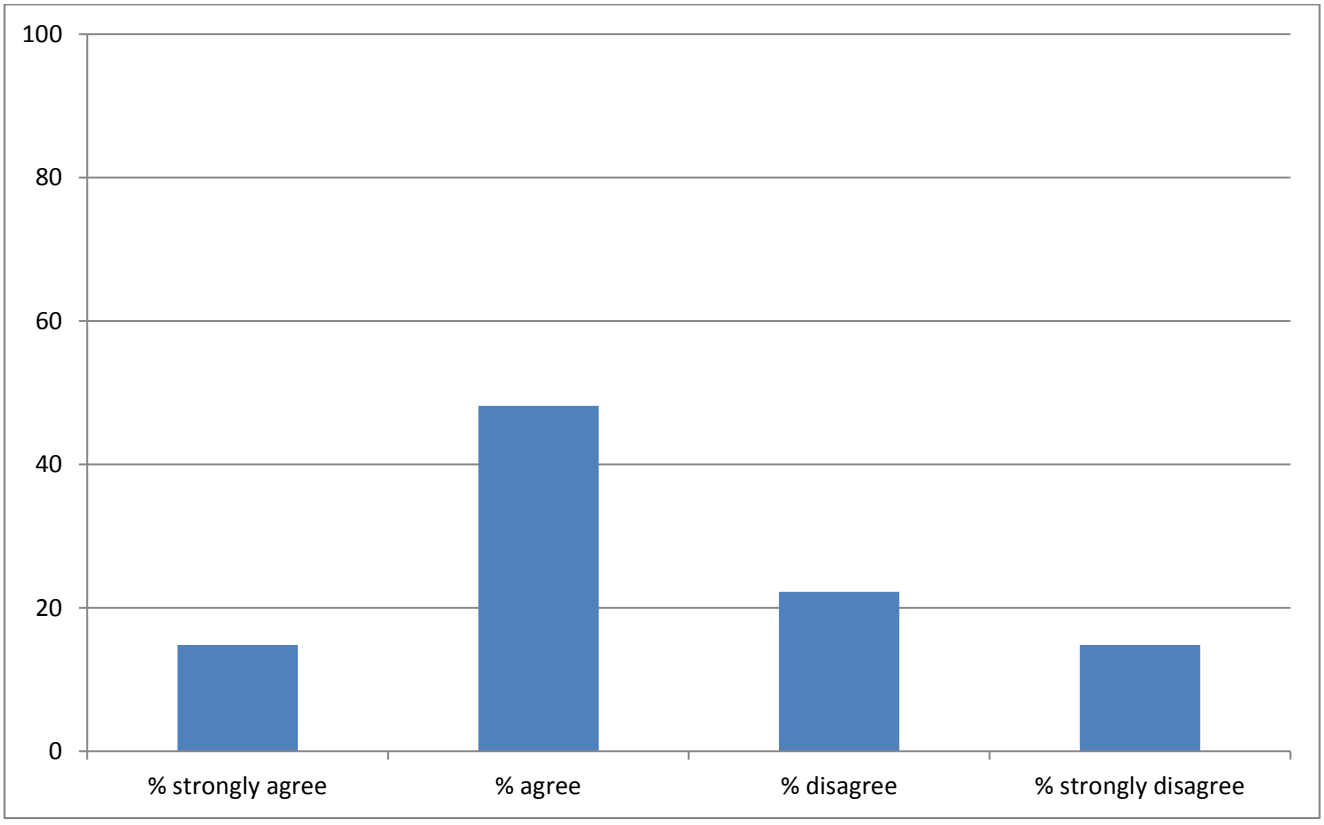


Figure 17: Response to Question 25. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=26)

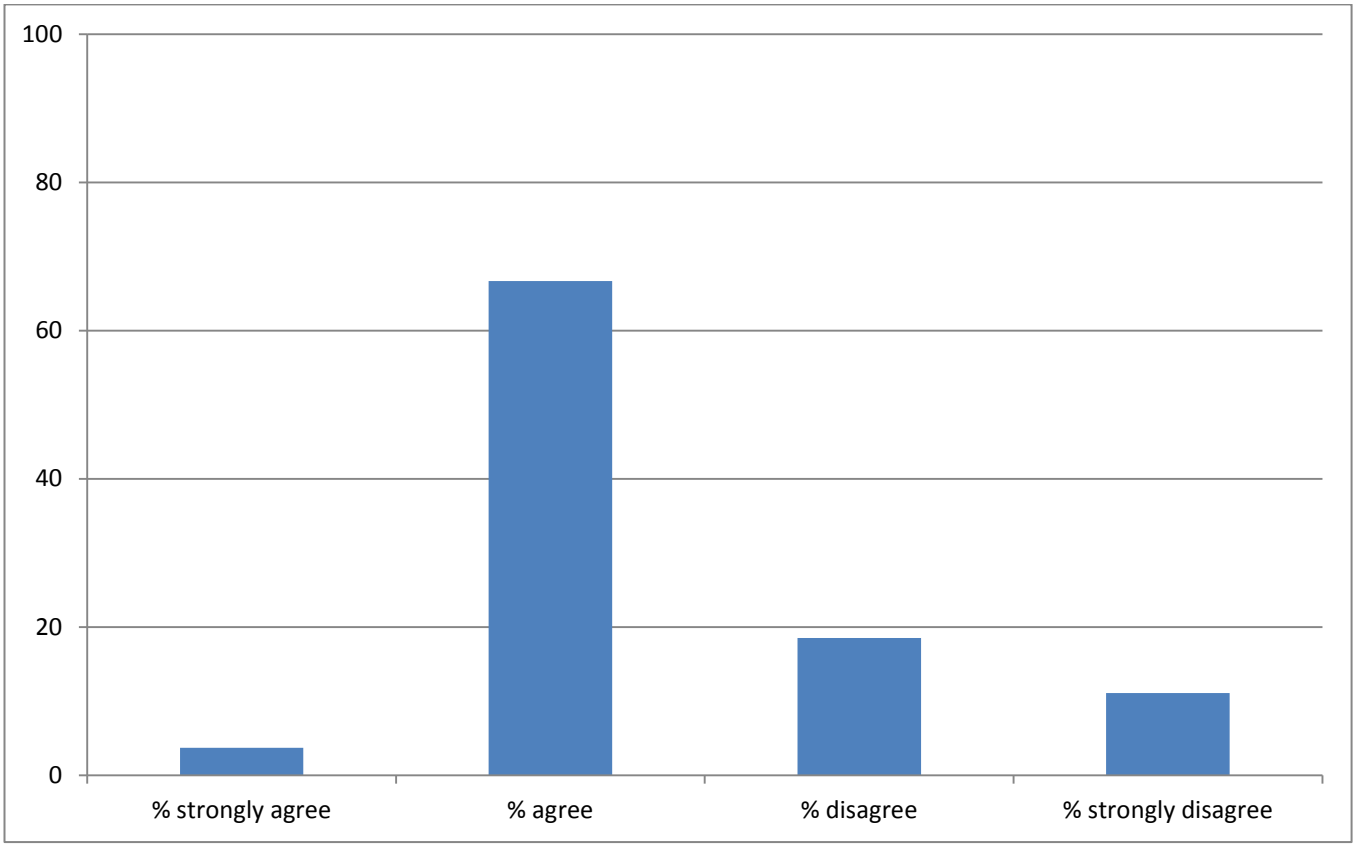



Figure 18: Response to Question 26. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=26)

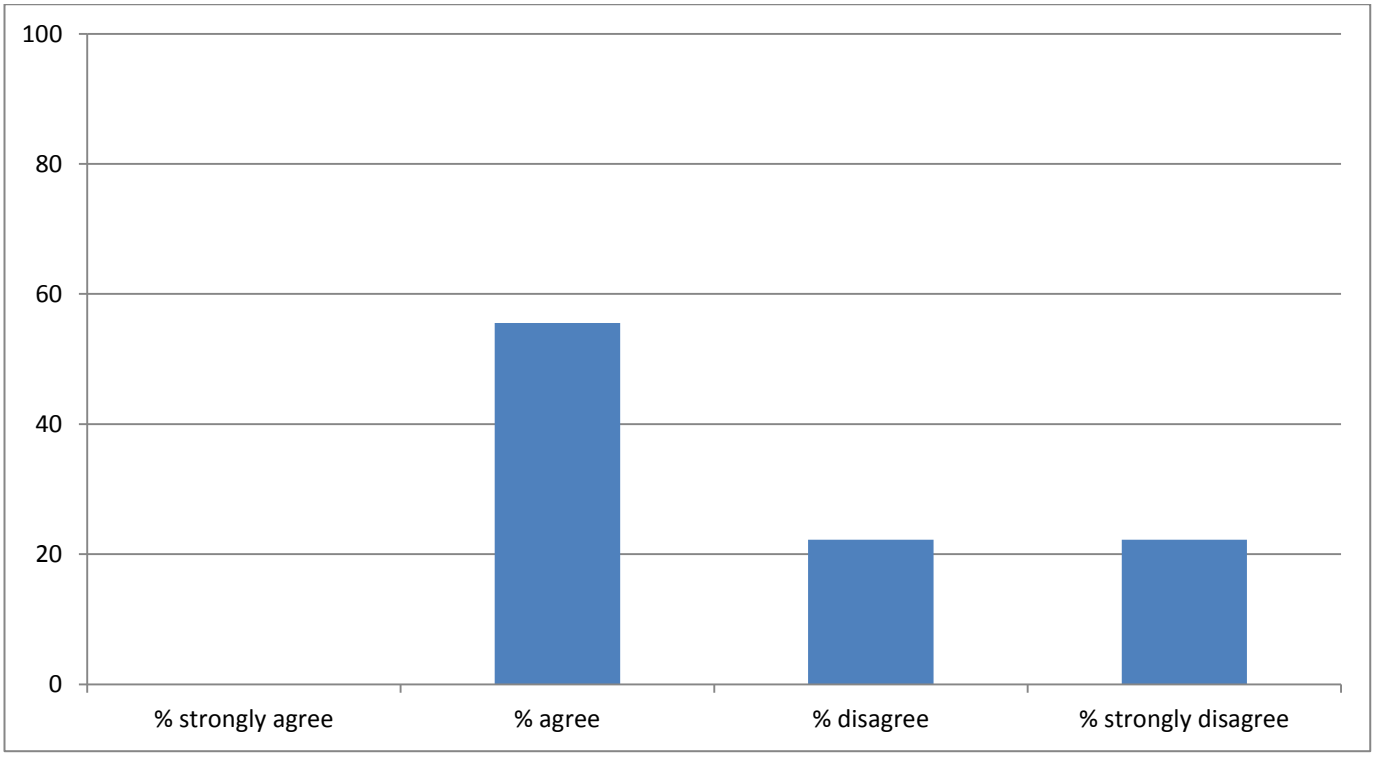


Figure 19: Response to Question 27. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=26)

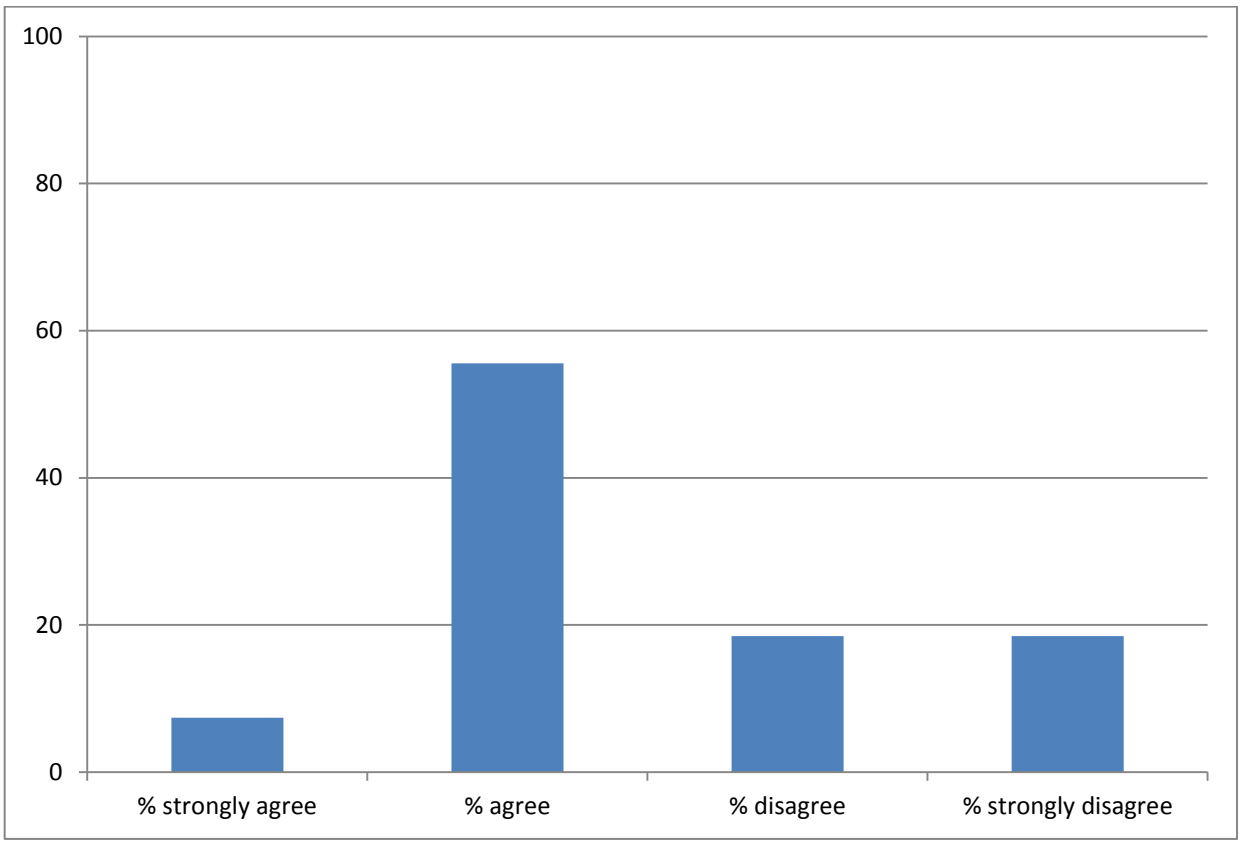



Figure 20: Response to Question 28. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=26)

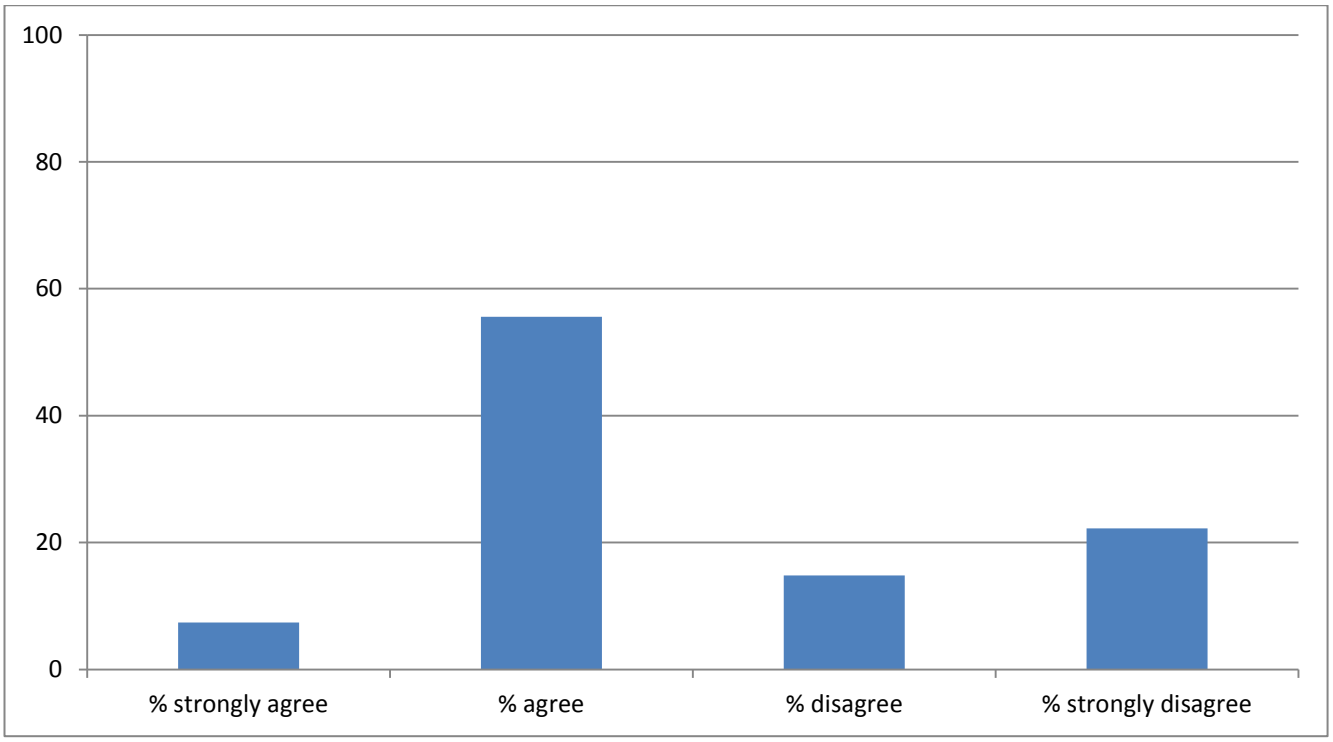


Figure 21: Response to Question 29. Unit 3: The unit description clearly describes the focus and scope for this unit (n=28)

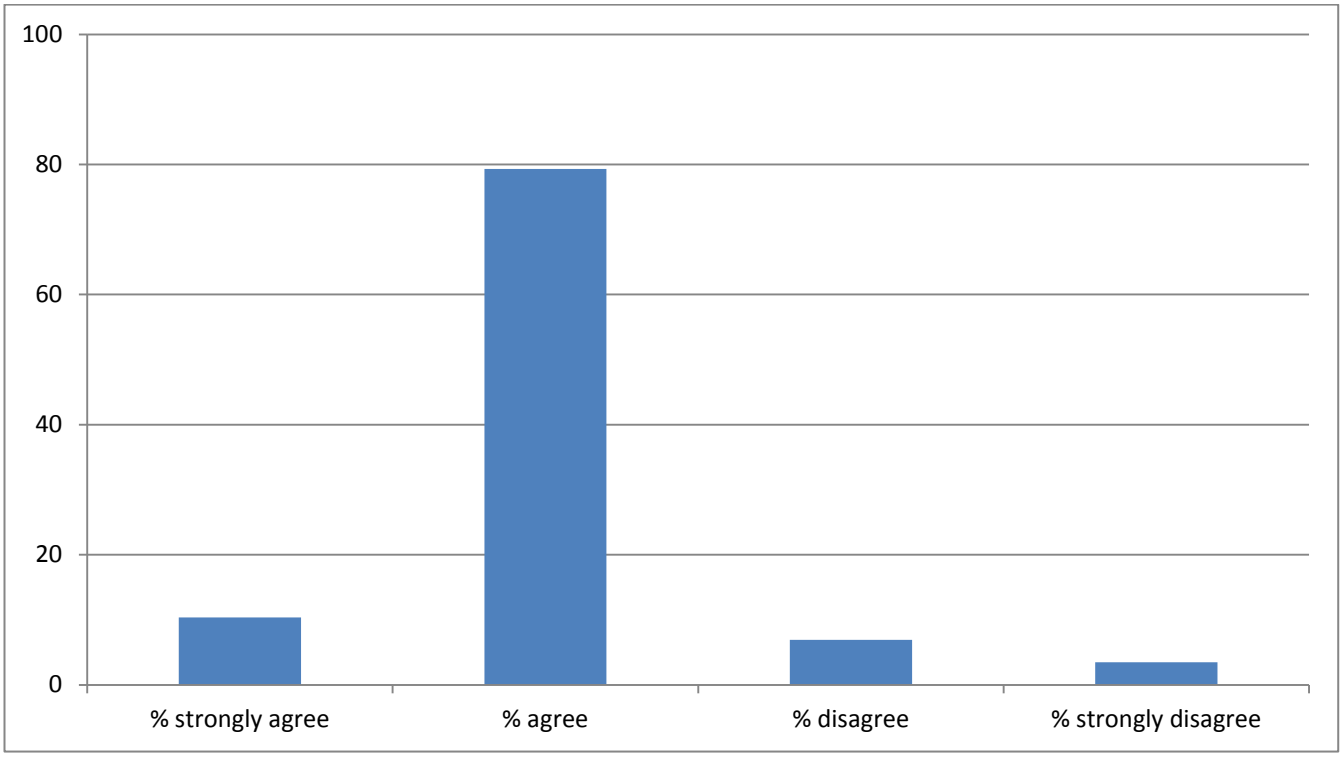



Figure 22: Response to Question 30. The unit outcomes describe clearly the expected learning for this unit (n=27)

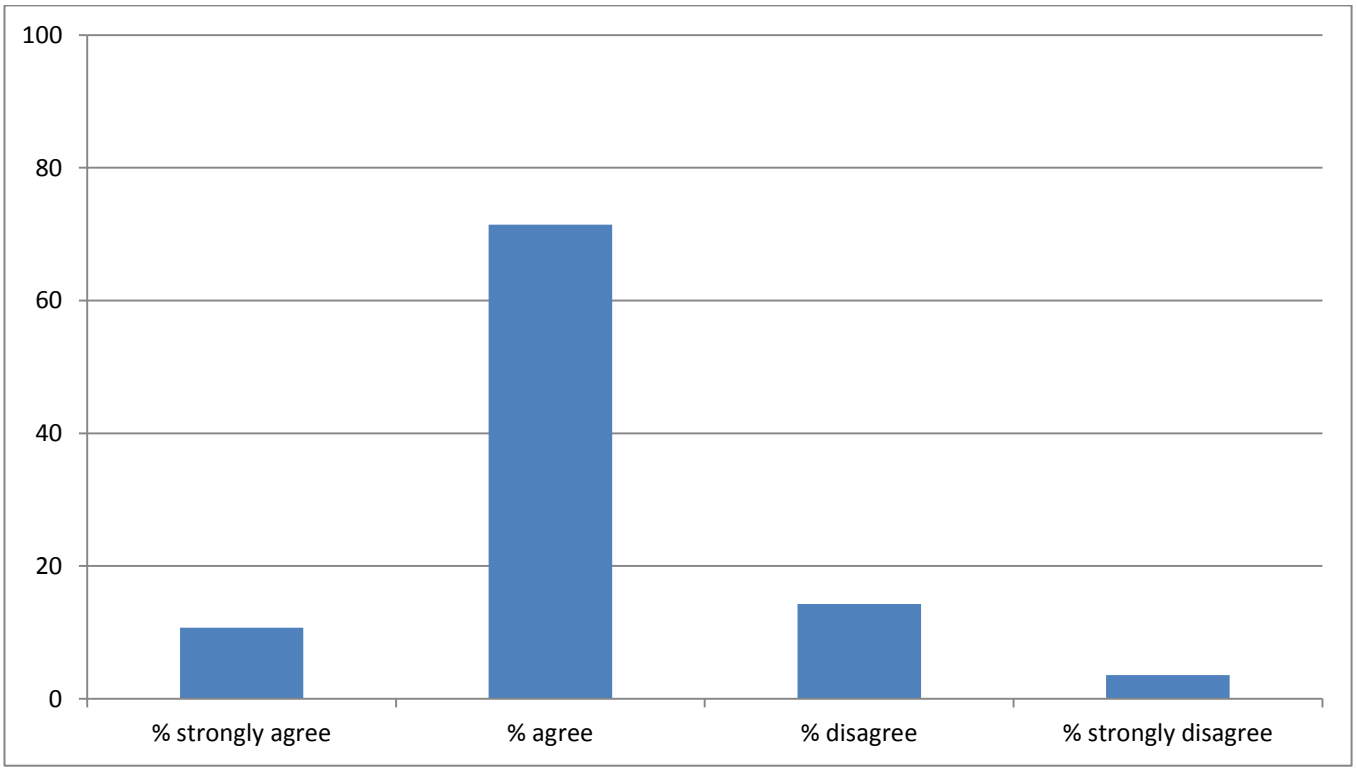


Figure 23: Response to Question 31. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=28)

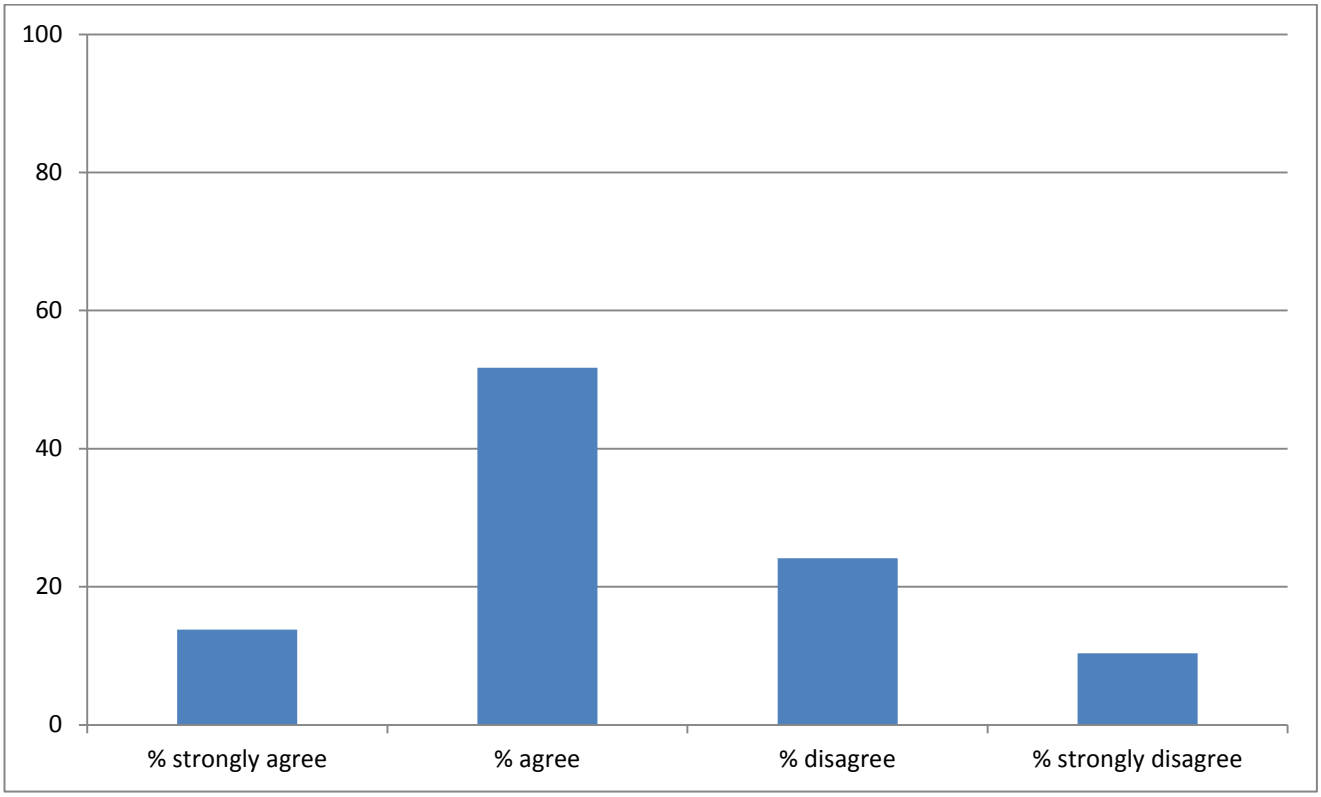



Figure 24: Response to Question 32. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=28)

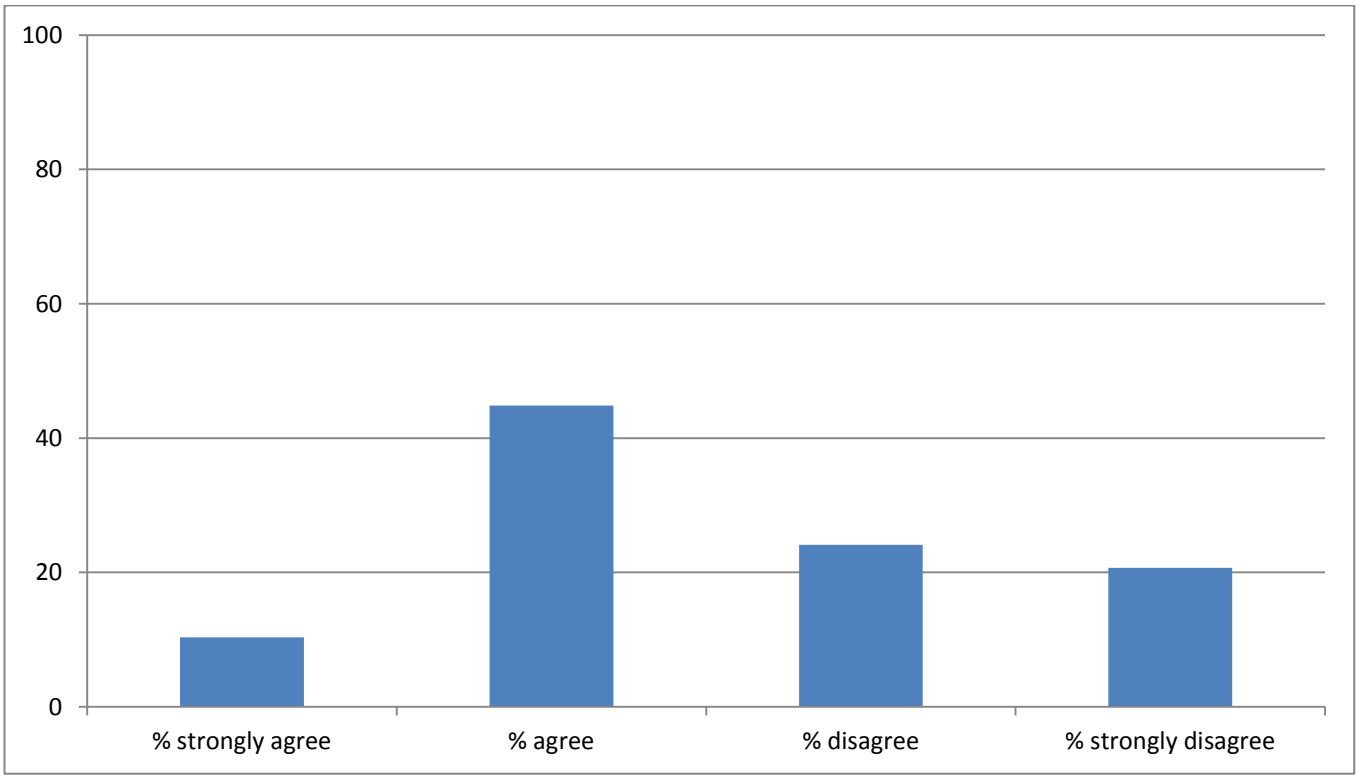


Figure 25: Response to Question 33. The content descriptions are specific about what is to be taught (n=27)

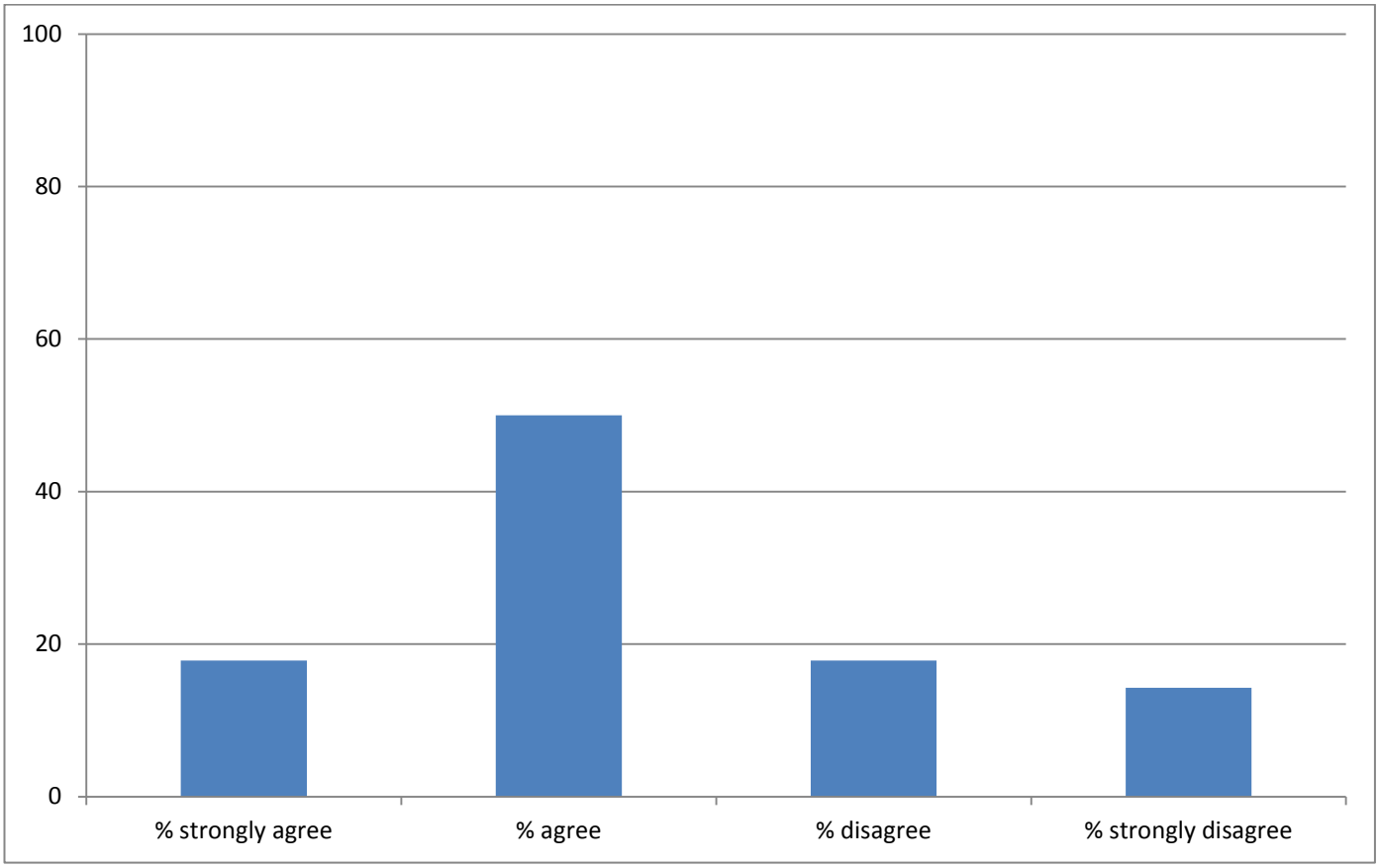



Figure 26: Response to Question 34. Unit 4: The unit description clearly describes the focus and scope for this unit (n=27)

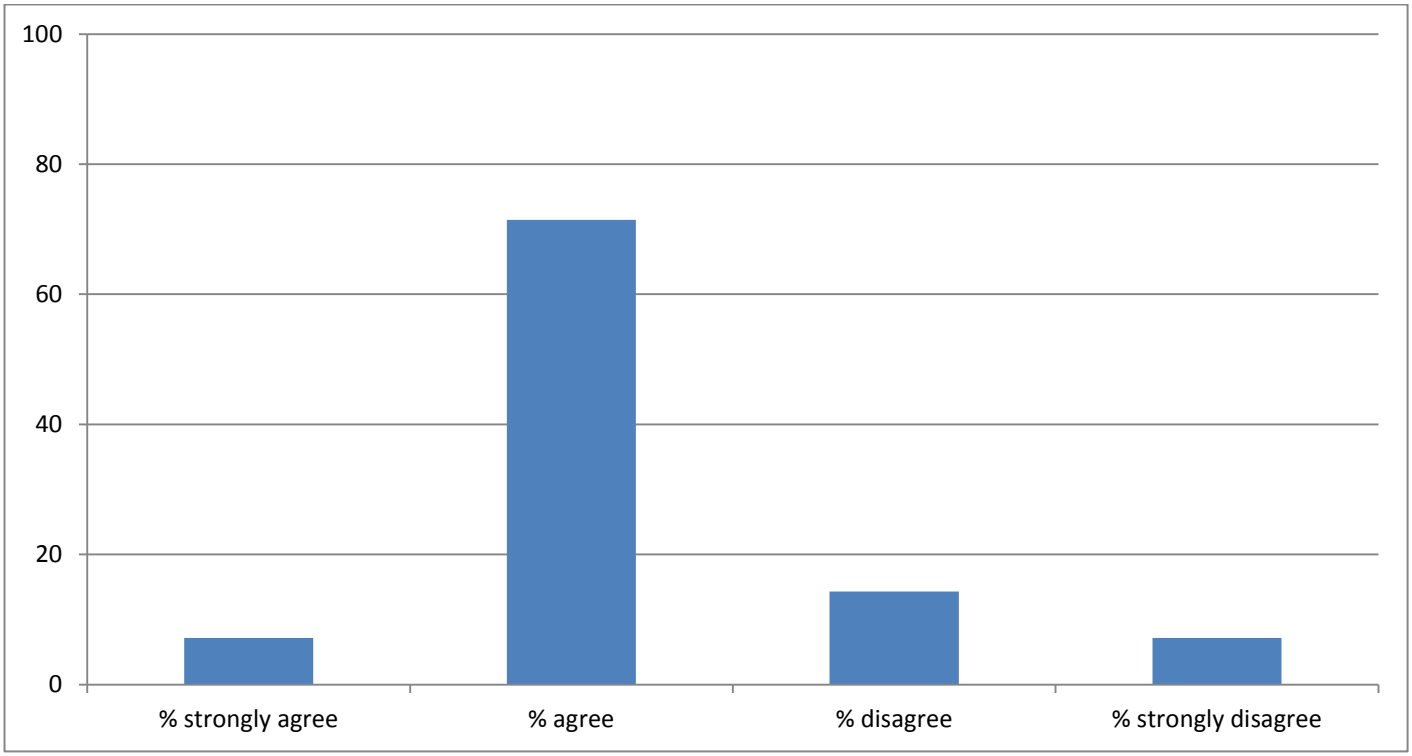


Figure 27: Response to Question 35. The unit outcomes describe clearly the expected learning for this unit (n=26)

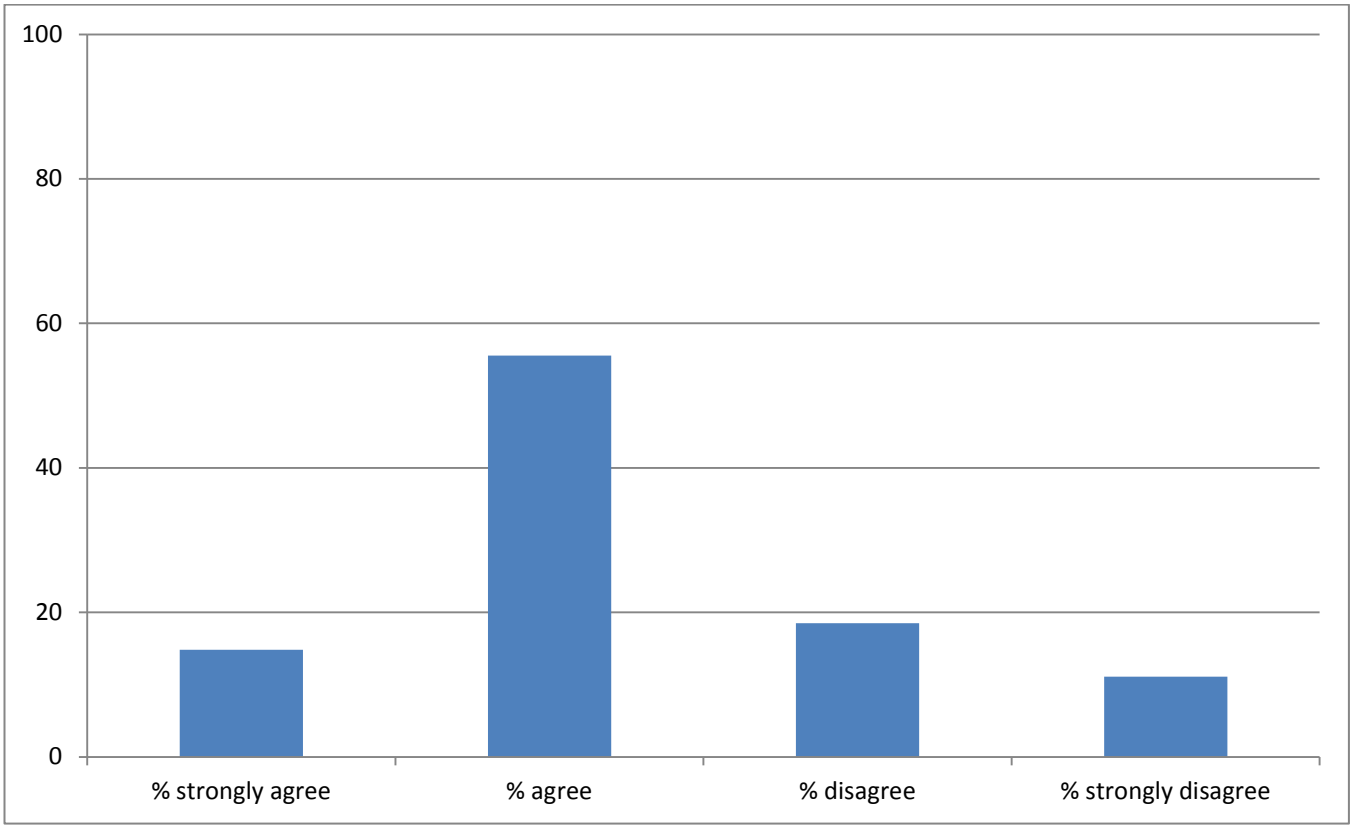



Figure 28: Response to Question 36. The unit contains relevant and appropriate content (knowledge, understanding and skills) (n=27)

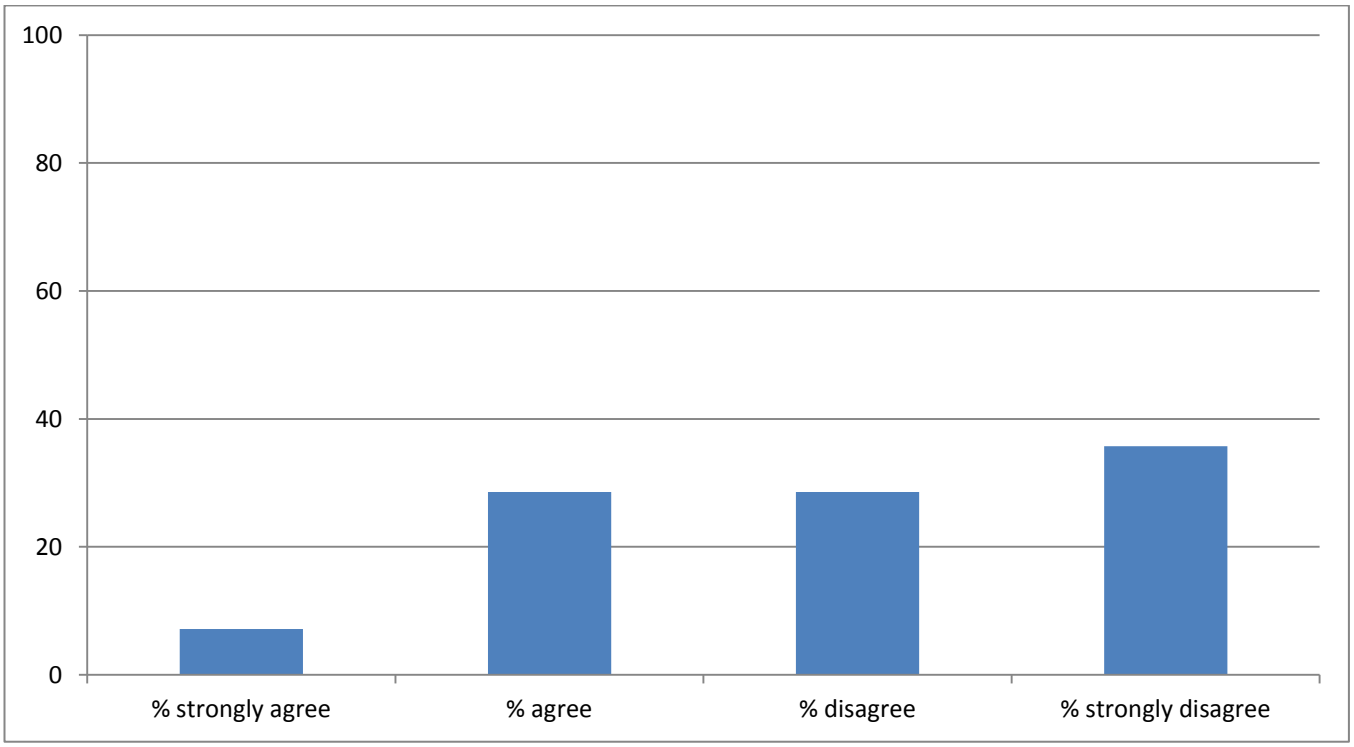


Figure 29: Response to Question 37. The unit contains an appropriate amount of content; that is, it can be taught within 50–60 hours (n=27)

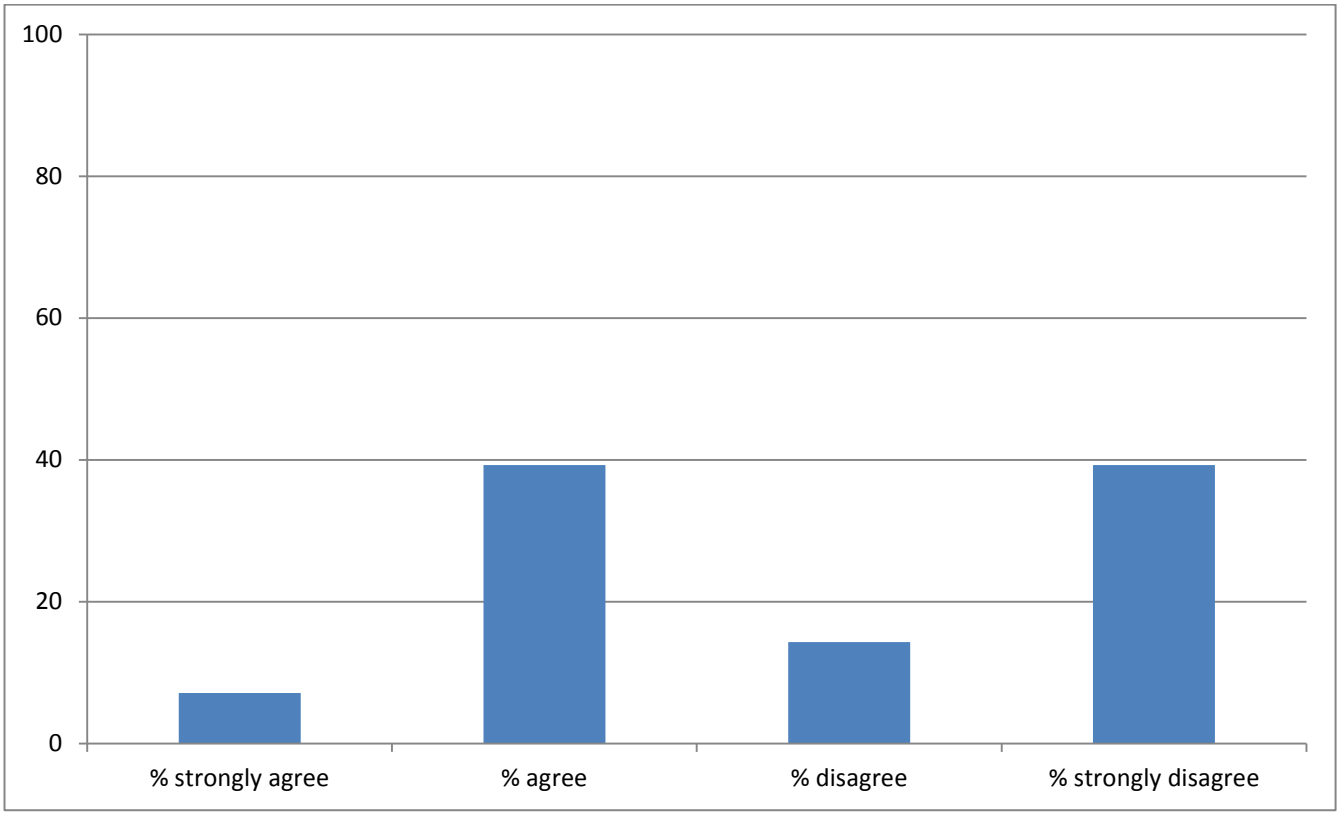



Figure 30: Response to Question 38. The content descriptions are specific about what is to be taught (n=26)

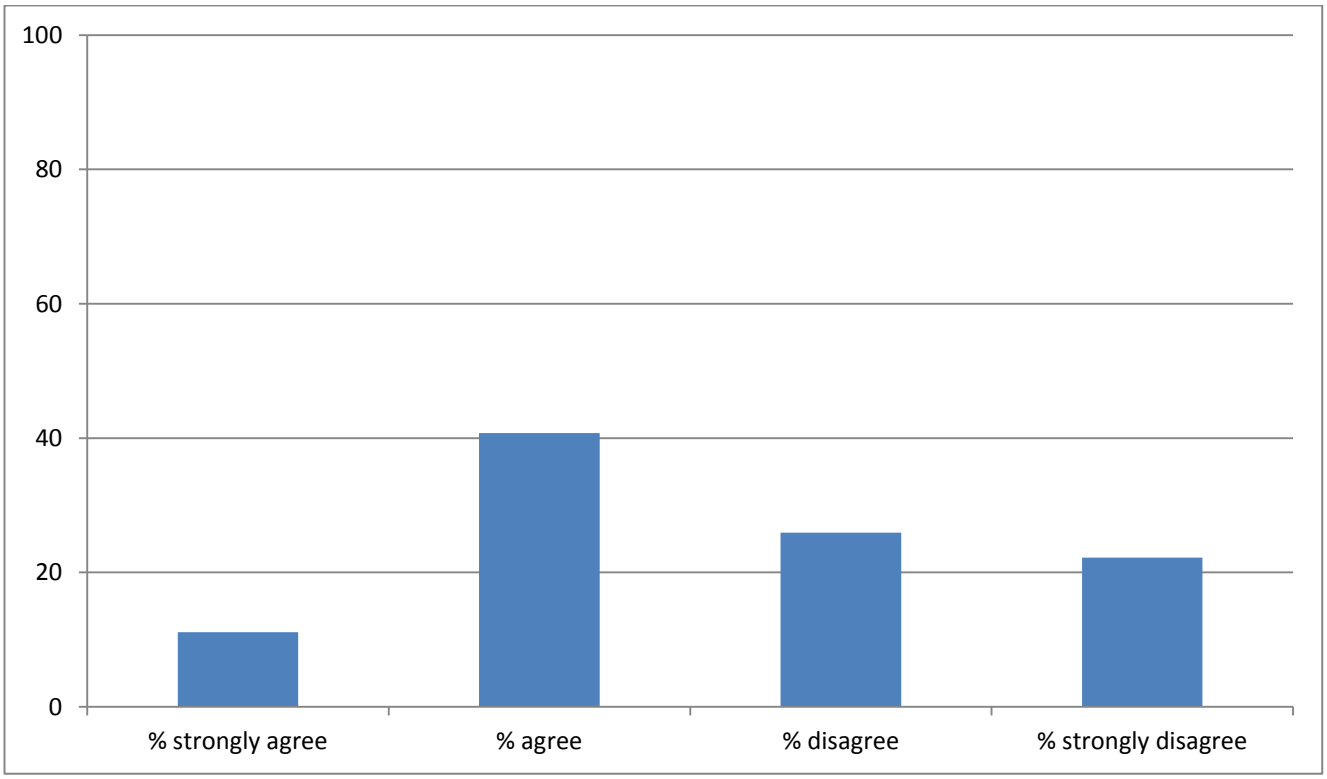


Figure 31: Response to Question 39. There is clear alignment between the understanding and skills dimensions of the achievement standards, and the unit learning outcomes and content descriptions (n=27)

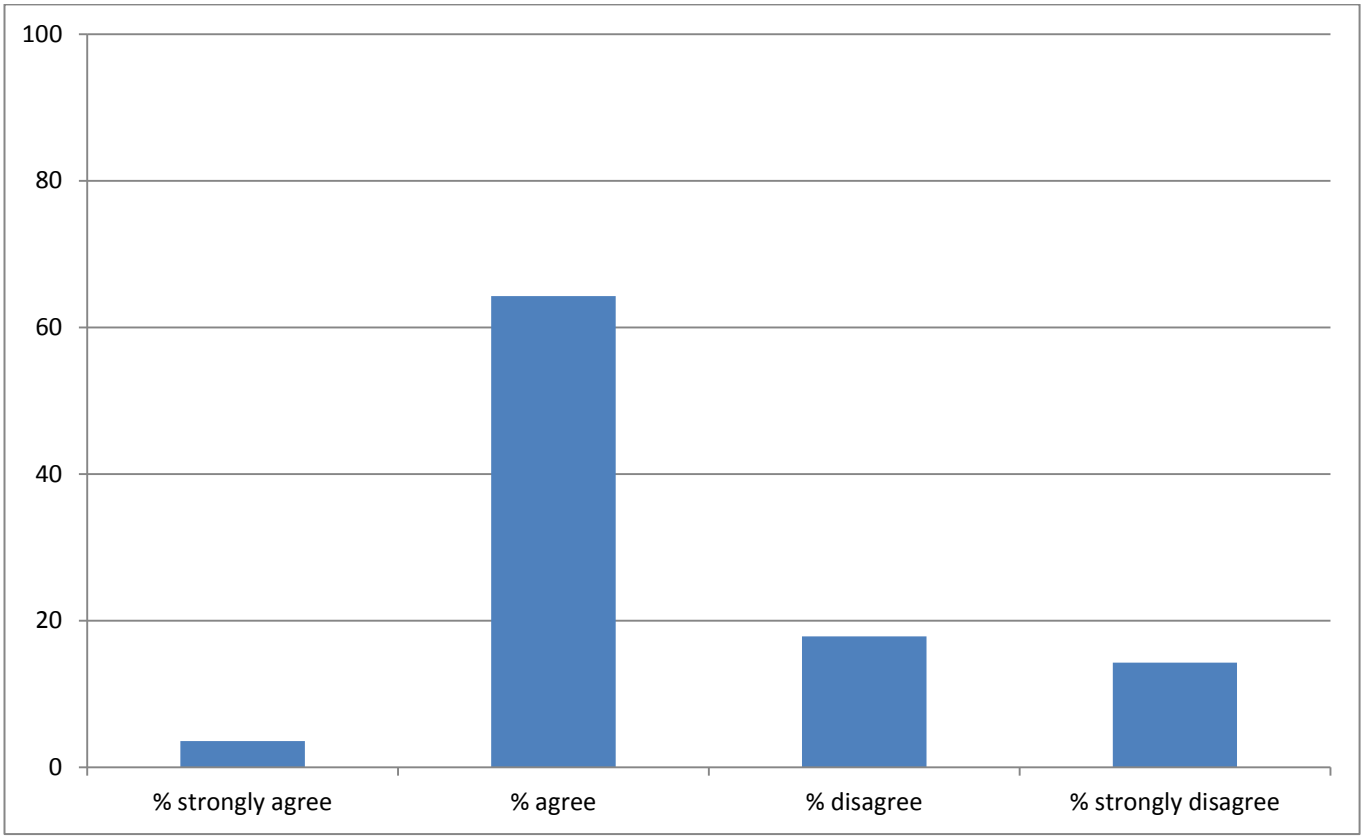



Figure 32: Response to Question 40. The achievement standards are clear and comprehensive descriptions of the increasing complexity of understanding and sophistication of skills (n=27)

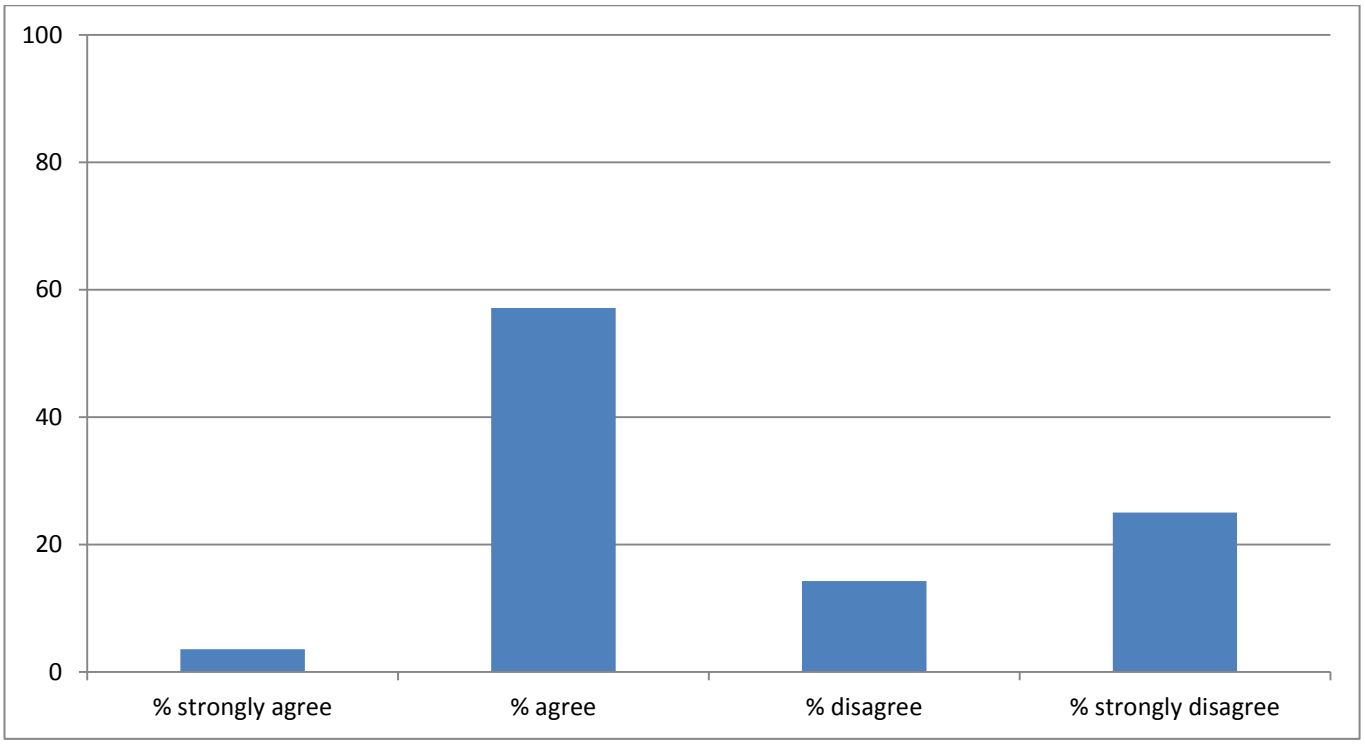


Figure 33: Response to Question 41. The achievement standards are pitched appropriately; that is, they are realistic yet sufficiently challenging for students undertaking these units (n=27)

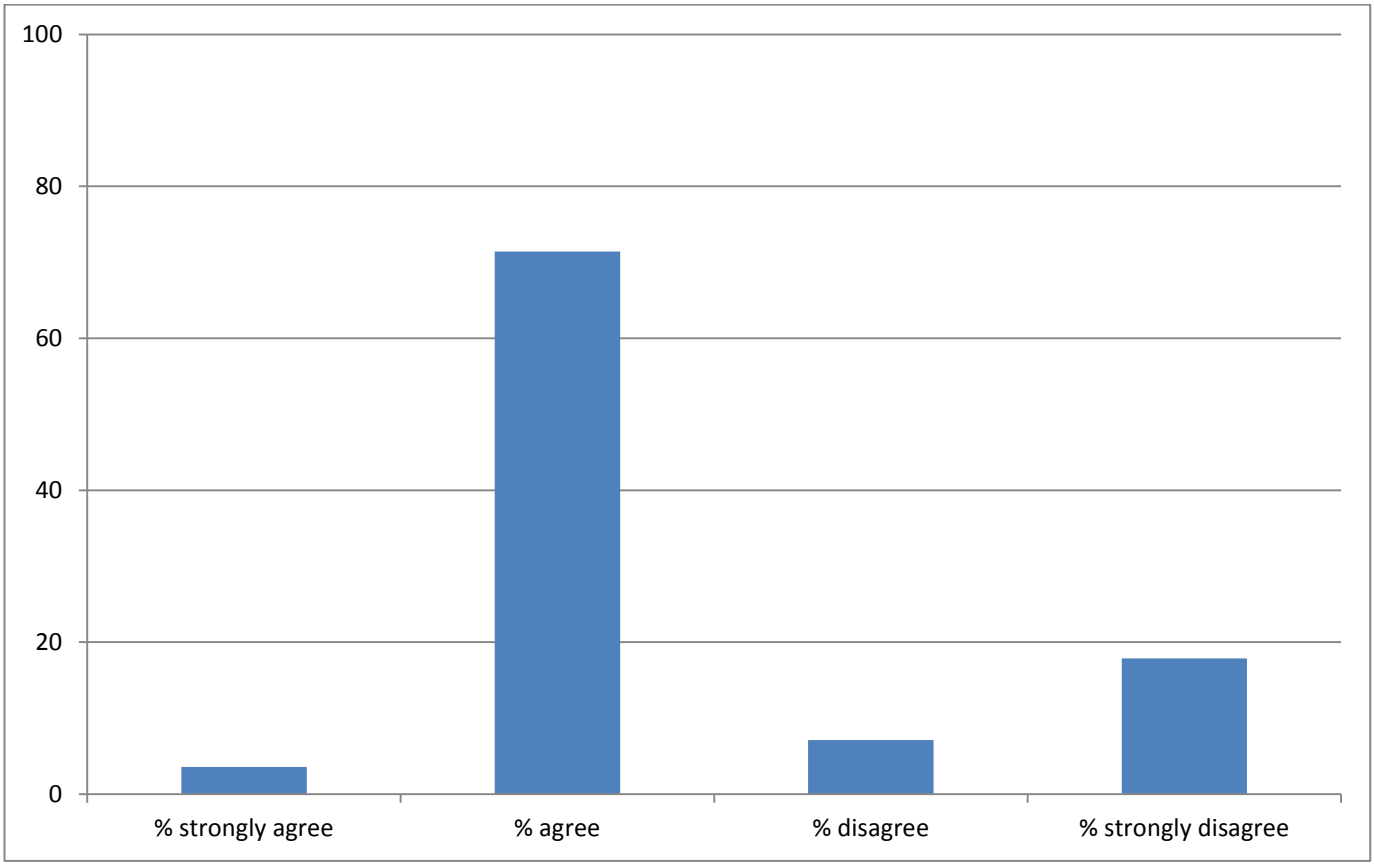



Figure 34: Response to Question 42. The five levels of achievement standard clearly and appropriately distinguish performance; that is, they describe distinctive characteristics of achievement for understanding and skill in this subject at this level (n=27)

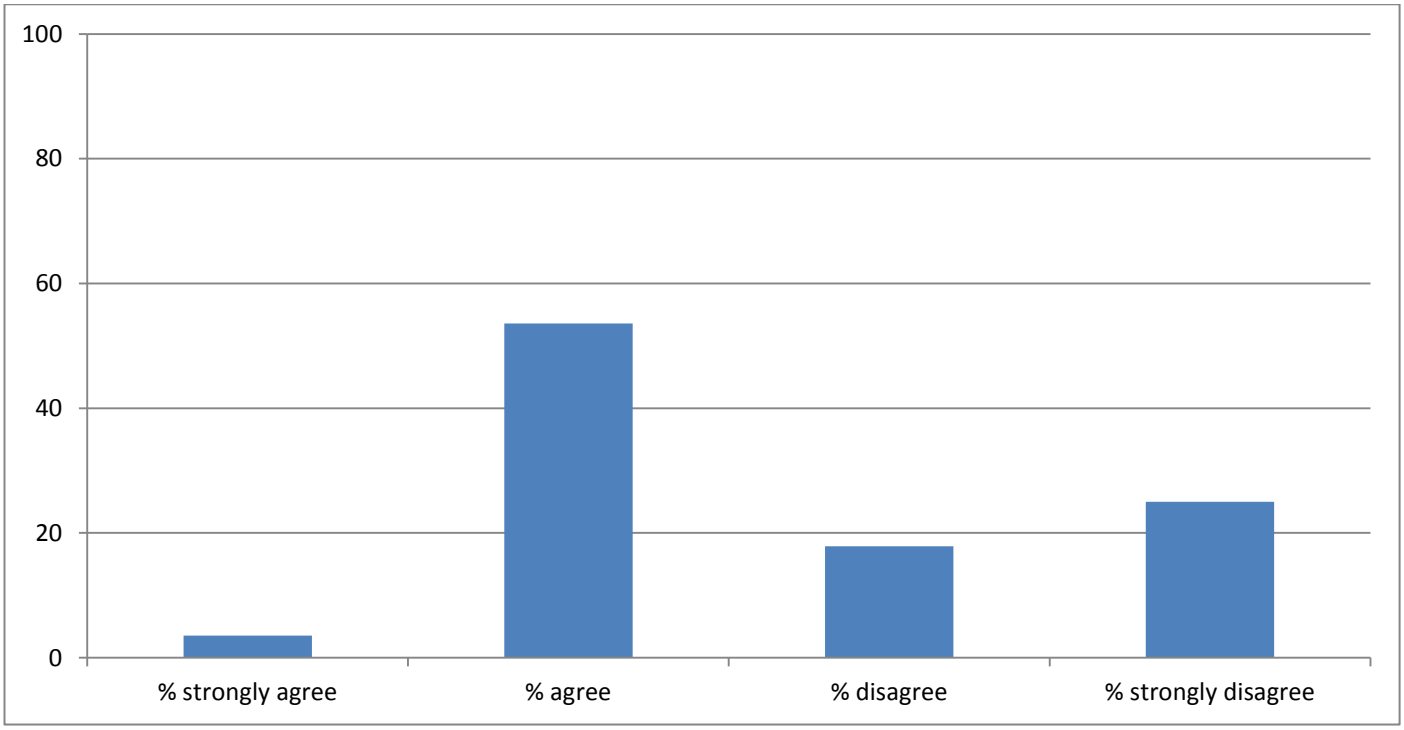


Figure 35: Response to Question 43. The general capabilities that naturally fit with this subject are appropriately represented (n=25)

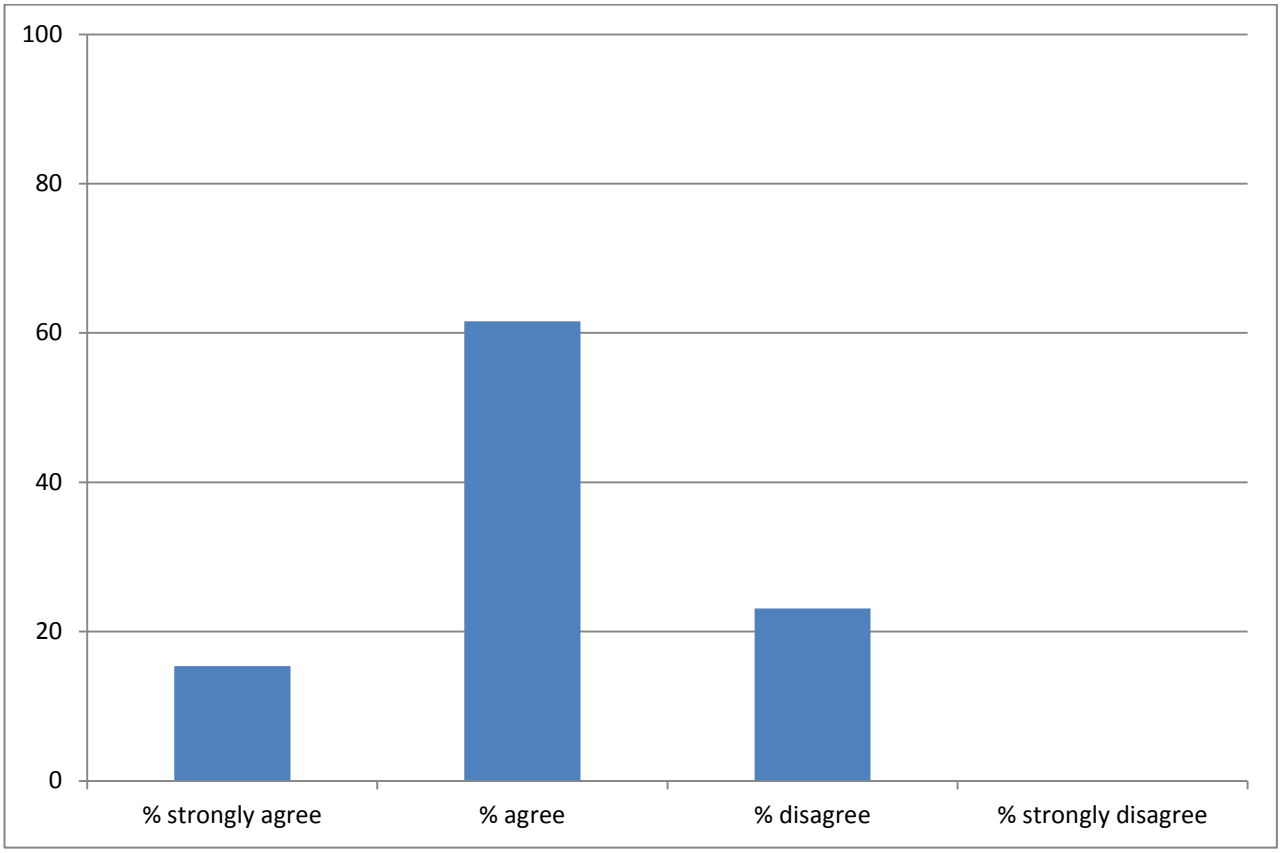



Figure 36: Response to Question 44. The cross-curriculum priorities that naturally fit with this subject are appropriately represented (n=25)

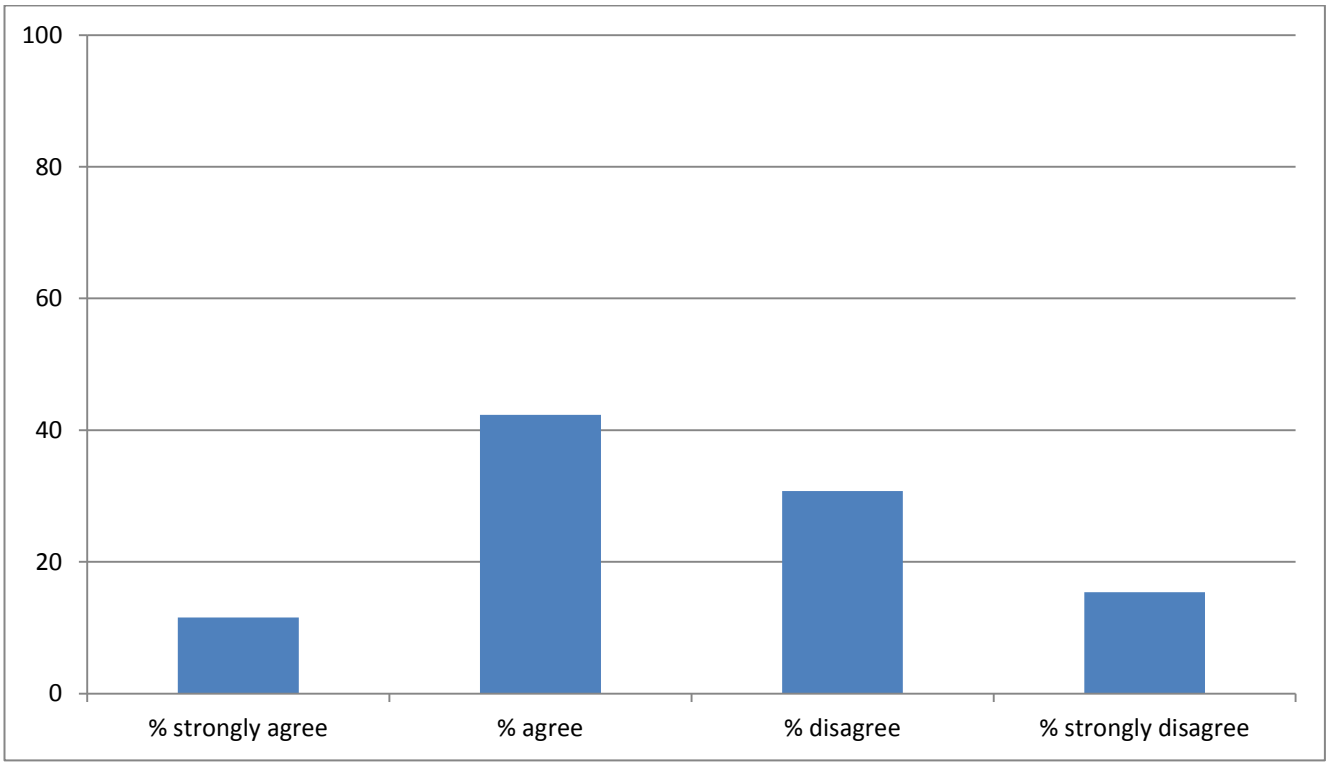
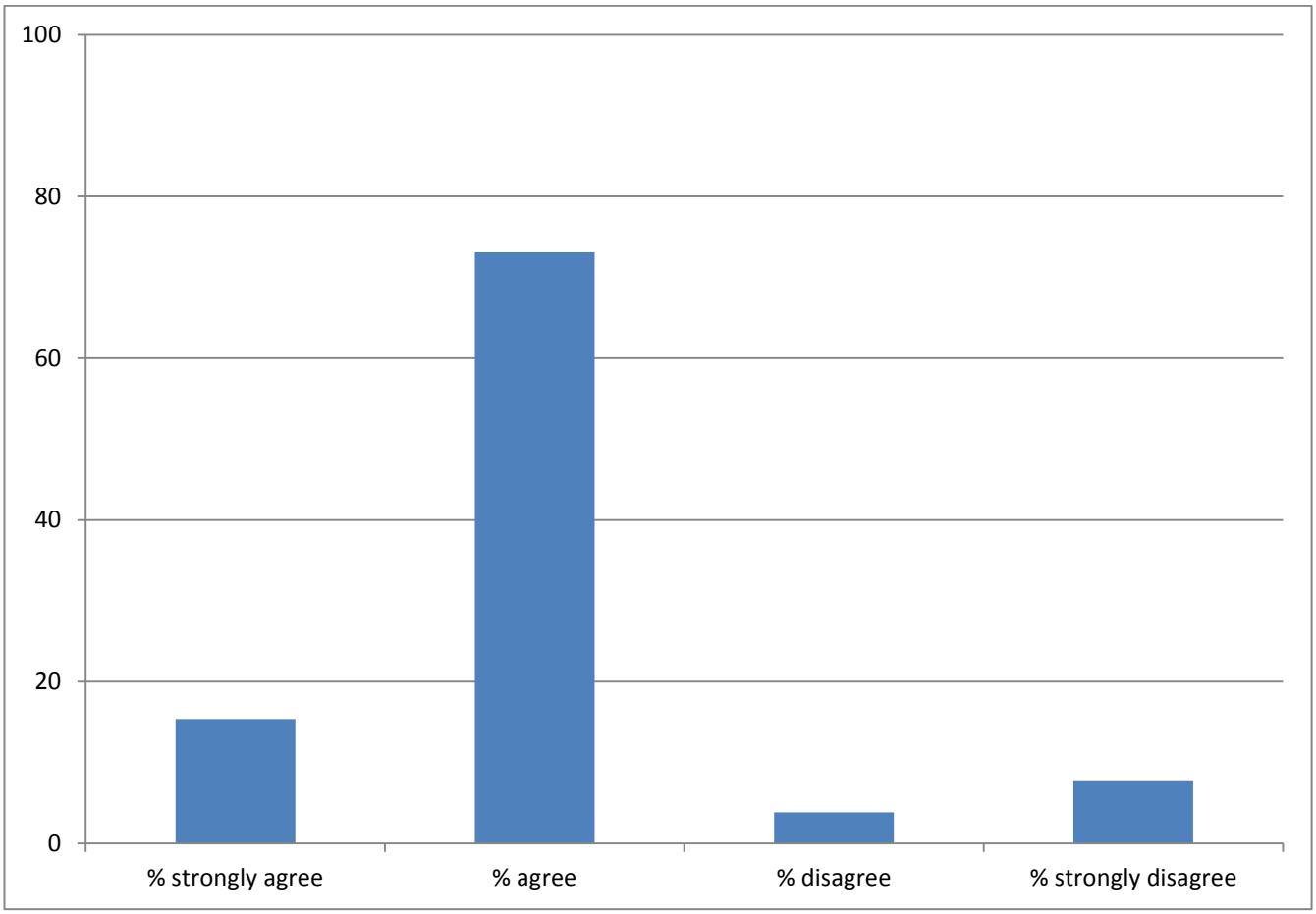


Figure 37: Response to Question 45. The glossary is comprehensive (n=25)



## Appendix 2 – Written submission respondents

This appendix lists the organisations, groups and individuals who made written submissions on the consultation draft curriculum across the Science learning area.

| Organisation | State or Territory | Respondent type/industry | Number of contributors | Subject |
|---|---|---|---|---|
| Ag Institute Australia (Australian Institute of Agricultural Science and Technology) | National | Professional Association | 4 | Earth and Environmental Science |
| Animal Ethics in Education Reference Group | National | Other | 6 | Biology |
| Asia Education Foundation | National | Professional Association | Not specified | All subjects |
| Astronomical Society of Australia | National | Professional Association | 9 | Physics |
| Australian Academy of Science (AAS), National Committee for Earth Sciences | National | Professional Association | 1 | Earth and Environmental Science |
| Australian Academy of Science (AAS), National Committee for Chemistry | National | Professional Association | 8 | Chemistry |
| Australian Animal Welfare Advisory Committee (AAWAC) Education and Training Working Group | National | Other | 14 | All subjects |
| Australasian Science Education Research Association Ltd (ASERA) | National | Professional Association | 10 | All subjects |
| Australian Science Teachers Association (ASTA) | National | Professional Teaching Association | 250 | All subjects |
| Australian Securities and Investments Commission (ASIC) | National | Independent Statutory Organisation | 2 | All subjects |
| Australian Council of Deans of ICT (ACDICT) | National | Professional Teaching Association | 1 | All subjects |
| Geological Society of Australia (GSA) | National | Professional Association | 1 | Earth and Environmental Science |
| Master Electricians Australia | National | Professional Association | 4 | All subjects |
| Open Source Industry Australia Ltd | National | Professional Association | 2 | All subjects |
| Primary Industries Education Foundation | National | Professional Association | Not specified | Earth and Environmental Science, Biology |
| Royal Australian Chemical Institute (RACI) | National | Professional Association | 72 | All subjects |
| Royal Society for the Prevention of Cruelty to Animals (RSPCA) Australia | National | Community organisation | 4 | Biology |

| Organisation | State or Territory | Respondent type/industry | Number of contributors | Subject |
|---|---|---|---|---|
| Australian Human Rights Commission | ACT | Independent Statutory Organisation | Organisation wide | All subjects |
| Office of the Board of Senior Secondary Studies | ACT | State or Territory Education Authority | Not specified | All subjects |
| Board of Studies (BOS) NSW | NSW | State or Territory Education Authority | 1 | All subjects |
| Catholic Education Office (CEO) Sydney | NSW | State or Territory Education Authority | Not specified | All subjects |
| Ecosolve Pty Ltd | NSW | Other | 1 | All subjects |
| Our Lady of Mercy College Parramatta | NSW | School | 1 | Chemistry |
| Our Lady of Mercy College Parramatta | NSW | School | 2 | Biology |
| Science Teachers' Association of New South Wales (STANSW) | NSW | Professional Teaching Association | 35 | All subjects |
| Southern Cross University | NSW | Academic | 1 | All subjects |
| Southern Cross University | NSW | Academic | 1 | Earth and Environmental Science |
| Southern Cross University | NSW | Academic | 1 | Biology |
| Northern Territory Board of Studies (NT BOS) | NT | State or Territory Education Authority | Not specified | All subjects |
| All Saints Anglican School, Gold Coast | QLD | School | 1 | Biology |
| Anglican Church Grammar School | QLD | School | 1 | Earth and Environmental Science |
| Animal Welfare League of Queensland | QLD | Community organisation | 6 | Biology |
| Brisbane Boys College | QLD | School | 2 | All subjects |
| Brisbane Catholic Education | QLD | State or Territory Education Authority | Not specified | All subjects |
| Cavendish Road State High School | QLD | School | 2 | All subjects |
| Independent Schools Queensland (ISQ) | QLD | State or Territory Education Authority | Not specified | All subjects |
| North Bundaberg State High School | QLD | School | 1 | Physics |

| Organisation | State or Territory | Respondent type/industry | Number of contributors | Subject |
|---|---|---|---|---|
| Open Source Industry Australia Ltd | QLD | Professional Association | 2 | Physics |
| Queensland Studies Authority (QSA) | QLD | State or Territory Education Authority | Not specified | All subjects |
| Royal Geographical Society of Queensland | QLD | Professional Association | Not specified | Earth and Environmental Science |
| Ryan Catholic College | QLD | School | 2 | All subjects |
| Science Teachers' Association of Queensland (STAQ) | QLD | Professional Teaching Association | 18 | All subjects |
| St Joseph's College Gregory Terrace, Brisbane | QLD | School | 4 | All subjects |
| St Rita’s College | QLD | School | 2 | Biology |
| St Rita’s College | QLD | School | 2 | Chemistry |
| The Royal Geographical Society of Queensland Inc. | QLD | Professional Association | 1 | Earth and Environmental Science |
| Westside Christian College | QLD | School | 1 | All subjects |
| Australian Institute of Physics (AIS) SA Branch | SA | Professional Teaching Association | 3 | Physics |
| Eynesbury Senior College – Science Faculty | SA | School | 7 | All subjects |
| Perth College | SA | School | 2 | Chemistry |
| South Australian Certificate of Education (SACE) Board | SA | State or Territory Education Authority | Not specified | All subjects |
| Claremont College | TAS | School | 39 | Biology |
| Curriculum Services Department of Education | TAS | State or Territory Education Authority | Not specified | All subjects |
| School of Chemistry, University of Tasmania | TAS | Academic | 1 | All subjects |
| Science Teachers' Association of Tasmania (STAT) | TAS | Professional Teaching Association | 50 | Biology |
| Tasmanian Qualifications Authority (TQA) | TAS | State or Territory Education Authority | Not specified | All subjects |
| University of Tasmania | TAS | Academic | 1 | Chemistry |

| Organisation | State or Territory | Respondent type/industry | Number of contributors | Subject |
|---|---|---|---|---|
| Australian Institute of Physics (AIP) (Vic Branch) Education Committee | VIC | Professional Association | 120 | Physics |
| Bialik College | VIC | School | 1 | Physics |
| Catholic College Bendigo | VIC | School | 1 | Earth and Environmental Science |
| Catholic Education Office (CEO) Melbourne | VIC | State or Territory Education Authority | Not specified | All subjects |
| Catholic Ladies' College | VIC | School | 1 | Earth and Environmental Science |
| Chemistry Education Association (CEA) | VIC | Professional Teaching Association | 1 | Chemistry |
| Melbourne Girls Grammar | VIC | School | 5 | Biology |
| Royal Society for the Prevention of Cruelty to Animals (RSPCA) Victoria | VIC | Community organisation | 9 | Biology |
| Teacher Earth Science Education Programme (TESEP) | VIC | Professional Teaching Association | 1 | All subjects |
| Victorian Catholic Schools Parent Body (VCSPB) | VIC | Parent Association | Not specified | All subjects |
| Victorian Curriculum and Assessment Authority (VCAA) | VIC | State or Territory Education Authority | Not specified | All subjects |
| Association of Independent Schools Western Australian (AISWA) | WA | State or Territory Education Authority | 39 | All subjects |
| Canning College | WA | School | 1 | All subjects |
| Department of Environment and Conservation | WA | Government Department | 3 | Earth and Environmental Science |
| Department of Environment and Conservation | WA | Government Department | Not specified | All subjects |
| Earth Science Western Australia (ESWA) | WA | Professional Association | 5 | Earth and Environmental Science |
| School Curriculum and Standards Authority (SCSA) | WA | State or Territory Education Authority | Not specified | All subjects |
| Science Teachers' Association of Western Australia (STAWA) | WA | Professional Teaching Association | Not specified | All subjects |

## Appendix 3 - Consultation findings – states and territories

This section provides hyperlinks to responses to the draft senior secondary Science curriculum from those authorities responsible for senior years curriculum in their respective states and territories.

| Authority | State/Territory | Submission prepared |
|---|---|---|
| Board of Senior Secondary Studies | ACT | Feedback from consultation meetings |
| Board of Studies | NSW | From BOS NSW consultation processes and input from educational sectors of NSW |
| Board of Studies | NT | From consultation meetings conducted by BOS consultants |
| Queensland Studies Authority (QSA) | QLD | In partnership with Education Queensland, Queensland Catholic Education Commission (QCEC) and Independent Schools Queensland (ISQ) |
| South Australian Certificate of Education (SACE) Board | SA | In partnership with Government, Catholic and Independent sectors in South Australia |
| Tasmanian Qualifications Authority (TQA) | TAS | Response including matters discussed by the TQA and from a program of workshops and consultation meetings with senior secondary teachers |
| Department of Education, Tasmania | | From consultations held in schools and colleges throughout the state |
| Victorian Curriculum and Assessment Authority (VCAA) | VIC | In partnership and on behalf of Department of Education and Early Childhood Development, Catholic Education Commission Victoria and Independent Schools Victoria |
| Schools Curriculum and Standards Authority (SCSA)<br>*ACARA has been advised that the Western Australian response to consultation is to be published subsequent to further consultation.* | WA | In partnership with Department of Education (WA), Catholic Education Office of WA, Association of Independent Schools of WA |