International Grades – Open Technologies

High Quality Qualifications for the
2016 School League Tables

The specification for

TLM/NAACE Level 1 and Level 2 Certificates in Open Systems Computing (QCF)

For the 2016 league tables onwards

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This is version 1.0 of the specification for TLM Level 1 and Level 2 qualifications in Open Systems Computing developed in partnership with the National Association for Advisers in Computer education and the Open Source Consortium of Companies.

The assessment model for the qualifications presented in this publication was designed by TLM in consultation with other awarding organisations, schools, OSC and NAACE.

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1. Introduction

1.1 We believe these new and innovative qualifications provide the most inclusive and cost-effective qualifications available for the new Computing curriculum emphasis while preserving the necessary rigour for stretching the highest attaining candidates. In addition, there is a clear intention to reduce the bureaucratic overhead on teachers while preserving the benefits of coursework for motivating learners and dealing validly with recognition of practical competence in what are essentially practical and vocational skills and activities. We have demonstrated that we can provide Level 1 and Level 2 qualifications that are accessible to all learners while still differentiating the top performing students. This enables a clear progression route for the weakest mainstream learners through to identifying those that are likely to be successful in academic A levels.

1.2 The qualifications enable coverage of a wide range of general knowledge, understanding and competences. At Level 1 these will support all by leaving progression routes open to Level 2 that will benefit any young person aspiring to progress into the professional IT sector.

1.3 This specification is for 2 qualifications, one at Level 1 and the other at Level 2 targeted on secondary schools. It has the following key benefits.

1. based on the new computing programs of study for Key Stage 3 thus providing an assessment model providing progression from it to Level 2.
2. devised in consultation with the National Association for Advisers in Computer Education.
3. clear and flexible unit based structure referenced to the European Qualifications Framework (EQF).
4. straightforward assessment of competence in real rather than contrived contexts.
5. grading through controlled exams introduced progressively from KS3 to KS4.

1. provides a focus for continuing professional development for teachers through moderation/verification feedback.
2. moderation/verification of coursework on demand.
3. three examination opportunities per year.
4. use of open source cloud based technologies to reduce costs and add value for schools.

5. reduced bureaucracy for teachers and flexibility for them to target specific interests.

1.4 These qualifications lend themselves to formative assessment practices allied to summative differentiation by outcome that can optimise and motivate attainment for individuals rather than assume all will reach a certain level or grade at a particular time. We do this by providing a coursework component that is competence based, reflecting the best and most up to date research in assessment in the workplace complemented by a short academic style examination.

1.5 All candidates must complete the coursework before being eligible to take the exam. This provides an incentive to complete the coursework and makes it less likely that those sitting an exam are ill-prepared.

1.6 The Level 1 exam grades candidates across a range from Pass through Merit and Distinction to Distinction*. The Level 2 exam grades candidates from grade C through B and A to A*. The two qualifications at Level 1 and Level 2 can stand alone but they are designed to provide a coherent progression route starting with coursework at Level 1 for a basic level 1 pass and then an exam to determine the Level 1 grades. Level 2 coursework is differentiated from level 1 by more demanding assessment criteria and the general QCF level descriptor for level 2 compared to Level 1. If coursework is completed to the Level 2 standard the candidate can go on to take the Level 2 exam which will then differentiate grades A*-C.

1.7 In this way we can provide valid competence based assessment and rigorous testing of knowledge and understanding at a lower cost than both traditional vocational and academic methods applied separately. If replicated across schools it would potentially save significantly on current expenditure on assessment and examinations.

2. Summary of the qualifications specifications

2.1 The Level 2 certificate is graded across 4 levels from A*-C with A* the highest grade equating to 80%+ of the available marks and grade C equating to a minimum of 50%. The Level 1 certificate is graded across 4 levels, pass for completing the coursework to the level 1 standard, pass with merit for achieving 50% or more marks in the examination, pass with distinction for achieving 70% or more marks in the examination and pass with distinction* for achieving 90% or more of the marks in the examination.

Content

2.2 The qualification content has been designed for use in schools by referencing it to the new National Curriculum programmes and testing it against similar assessments carried out in current level 2 qualifications. It is also designed to enable learners to meet the needs of employers, through consultation with the Open Source Consortium of Companies, Linux Professional Institute, NAACE partner companies and Mirandanet partner companies. Guidance for coursework is aligned with the CBI employment criteria. Guidance takes into account the lack of experience of many teachers in this area ensuring that the most academically able can be stretched and routed to appropriate academic progression at Level 3. The links with NAACE and its professional development activities provide the potential for low cost staff development and keeping teachers up to date in what is still a rapidly changing field. Unlike purely academic qualifications, regular reference is made to practical open standards and the use of real equipment rather than simulations or generic terms only. There is an emphasis on increasing understanding of the importance of open systems in keeping with recent Cabinet Office policy.

Assessment

2.3 The qualifications at both Level 1 and Level 2 have two assessment components with each component covering the full course content.

1. Coursework assessed in terms of competence in practical areas where knowledge and understanding can be applied in real and motivating contexts.
2. An externally set and externally marked examination to assess knowledge and understanding that underpins user competence.

Both of these assessment components cover the full range of content as far as it is validly assessable by the particular method. There are 70 marks available from externally set externally marked assessment and 30 marks from externally moderated internally assessed coursework.

2.4 Both qualifications are unit based and each consist of 3 units. Units have credit values in the qualifications and credit framework (QCF). A minimum of 15 credits is needed for each qualification equating to 120 Guided Learning Hours. Each unit is designed to be 5 credits and 40 GLH.

The synoptic examination of knowledge and understanding that is used for grading is based on a syllabus related to all the available units. The design does not allow candidates to compensate for weak coursework by doing well in the exam only. They must complete the coursework to a satisfactory standard at the level to be eligible to take the examination. A weak examination performance will limit the attainment at level 1 to a pass and could prevent the award of any grade at all at Level 2. It is likely that candidates with a satisfactory coursework performance will at least pass but that is not inevitable and they must take the the exam to pass. The exam then also provides an additional very low cost dimension to external moderation/verification feedback for the coursework. Centres with a high proportion judged to be satisfactory on coursework yet failing to gain sufficient marks in the examination flag up a need for further investigation and will help prioritise CPD.

Summary of the rationale

2.5 The assessment is specifically designed to motivate learning that will support the highest grade(s) attainable by each candidate with both coursework and exam covering the entire subject content. Learners must demonstrate that they can achieve at least 15 credits before being eligible for the examination. There is considerable flexibility to enable contexts of individual interest to be explored in depth. Those that have completed the coursework in areas of personal interest and to a high standard are far less likely to fail to achieve at least the minimum standards set in the examination. This ensures basic practical competence in realistic and motivating scenarios as well as at least some general knowledge and understanding in the more academic sense.

Aggregation of marks

2.6 **Level 1 candidates** will be deemed to have achieved a pass when units to a minimum value of 15 credits have been assessed so that there is evidence of secure performance against the assessment criteria and therefore competence against the specified learning outcomes. They are then eligible to take the examination. The examination is worth 50 marks. Candidates will achieve a merit grade if they score 25 marks or more, a distinction if they gain 35 marks or more and distinction* if they gain 45 marks or more. Candidates will be provided with their marks as well as their grade. Candidates can take this examination when their assessors judge that they are ready and when they have completed the coursework to a level 1 standard.

[The published grade boundaries may be subject to change]

2.7 Level 2 candidates will gain 30 marks from providing coursework evidence that meets the level 2 assessment criteria as determined by their assessor with independent moderation/verification samples. They are then eligible to take the examination which provides a further potential 70 marks. If the candidate achieves a total score of 50 marks from the coursework and the examination they will be awarded a grade C. For 60 marks or more a grade B, for 70 marks or more a grade A and for 80 marks or more a grade A*. In this way those candidates that are more suited to academic work will be differentiated from those more likely to benefit from further practically based study at Level 2 or Level 3. The examination questions get progressively more difficult and those achieving the highest marks will be those most likely to be suited to academic A level study at Level 3.

[The published grade boundaries may be subject to change]

2.8 Any candidate that completes the coursework to a satisfactory standard at Level 2 but fails to gain sufficient marks in the examination will still receive unit certificates and a full qualification at Level 1 if they have sufficient Level 1 credit and have not already been awarded the Level 1 certificate. We expect this situation to be relatively rare but from an individual's point of view it prevents them doing 2 years' work and coming away with nothing because they had a bad day in an exam or missed the exam through unavoidable personal circumstances.

2.9 In the interests of inclusion, there will be no additional fees for this. A subscription model that covers all these qualifications means that schools can enter as many candidates as they believe can meet the criteria and there are no hidden costs such as late entry fees, double entries or replacement certificate fees. This maximises the opportunities for learners to get their achievements recognised without the school worrying about financial penalties.

3. Qualification Content

3.1 The qualification is made up from units in the Qualifications and Credit Framework (QCF). It is founded in the New KS3 programmes of study for Computing extended to cover the full range of level 1 and level 2 attainment. The QCF is referenced to the European Qualifications Framework (EQF), the largest system for referencing nationally accredited qualifications in the world. Unit credit is designed to be compatible with the European international credit transfer system ECVET. The units were designed by TLM in collaboration with teachers currently working in the classroom, NAACE and the OSC. In order to provide learners with the skills needed by employers, especially the small and medium sized enterprises that employ 60% of the private sector workforce, extensive consultation with small business leaders has taken place. This specification is a distillation of this extensive market research specifically geared to supporting learning in schools. There is an emphasis on developing the transferable knowledge, skills and competences that will support raised attainment in the core subjects of the curriculum as well as providing the grounding need for future computing professionals. There are references to science and mathematics especially in terms of control of variables, number systems, and physical electronics. Specialist vocabulary with words such as recursion, abstraction, iteration, bandwidth and algorithm will help support technical English at a level beyond that of most adults.

Key subject aims

3.2 The overarching aim is to enable learners to broaden their understanding of technical open systems so they are better equipped decision makers in a technological age. Those seeking careers in digital technologies will have an appropriate grounding in open systems computing to enable them to make rational decisions about their progression routes into employment in this sector.

Subordinate aims include:

1. developing the knowledge and skills needed for employment.
2. gaining practical experience needed to underpin lifelong learning.
3. increasing the knowledge needed to transfer skills and understanding between contexts.
4. reinforcement of learning in the core subjects of English, mathematics and science.

5. developing practical skills in creativity and problem solving in technological contexts of personal interest.
6. developing an understanding of their place in the community and society.
7. developing safe, secure and responsible attitudes to working with other people.
8. developing the skills to working collaboratively with IT.
9. developing knowledge in the field of critical evaluation and feedback.
10. developing and understanding of open systems and the dangers of lock-in to specific proprietary technologies.

Knowledge and understanding

3.3 The following knowledge and understanding will be required to support learning for each qualification. At each level the understanding needed is in keeping with the QCF general description of the qualification level.

1. Demonstrate knowledge and understanding associated with the computing terms:
   abstraction, algorithm, programming language, instruction, data, source code, executable code, variable, Boolean Operators AND, NOT, OR, NAND, wildcard, binary, conditional statement, pixel, e-safety, copyright, license, open source, open system, proprietary, analogue, digital, CPU, RAM, Bus, Harddrive, USB, RJ45, interface, bandwidth, server, contention, network bottleneck, local area network, wide area network, protocol, firewall, permissions, UTP, fibre optic, wifi, 3/4G, encryption, client, switch, router.
   Demonstrate knowledge and understanding associated with the information and data terms:
   data, information, filetype, file properties, search, validity, remix, acceptable use policy, strong password, spam, malware, compatible, interoperable, cloud, desktop, mobile, software as a service, digital lock-in, validity, accurate.

3.4 Opportunities are provided to support the following skills, the great majority of which will be assessed directly in coursework in valid contexts.

1. modify open source code to produce new functionality
2. originate, test and debug code
3. find and use useful free resources from the internet including software

4. use technology to support collaborative projects eg with peers in different countries
5. make objective comparisons between computing resources
6. work safely within an overall acceptable use policy and respect other people
7. find patterns in data and information
8. compare computational models
9. transfer competence in computing and ICT context to other subject contexts.
10. communicate data and information in a form fit for purpose and audience.
11. use remix legally to add value to existing resources
12. solve problems systematically and rationally.
13. self and peer assess to gauge the effectiveness of their own learning.
14. think creatively, logically and critically.
15. evaluate their own and others' work and roles in teams and in computing projects.
16. apply language and mathematics in real and relevant contexts.
17. adopt enterprising approaches to new situations.

Unit contents

3.5 The content of units is in Annexe A below with some examples of interpreting the criteria. These are available in more detail on the TLM community learning site and will be linked to progressively more free and open supporting resources as these become available. NAACE members are invited to make contributions under Creative Commons licensing to promote sharing and improvement of the resources.

3.6 All centres have an assigned Account Manager who will be very pleased to help at any time. Our aim is to give professional assessors, most of whom are qualified teachers, the confidence to make judgements with a minimum of bureaucracy so that they can focus their time on maintaining their professional knowledge and skills and support learning through effective teaching rather than "chasing paper". There is often a confusion between bureaucracy and rigour, since unnecessarily complex bureaucracy can actually detract from rigour by obscuring the importance of the outcomes in unnecessary process. We also encourage coursework to be carried out in valid and real contexts rather than as contrived simulations. Competence is best assessed in context. All assessors must sign an agreement to uphold standards and feedback from moderation/verification will support consistency.

3.7 **Websites** - TLM provides support through a cloud based system for evidence management linked to grading and certification. Providing assessment grades and the management of certification through the Awards Site is mandatory and all assessors are provided with training in its use. It is simply a matter of recording learner competence against the unit criteria as the evidence is collected and claiming a certificate on behalf of the learner when a unit has been fully assessed.

3.8 The use of the community learning site is optional at no additional cost. It provides facilities for learners to submit their evidence online, linking it to the assessment criteria across single or multiple units. The assessor can accept or reject this evidence and comment on it providing a full audit trail for evidence. Moderator/verifiers can get immediate access to this evidence and so it is potentially a lot more efficient than alternative methods. No paper, no e-mails with file attachments necessary. There are facilities for progress tracking that can be based on criteria and/or units and reports that can be shared securely online with parents. The system can be linked as an extension to any standards compliant VLE/e-portfolio system for centres that are already committed to a specific VLE product. Training can be provided and free support is available from your Account Manager. The aim is to eliminate all paper based bureaucracy, all screen-shots and referencing that draws time away from teaching. As far as possible we want assessment of real tasks in real contexts that are truly representative of a real working environment. This is a fundamental goal for the competence based assessment at the heart of the Qualifications and Credit Framework and European Vocational Education and Training policy (ECVET). It is the way in which most employers will judge the effectiveness of individuals in their tasks at work.

3.9 **Telephone** and e-mail support is available to all Centres. There is a general convention of firstname.secondname@theingots.org for e-mail addresses. It is usually best to e-mail your account manager in the first instance. Google hangouts can be arranged for video conferencing support.

4. Assessment

Assessment summary

Coursework

4.1 Evidence has to be provided against the unit assessment criteria from practical tasks related to the learners' everyday work. This is likely to be from specialist lessons related to computing but can and should include evidence from across the curriculum. This will ensure that what is learnt in Computing has some chance of contributing to raised standards in all subjects. The way evidence is gathered is up to the assessor, the only requirement is that it clearly supports the judgements against the assessment criteria and the relevant learning outcomes. If on moderation the account manager finds gaps in evidence related to a particular candidate they will request more evidence before approving the award of the unit certificate. Assessors must then adjust their work to ensure all their learners are providing the appropriate level and breadth of evidence. We encourage early submission of at least some evidence so that assessors are confident from the feedback that what they are providing is sufficient (and indeed not over-kill). In this way we can maintain standards while supporting improved efficiency.

4.2 Synoptic assessment has become a popular term. In essence all the coursework assessment can be synoptic in that the evidence provided is against synoptic assessment criteria underpinning the learning outcomes for the unit in the context of a synoptic level descriptor. Competence can and should be evidenced by projects that draw upon all or large subsets of the content. Synoptic evidence of competence to a minimum value of 15 credits across the units is mandatory for both the level 1 and level 2 certificates. This equates to a minimum of 120 guided learning hours, 40 hours for each 5 credits. Dividing into a unit structure is for convenience and compatibility with international conventions for referencing national qualifications frameworks and to enable credit transfer eg as in the European system ECVET. It is **NOT** intended to determine the method of delivery. Teachers are free to cover units concurrently deciding where the elements are logically related. We encourage the use of the flexibility provided to target particular interests of learners to motivate them in persevering in difficult areas to up the level of expectation in cognitive development.

4.3 There are corresponding units at Level 1 and Level 2 with many common criteria. In broad terms differentiation is related to the degree of autonomy of the learners so that Level 1 and Level 2 learners can be taught in the same groups. Level 2 learners will also have more capacity to tackle academic style questions

requiring explanations and more detailed understanding and insight. The outcomes for individuals in terms of the broad level descriptors allied to the assessment criteria, verified by the teacher/assessor and externally moderated by TLM will determine the final outcome. Grouping learners is up to the school but the design enables maximum flexibility. Some students can achieve Level 1 first for example in Year 10 and then progress to Level 2 units from coursework and then finally to a Level 2 grade through the exam.

Progression and inclusion

4.4 There are some fundamental misunderstandings of unit based assessment with regards to progression and inclusion. The paragraphs below will explain how criticisms related to these issues can be rejected. It is mainly an issue of having higher levels of professional expectation and better CPD strategies rather than simply “dumbing down” to less professional approaches.

4.5 Learners gaining Level 1 credit can carry this forward into the Level 2 qualification because the Level 2 qualification allows a certain amount of Level 1 credit to count in the coursework. The Level 1 qualification has much the same content as Level 2 albeit in less demanding forms. In practice differentiation by outcome is possible enabling Level 1 and 2 candidates to be taught in the same groups but there is nothing to prevent setting by level or even expected grade and level. If that is likely to improve outcomes for learners. This makes arrangements for progression much more flexible and potentially more seamless. It would be possible to start with Level 1 expectations in Key Stage 3 build to Level 2 in Key Stage 4 with some Level 3 work for particularly able candidates. Such organisation is up to the school, the qualification design simply enables this and the payment model enables more scope to reward learners more regularly with the aim of increasing their motivation. It is **NOT** about simplistically dividing the curriculum into discrete units to be minimalistically ticked off and then forgotten.

4.6 These strategies make the Level 2 certificate more accessible to a wider range of candidates since any candidate failing to meet the coursework requirements at Level 2 is eligible to be certificated at Level 1 if they have met all the Level 1 criteria which is likely. They can be graded in the Level 1 exam when ready. They do not need to be fully at the Level 2 standard at the start of the course but they can progress to it by the end and have certificates to reward their achievements along the way with upgrades from Level 1 to level 2 when appropriate.

4.7 It is very unlikely that any learner embarking on a TLM qualification based on these methods will not achieve at least some kind of recognition for their work at a level appropriate to their current attainment level with a progression route from where they end up to higher levels. This inclusion is achieved without sacrificing rigour for the highest attainers since the questions in the examination targeting the A/A* grades can be as difficult as necessary without risking weaker candidates dropping out of a grade altogether. Indeed able students can start Level 3 work in KS4 differentiated by outcome.

4.8 Beyond Level 2 it is possible for Level 2 units to be converted to Level 3 by candidates if they provide evidence that is clearly at the higher level. For the highest attainers this provides an accelerated route to Level 3 so that they are not just marking time at the end of KS4. This is where current systems fail the highest level attainers. Some individuals can cope with university level work in KS4, not many but these individuals matter just as much as those with learning disabilities and so we need systems flexible enough to cope with them.

4.9 Coursework, particularly at Level 2 should reflect useful and meaningful activities with practical activities useful to other people and the wider community as well as the candidates themselves. Examples might be to contribute to an open source project or provide “apps” for staff in their own school. We want to encourage work that reflects contemporary society and the free tools and technologies that enable ALL individuals to contribute, not only those that can afford to. Projects lend themselves to cross-curricular work supporting raising attainment in other subjects, numeracy, literacy and information skills. It is far better to learn through creating original work (or original remixes of other people’s work) that has a real and practical purpose than to do simulations or theoretical exercises and that is fundamental to TLM’s coursework philosophy.

Criticisms of coursework answered

Criticism 1: Coursework is too susceptible to plagiarism and other forms of dishonesty.

A Google search will have a high chance of finding any extended text that has been copied from an online source. If we are genuinely concerned about “copying from the internet” simply inform teachers of how to combat the issue using freely available tools. Require teachers to accept professional responsibility for the authenticity of their learners’ evidence. If teachers really want to cheat why would they not simply tell students the answers to an exam? If learners want to cheat why not simply forge a convincing looking certificate? There is no tradition of easy

certificate authentication so there is a high probability that forgery will be successful. A complementary examination means that we can check back to see if individual teachers are “passing” student coursework for a disproportionately high number that then fail the examination. That provides an evidence source to cross-reference the quality assurance in order to better target staff development. Work smarter not harder!

Criticism 2: Unit based assessment means that knowledge is in compartments.

Unit structures are for administrative convenience **NOT** teaching plans. There is nothing to stop elements of several units being supported through one or more projects concurrently. Most academic syllabuses are divided up into sections. That is no different in practice to labelling the sections units. There is no requirement to assess units at a particular time. If most evidence is provided at the end of the course across all units why is that any different in principles related to timing from a controlled synoptic terminal examination? If teachers do not teach unit based courses effectively, train the teachers, don’t blame the tools.

Criticism 3: Unit based assessment does not support progression.

On the contrary, the scope of unit based qualifications organised in a levelled framework provides a better support for progression when the unit content and structure is designed for that purpose. Where qualifications are opportunistically designed to simply target one level in a terminal examination that is only representative of a subset of the learning, there is a good argument that progression is badly supported but that is true of any qualification whether unit based or not.

Criticism 4: Competence based assessment has to be lowered to the level of the least difficult assessment criterion.

In well designed assessment units the assessment criteria are contextualised to the general level specified in the overall level descriptors. This means all assessment criteria should be interpreted in terms of that overall level descriptor. It is impossible to measure anything with absolute precision and it is scientifically bogus to claim we can, even if it is politically sensitive to admit that there will be some uncertainty in assessment outcomes when applied to individuals. This is true of both coursework based and exam based methods. The important thing is to get a reasonably consistent set of outcomes within the expected degrees of uncertainty.

The competence based component of these qualifications is intended to provide a baseline consistent with the level. Grading is achieved by a terminal examination. This means we can match the assessment method to the aspect of attainment such that we cover all aspects of learning but we also provided reliable differentiation that can accurately inform progression routes for individuals.

Criticism 5: Exams have always been the tried and trusted way of assessing attainment. There is no need for anything else.

Written examinations have been widely used for academic assessments in schools and universities. However, that is largely due to their academic heritage where theory is often more important than practice. Even so coursework is well-established where there are practical elements eg in science and medicine. Few jobs assess prospective candidates exclusively using written exams. In most practical areas from brain surgery to teaching, no-one would trust a written examination on its own to prove competence. That is not to say such examinations are not of value. The key is to use coursework **and** examinations intelligently together in order to provide something that is better than either treated in isolation.

The Examination

4.10 Examinations at Level 1 and Level 2 are primarily for grading. The details of the way grades relate to marks are provided above in section 2.

Weightings

4.11 There are two classes of objectives. AO1, AO2, AO3 are generic assessment objectives:

AO1 - Recall, select and communicate knowledge and understanding.
AO2 - Apply knowledge and understanding through analysis, reasoned judgements and drawing conclusions.
AO3 - Practical and technical skills related to applying skills knowledge and understanding in context.

Additionally, the qualification units each specify subject specific learning outcomes. The qualification design draws on both classes of objective to ensure balanced representation and that the assessment is a valid representation of what has been learnt.

4.12 The assessment objectives provided by the unit learning outcomes are evenly weighted in the coursework element since all must be achieved in order to pass.

The synoptic examination provides a terminal summary of the knowledge and understanding directly related to the unit learning outcomes and assessment criteria. It uses the content definitions in section 3, designed to be broadly representative of the aspects of the learning outcomes testable in a written controlled examination. The examination provides a means of testing associated knowledge and understanding, powers of analysis and reasoning and of grading the qualification whereas the course work ensures that there is basic competence in their practical implementation in real and relevant contexts across the range of the subject matter.

4.13 At level 1 the examination weighting of AO1 is 50% and AO2 50%. At level 2 the examination is weighted 20% AO1 and 80% AO2 in the examination and approximately equally in the coursework.

4.14 The overall weighting of the objectives varies depending on the grade because for higher grades AO2 contributes a greater proportion of the marks. This is a deliberate strategy because AO2 is the most important learning when it comes to academic learning at Level 3. The assessment will therefore better inform progression pathways while still having the characteristic of inclusion. At level 2.

Grade C approximately weighted AO1 - 40%, AO2 - 40%, AO3 20%.
Grade A* approximately weighted AO1 - 25%, AO2 - 65%, AO3 10%

4.15 This then provides evidence that the Grade A* candidate is likely to be more suited to future academic study whereas the Grade C candidate is likely to find it difficult to cope with courses highly dependent on academic testing.

Learner entry and costs

4.16 TLM/NAACE subscription model enables schools to enter learners at times convenient to them. There are no late entry fees and no additional fees should a learner fail to produce evidence at a particular level but can meet the criteria at a lower level. This can reduce costs to the school by more than 50% when compared to GCSEs and significantly more than this when compared to some GCSE alternatives. Examination entry will depend on whether or not learners meet the coursework criteria. This again saves money because the school is not paying for examination administration for learners that are unlikely to be successful or for

whom there is little or no benefit in taking an exam. There are no fees for replacement certificates or verification of certificates because all certificates can be directly authenticated against a secure database. For details of current subscription costs please contact us or refer to the web site. All of these design features are intended to reduce direct costs but just as importantly the indirect administrative overhead that diverts teachers from teaching.

Online examination

4.17 The examinations can be delivered in a traditional paper based format or online. There is a surcharge for paper based examining reflecting the extra cost involved. The online versions have a secure web user interface and requires no software installation. They can run through any standards compliant web browser on any type of computer. The user is restricted to an area in the centre of the screen during the examination and has no access to the internet, or any other storage device without moving the mouse pointer out of the secure area and this will set off a warning. Persistence will result in disqualification from the examination. Since the Level 2 online exam contains open-ended questions it has to be physically marked and so the results will not be immediately available but we will aim to have these ready within 2 weeks of taking the exam. The Level 1 examination is multiple choice questions and so the results will be available immediately. For those taking the examinations in the traditional paper based format it is likely to take 4 weeks to finalise results.

Examination windows

4.18 The exam will be available for three windows per year in December, March/April and June/July. It is the Centre's Principal Assessor's responsibility in line with the agreement signed with TLM to ensure that security is maintained for the examination. No candidate should have prior access to the questions in an examination paper either directly or indirectly, before they sit the paper. We will have several versions of the examination available and if there is any suspicion of compromise of security, the Principal Assessor should contact TLM to work out a solution. Assuming there is no malpractice, it might simply be a matter of scheduling an alternative paper. Papers will be planned to be of similar difficulty. Candidates can retake an examination at the following sitting if they have not claimed a qualification based on a previous result.

Internal standardisation of coursework

4.19 The Principal Assessor has the ultimate responsibility for consistency in assessment standards within a centre. All assessors have signed a contract agreeing to uphold standards and should therefore co-operate with the Principal Assessor and Account Manager at TLM to ensure that standards across the centre are consistent. It is advisable to send work samples to TLM early to check that evidence is at the right standard so that there is time to make any adjustments necessary to the course and learner expectations. TLM will generally check a higher quantity of work from new assessors and feedback to ensure that they are confident to make appropriate judgements over time. This reduces risk and improves efficiency in the longer term.

Authentication

4.20 All assessors must take reasonable steps to ensure that any coursework evidence submitted by candidates is a true reflection of the candidates' competence. This is in keeping with the assessor undertaking to uphold and maintain standards in the contract with TLM.

4.21 Certificates can be authenticated directly online using the certificate number or by scanning the QR code on the certificate. There is no charge and it makes it more likely that certificates will be checked and that in turn improves security. Certificate forgeries are a significant problem when authentication is not simple and straightforward because convincing forgeries are easy to achieve with recent technologies and will get easier as time goes on.

5. Other considerations

Access arrangements and special requirements

5.1 All TLM's qualifications are intended to be accessible, as widely as possible. There is an extensive policy documented on the web site at https://theingots.org/community/QCF2.13
Centres should contact TLM if they have any questions related to accessibility issues.

Language

5.2 The language for provision of this qualification is English only. This will only change if we have a significant demand in another language that is sufficient to cover the additional costs involved and some cultural alterations will be needed. TLM will actively support any work in this line that can be shown to cover costs.

Malpractice

5.3 TLM has comprehensive policies and procedures for dealing with malpractice. These are documented with links on the web site at https://theingots.org/community/QCF5.29-5.32 Assessors should be familiar with these policies and make them clear to candidates. Assessors should inform their account manager if they suspect any instance of malpractice that could have a material effect on the outcome of any assessments, either for themselves or colleagues. This is part of the upholding of standards that is part of the contract with TLM.

Equality of opportunity

5.4 TLM promotes equality of opportunity through policies and procedures. These are again documented in detail on the web site at https://theingots.org/community/QCF2.11-2.14

Resources, support and training

5.5 A clear goal of this computing qualification is to enable learners to support their own learning and to reduce dependency in order to become "lifelong learners". The information technology revolution makes this progressively easier and as far as possible we encourage the use of technology and up to date methods especially those based on empirical evidence.

5.6 TLM encourages the use of Free and Open Source applications to reduce costs and to further inclusion. All of the key software applications needed to support any of the assessed units are available freely from the web including programming languages, operating systems, office suites, graphics and sound editing. As a nation we could save hundreds of millions if not billions of pounds in software licensing fees by providing users with the skills, knowledge and confidence to migrate to free and open source applications. YouTube, OpenClipart.org, Wikipedia and many other sites provide free content that supports learning and the number and range of such sites is increasing. Please use them.

5.7 Any numerate, literate and information savvy youngster with the motivation to learn can probably get to PhD level entirely using free resources **IF** they are highly digitally literate as well as literate and numerate in the more conventional sense. The mission of TLM and its qualifications, is to increase take up of learning by empowering the learners to enter a training and qualifications market on their terms at a price that they can afford. These computing qualifications are designed to support learning that enables access to Further Education, Higher Education and Employment for a wider range of young people.

6. Grade Descriptions

A **grade A** candidate will exhibit most the following characteristics.

6.1 Candidates demonstrate a high level of independence in using their knowledge and understanding to support activities beneficial to themselves and others in everyday contexts. They recall, select and communicate a thorough knowledge and understanding of the general competences needed to support lifelong learning and personal well-being.

6.2 They apply knowledge, understanding and skills to a variety of situations, selecting and using knowledge and information efficiently to solve problems and produce effective support for their own learning as well as the needs of others. They relate these to comparable activities in the world of work. They manipulate and process data efficiently and effectively based on objective criteria. They interpret information and transfer knowledge and understanding from familiar to unfamiliar contexts. They work creatively exploring and developing ideas. They adopt systematic approaches to safety, promoting secure and responsible practices.

6.3 They use scientific methods to analyse problems such as control of variables and observations to identify needs and opportunities. They set hypotheses in relevant contexts and critically analyse and evaluate the knowledge they gain. They review their own work and that of others making supportive and constructive criticism where appropriate. They communicate effectively, demonstrating a clear sense of purpose and audience.

A **grade C** candidate will exhibit most of the following characteristics.

6.4 Candidates demonstrate the ability to select and use relevant knowledge, ideas, skills and procedures to complete well-defined tasks and address straightforward problems. They take responsibility for completing tasks and procedures and exercising autonomy and judgement subject to overall direction or guidance.

6.5 They use understanding of facts, procedures and ideas to complete well-defined tasks and address straightforward problems in supporting their learning. They interpret information and ideas related to the social and commercial impact of their actions, showing awareness of the types of information that are relevant to

their areas of study. They identify, gather and use relevant information to inform their actions and make judgements about how effective their actions have been.

6.6 They work safely and securely, identifying key risks, taking reasonable actions to avoid them. They collaborate in reviewing their work evaluating the way they and others use IT and they take positive actions to improve. They use IT to communicate, demonstrating consideration of purpose and audience.

Annexe A - Example examination Level 1

The following principles will apply to the design and structure of each exam.

Questions will vary in the general area of the required learning outcomes specified in the units and cover all the assessment criteria in the approximate proportions presented in this document. Questions will reflect a balance of the content listed and explained in the guidance in keeping with Level 1 as defined by the QCF global level descriptors. Each question is worth 1 mark.

Questions

1. A circle is an abstraction of

    a) A wheel
    b) A tree
    c) A computer
    d) A train

2. A colour image is made up from

    a) only black and white dots
    b) red, green and blue dots
    c) only green and blue dots
    d) black, blue and white dots

3. The dots making up an image are called.

    a) dotties
    b) picts
    c) pixels
    d) idiot

4. Here are some instructions.

REPEAT
Forward 100
TURN LEFT 90
4 TIMES

This sequence will make someone

a) Walk in a circle
b) Walk around a square
c) Walk up and down
d) Walk backwards

5. Which of the following statements is TRUE?

a) A pattern of 1s and 0s can provide the information to make a detailed colour image.
b) A pattern of 1s and 0s can only provide the information to make a black and white image.
c) A pattern of 1s and 0s can not provide the information to make any sort of image.
d) A pattern of 1s and zeros can provide the information to make any sort of image but it will be fuzzy and unclear.

6. A postman has 80 letters to post in a row of 100 houses. Which of the following would be a good strategy to finish quickly?

a) Start at one end of the street, take a letter, go to the address on the letter and repeat the whole sequence until finished.
b) Start in the middle of the street, take a letter, go to the address on the letter and repeat the whole sequence until finished.
c) Sort the letters into number order and then deliver them from the middle of the street.
d) Sort the letters into number order and then deliver them in order from one end.

7. An algorithm is

a) a table of numbers
b) a steady beat in music
c) the part of the human brain that is used for mathematical calculations
d) a set of rules used to solve a problem

8. In computing, an ordered list is a list

a) which is provided by a menu
b) in which the order of the items is important

c) which has to be carried out immediately
d) in which the first item has a special role

9. When comparing two computer programs for efficiency, it is important to

a) know the companies that own them
b) ensure they are exactly the same length
c) ensure they are both operating on the same data
d) ensure they are running on different hardware

10. Here is some programming code.

```
string date = 7th
CASE date OF

WHEN 7th :PRINT “My Birthday”
WHEN 12th :PRINT ”Your Birthday”

ENDCASE
```

The result of running this program would most likely be

a) Your Birthday
b) My Birthday
c) My Birthday Your Birthday
d) Our Birthdays

11. Here is a programming instruction.

```
ADD r0,r1,r2
```

Here are some examples of it with real numbers

```
ADD 7,3,4
ADD 5,3,2
ADD 9,1,8
```

Which of the following is another correct example?

a) ADD 9,0,0

b) ADD 6,7,5
c) ADD 3,9,6
d) ADD 8,4,4

12. In question 11,

a) the data for the instruction are stored in registers r0,r1,r2
b) the instructions are stored in registers r0,r1,r2
c) there is no data only instructions
d) there is no way to tell the difference between data and instructions

13. The movement of the printer inkjets in a printer, the movement of the cutting tool in a computer driven milling machine and automatic switching on a cooling system for a nuclear reactor core are all examples of

a) control technology
b) design technology
c) biotechnology
d) future technology

14. Which of the following is a loop? (AO2)

a) PRINT “Hello World”
b) WHILE TRUE: PRINT”TRUE”:ENDWHILE
c) DATA 1,3,4,7,6,9,2,3,4
d) DEFPROCloop:PRINT”Loop”:PRINT”OUT”:ENDPROC

15. Jane has just finished her program and when she runs it the screen goes blank so she knows it isn’t working but she is not sure why. Jane should be advised to

a) run the program again because it will probably work after a rest.
b) start at the top and read the program listing carefully to find the errors
c) put some print statements with pauses in the program to find out where things are going wrong
d) switch to a different computer

16. Why is it useful to write a program with a partner?

a) If you choose a clever partner they can do all the work
b) Programming can be lonely

c) If you make a mistake you can blame the partner
d) A partner might see a mistake that you miss

17. Fred has set some variables in his program to represent the length of his garden and the length of his garden hose. Which of these would be a good name to use for each

a) length_of_garden and length_of_hose
b) L1 and L2
c) L and l
d) Lg and lh

18. Using a long variable name will

a) slow the computer down
b) use up too much memory
c) make the software insecure
d) none of these

19. Here are 4 logic statements

a) the light is on AND the door is closed
b) the light is on OR the door is closed
c) the light is on AND the door is NOT closed
d) the light is on OR the door is NOT closed

Which one would be true if the light is off and the door is open?

20. A search engine puts a particular web site at the top of the list of results. Which of the following is most unlikely to be the reason?

a) The site has a lot of connections to it from other sites and has information relevant to the search
b) The site owners paid for it to be at the top of the list
c) The site was new and had some relevant information
d) The site had a lot of keyword tags relevant to the search

21. While searching for a file on his computer, Ali types *.odt into the search box.

This search will provide

a) only the name of a file called *.odt
b) all the files with the .odt extension
c) all the files in a folder called *
d) all the files in a folder called odt

22. The number of binary digits (bits) in a byte is

a) 1
b) 2
c) 4
d) 8

23. The binary number 10 in decimal numbers is

a) 10
b) 0
c) 2
d) 8

24. Which of these statements about open standards is true

a) Open standards are a big security risk
b) Open standards enable competition between technology companies
c) Open standards are usually of low quality and should therefore be avoided
d) Open standards only apply to open source software

The table shows data logged in a science experiment. Use this table for questions 25 to 27

Temp	25	26	27	27	25	23	20	°C
Time	0	1	2	3	4	5	6	S

25. The computer sensor has to

a) Convert temperatures to voltages
b) Convert time into seconds
c) Be at least 16 bit for this accuracy
d) Be made from mercury

26. Which of the following computer devices will need to be connected between the sensor and the computer?

a) keyboard
b) mouse
c) DAC
d) ADC

27. The accuracy of the temperature measurements

a) is to the nearest degree
b) is much more accurate than to the nearest degree because a computer is being used
c) is less accurate than to the nearest degree according to the table
d) could be increased by taking the reading faster

28. Lisa wants to publish a book with an online publisher. The publisher requires a cover in .svg format and the contents in .pdf format. Which two applications will be best for this purpose?

a) A vector drawing program and a word processor that can export pdf files
b) A multimedia editing program and a web browser
c) A photo editing program and a translation application
d) An iphone app and a pdf editor

29. When other people's work is combined and edited to produce a new and original work it is called

a) reformatting
b) refrigerating
c) remixing
d) remembering

30. A project plan should always include

a) a sequence of tasks
b) a complete written description
c) a financial budget
d) a project mentor

31. Whenever you write a new program

a) you don't own it until you submit a copyright application
b) you own the copyright automatically
c) you have to pay a fee to copyright it
d) it is in the public domain until you copyright it

32. A copyright license

a) will cost money in all cases
b) will only cost money if it is registered
c) will stop you from copying the work
d) will tell you what you can and can't do with the work

33. The GPL, Apache Software license and Creative Commons licenses are all examples of

a) left wing licenses
b) liberal licenses
c) conservative licenses
d) public domain licenses

34. In a computer, the processor

a) automatically checks data is ready
b) converts program instructions into actions
c) stores information permanently
d) stops the computer from over-heating

35. A computer provides a warning of bad sectors on its hard drive after being used for a year. Which is the best course of action?

a) Take out the old drive and throw it away

b) Ignore the warning and wait to see if it comes back
c) Ensure all the data on the hard drive is backed up
d) Switch off immediately and take to a computer shop

36. The image below is

a) USB memory
b) CPU
c) Motherboard
d) Hard drive

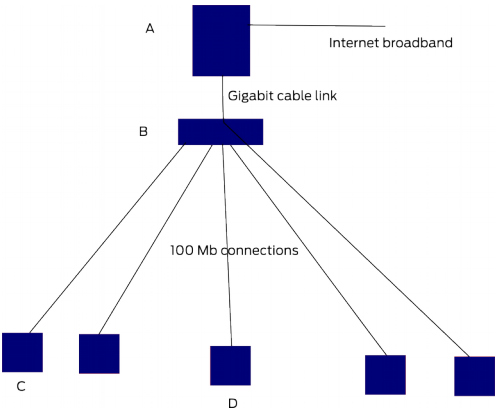
37. Which of the following is not a storage device?

a) USB memory stick
b) ADC
c) Hard drive
d) SDRAM

38. To make the battery in my smartphone last longer before needing a recharge I should

a) make the screen brighter
b) reduce my use of multimedia applications
c) plugin the headphones
d) change my ringtone

39. In the diagram below, which of the items labelled is most likely to be a server?



a) A
b) B
c) C
d) D

40. Web pages are viewed in your browser when

a) you send a web page request to a web server
b) you connect to the internet
c) you send e-mail to a mail server
d) you pay your service provider

41. You have a lot of applications running on your computer and it suddenly slows down so it is unusable and the hard drive light is on almost all the time. The most likely explanation is

a) the processor is overheating
b) the computer is obsolete and you need to buy a new one
c) the computer has run out of RAM
d) the hard drive is full

42. What type of user is likely to have the most permissions on a server?

a) Administrator
b) Unauthenticated user

c) Authenticated user
d) Account Manager

43. A server network connection has a bandwidth of 1 Gb. what is the maximum number of 100 Mb clients that it could manage if all were working to their maximum capacity?

a) 1
b) 5
c) 10
d) 20

44. In question 43 it might be easy for the server to support ten times as many clients if

a) they only occasionally operate with maximum demand and the load is spread randomly across the clients
b) the clients are all given faster network connections
c) the clients have a range of different but faster network connections
d) the clients all run the same software as the each other and the server and the processors are designed to run the software efficiently.

45. Which of these is not a local area network

a) A network of 100 computers connected to a stack of switches 70m away with the switches connected to a server 50m from them
b) A network of 20 computers connected to a stack of switches 70m away with the switches connected to a server 50m away from the switches
c) A network of 100 computers connected to a stack of switches 7km away with the switches connected to a server 5m away
d) A network of 1000 computers connected to a stack of switches 200m away with the switches connected to a server 5m away from the switches.

46. I have a protocol that says the number pattern 321 must identify each packet of data and the number immediately after this pattern is the number of characters in the data packet. Which of these is a valid set of data for a packet using my protocol?

a) 3218ABCDEFG
b) 3218abcdefgh

c) 1233XYZ
d) 1233xyza

47. Which of these is the most widely used internet protocol suite?

a) Netbui
b) Webnet2000
c) TCP/IP
d) Webhead

48. Wireless networks are

a) low bandwidth, high cost, poor range
b) high bandwidth, low cost, good range
c) low bandwidth, low cost, moderate range
d) high bandwidth, low cost, poor range

49. The difference between a switch and a router is that

a) routers are bigger than switches
b) switches direct data to devices connected to them while routers direct data between networks.
c) switches turn network signals on and off but routers maintain them and keep them running.
d) switches are open standards whereas routers are always proprietary.

50. A context aware application is one that

a) uses sensors that give information to the software about the user's environment
b) passes data between users of any particular manufacturers' equipment.
c) can pass information interoperably between applications from different providers.
d) uses sensors to block spam and malware getting to the users mailbox.

Annexe B - Example examination Level 2

The following principles will apply to the design and structure of each exam.

Questions will vary in the general area of the required learning outcomes specified in the units and cover all the assessment criteria in the approximate proportions presented in this document. Questions will reflect a balance of the content listed and explained in the guidance in keeping with Level 2 as defined by the QCF global level descriptors.

Questions

1. An abstraction could be

    a) The removal of code
    b) A type of computer
    c) Code that represents a physical object
    d) A programming technique to make loops run faster

(1 mark)

2. A compressed file

    a) has fewer bytes than an uncompressed file
    b) has more bits than an uncompressed file
    c) will be corrupt and impossible to open
    d) can only be achieved with graphic images

(1 mark)

3. The dots making up an image are called.

    a) pictograms
    b) pixies
    c) pixels
    d) particles

(1 mark)

4. Here are some instructions.

REPEAT
Forward 100
TURN LEFT 90
4 TIMES

This sequence will produce a simple abstraction of

a) A wheel
b) A box
c) A star
d) A person

(1 mark)

5. A weakness in most computational models is that

a) they can never be exactly the same as the thing that they model.
b) they are less expensive to make than a physical model.
c) they are easy to adjust to model something similar.
d) they can only be used by an expert computer scientist.

(1 mark)

6. A program loop is

a) an acronym standing for logic oriented optional program.
b) a piece of code that is repeated until some condition is met.
c) always infinite because it never terminates.
d) a method of translating source code to executable code.

(1 mark)

7. {IF A > B THEN DoThis} is an example of

a) an unconditional statement
b) a function
c) a string
d) a conditional statement

(1 mark)

8. A bubble sort and a merge sort are

   a) used to sort bubbles and prioritise emergencies
   b) examples of algorithms only suitable for different purposes
   c) examples of different algorithms for the same purpose
   d) used only in very complex circumstances

   (1 mark)

9. Write down the word that this definition describes.

   This is a process in which a function or procedure in a program calls itself as a subroutine in its code.

   (1 mark)

10. Consider the code below

```
string date = 7th
CASE date OF

WHEN 7th   :PRINT “My Birthday”
WHEN 12th :PRINT ”Your Birthday”

ENDCASE
```

    How would you modify this code to print Pavel’s Birthday on the 21st?

    (1 mark)

11. Here is a programming instruction.

```
ADD r0,r1,r2
```

    Here is some code that achieves the same result

```
Input number <r1>
Input number <r2>

MakeSpace <r0>

r0 = r1 + r2
```

Give examples of 2 sets of number that can be assigned to r1 and r2 in order to return the number 13 in r0.

(2 marks)

12. In question 11, do you think that the instruction ADD r0,r1,r2 is more efficient code than the code beneath it that achieves the same result? Explain your answer.

(2 marks)

13. Write down the names of 1 Mark-up Language and one Programming Language,

(2 marks)

14. Susan runs her program and it produces a syntax error. Explain how she might find the location of the problem in her source code.

(2 marks)

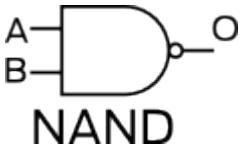
15. Explain the difference between source code and executable code.

(2 marks)

16. Michael is writing a program to sort a list of book titles. He uses the variable called bt for book titles. Angie says he would be better to name the variable book_titles but Michael says this will slow down his code and make it less efficient. Who is right and why?

(2 marks)

17. The diagram below shows a NAND gate



How would you ensure that the output O was switched off?

(1 mark)

18. An electronics engineer decides to buy only NAND gates to build logic game. Why would they do this?

(2 marks)

19. What is the sum of the binary numbers.

1001 + 1101

(1 mark)

20. What is the biggest hexadecimal number that can be represented by 4 bits?

(1 mark)

21. A computer interface has 8 connector pins. It is mapped to a memory location A that can contain the decimal numbers 0 to 255. If pin 1 goes from 0v to 5v when the number 1 is in location A and pins 1 and 2 go from 0v to 5v when the number 3 is in location A what is the state of pins 1 and 2 when the number 2 is in location A?

(2 marks)

22. What is the name of the device that converts electrical signals from a microphone into digital audio data?

(1 mark)

23. Give an example of 2 computer applications you have compared to do a job and explain briefly why you chose one over the other.

(3 marks)

24. Why would I use an export filter when saving a file?

(1 mark)

25. Explain why the World Wide Web is an interoperable environment.

(2 marks)

26. What considerations need to be taken into account when preparing an image file for use on the World Wide Web?

(2 marks)

27. Give three actions you need to take when planning a software project.

(3 marks)

28. Briefly describe a license you have used for your work and say why you chose it.

(2 marks)

29. Why is open Source software sometimes referred to as Free and Open Source Software?

(2 marks)

30. Name 2 hardware components that are essential to all computers.

(2 marks)

31. A CPU has a clock speed of 2 GHz. It can process 2 instructions in each clock cycle. How many instructions per second are processed?

(2 marks)

32. Why is there a limit to how fast a processor clock can be made to run?

(1 mark)

33. What number is missing in the place X in the following pattern?

2, 4, 8, X, 32

(1 mark)

34. A server has a database with accounts for 3 million users who are spread all over the world. Explain how one server could meet the the needs of this many people.

(5 marks)

35. A server is connected to a network by a 1 Gb connection to a central switch stack. There are 100 client computers connected to the switch each with a 100 Mb connection. Discuss whether or not the 1 Gb connection will be a limit in the network's performance.

(5 marks)

36. A 250m reel of fibre optic cable costs £500. A 300m reel of UTP Cat 6 cable costs £120. 15 client computer need to be connected to a switch 70m from the computers. UTP cable can be connected directly to the switch but fibre cable requires a media converter for each connection costing £30. What is the difference in cost between using fibre cable connections compared to UTP connections? (show your working)

(5 marks)

37. In Q. 36 what would be the advantage in using fibre optic cable?

(1 mark)

38. A smartphone can connect to a 3G network for data. Name a different wireless network type it can connect to.

(1 mark)

39. Write down the word that completes this sentence. HTTP, FTP, SMTP and TCP/IP are all examples of network P_____

(1 mark)

40. Give an example of a strong network password.

(1 mark)

Annexe C - Level 1 Units

Level 1 Computing
Unit 1 - Computer Science - 5 credits - 40 GLH

1. Design, use and evaluate computational abstractions	2. Understand algorithms	3. Be able to use programming languages	4. Understand binary and Boolean Logic
1.1 develop abstractions to represent physical objects	2.1 write algorithms for everyday tasks	3.1 originate useful code in a visual language	4.1 predict the outcome of statements containing AND, NOT and OR
1.2 use data patterns to represent physical objects	2.2 identify different algorithms that target the same task	3.2 originate useful code in a text based language	4.2 include AND, NOT and OR in information searches
1.3 follow instructions to produce a software abstraction	2.3 compare algorithms	3.3 identify structure in programs	4.3 identify reasons why some search results are likely to be more important than others
1.4 use software abstractions that model real world systems	2.4 apply logic to efficiency and effectiveness of algorithms	3.4 test code	4.4 relate boolean logic to program flow
1.5 identify strengths and weaknesses in computational models	2.5 change variables in an algorithm and predict the effect	3.5 edit source code to fix a bug	4.5 use wildcards in searches
	2.6 know how instructions and data are stored	3.6 choose variable names that aid clarity	4.6 represent numbers using binary patterns
	2.7 identify situations where codes control events		

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 1 qualifications

1. QCF general description for Level 1 qualifications
2. Achievement at QCF level 1 (EQF Level 2) reflects the ability to use relevant knowledge, skills and procedures to complete routine tasks. It includes responsibility for completing tasks and procedures subject to direction or guidance.
3. Use knowledge of facts, procedures and ideas to complete well-defined, routine tasks. Be aware of information relevant to the area of study or work
4. Complete well-defined routine tasks. Use relevant skills and procedures. Select and use relevant information. Identify whether actions have been effective.
5. Take responsibility for completing tasks and procedures subject to direction or guidance as needed

Requirements

1. Standards must be confirmed by a trained Level 1 Assessor or higher
2. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
3. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
4. When the candidate provides evidence of matching all the criteria to the specification, subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
5. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
6. This unit should take an average level 1 learner 50 hours of work to complete, with 40 hours of learning under specific teacher presence.

Assessment Method
Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award. Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate.

Expansion of the assessment criteria

1. The candidate will design, use and evaluate computational abstractions

1.1 I can develop abstractions to represent physical objects

Candidates should be able to develop simple abstractions related to physical objects

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance
Abstraction is used to reduce complexity. Drawing a circle to represent a wheel is an abstraction of the wheel and represents the possibility to describe many different wheels. Once we have the basic abstraction we can add further information to get different kinds of wheel. eg a big or small wheel, a spoked wheel or a tyred wheel. Candidates should be provided with many opportunities to take physical objects and create abstractions by eliminating the details associated with the main attribute being abstracted. This does NOT require a computer (although there is no ban!) Shapes such as a square to represent a box, a sphere to represent a ball, planet, or star are some of the simplest abstractions. Suitable activities could be to get candidates to use simple shapes to represent familiar objects. eg 3 equilateral triangles to represent a Christmas Tree. Work in pairs. One draws an object the other has to guess what it is and provide instructions to the first to add more shapes to it to make it easier to decide what the original object was intended to represent. In some case we might find the first idea morphs into something the originator of the first shape did not intend. We can infer from this that greater complexity and more information define an abstraction more precisely and more uniquely. So in the case of the Christmas tree the first student draws a triangle. The

second adds two more to make a tree shape. The first adds a star on the top so the tree becomes a christmas tree and so on. A triangle start could equally be a woman's skirt or a pyramid. Adding arms. legs and head would then start to define it as an abstraction of a female, adding blocks and putting next to a picture of a Sphinx makes it a pyramid. Notice that the context of an abstraction can help reduce ambiguity about what it is intended to be. Common use of abstractions is in road signs and other simple icons that represent more complex physical objects. Another game to play is taking complex objects such as a car and representing it with the simplest abstraction that a partner can recognise as a car. Doing this in a vector drawing program such as Inkscape will also help develop computer drawing skills. Vector drawing packages are a very easy to understand implementation of abstraction in software engineering since drawings are built up from simple objects that can be grouped to form other larger more complex objects. By adding detail (information) such as textures to surfaces, drawings become more and more realistic.

1.2 I can use data patterns to represent physical objects.

Candidates should be able to relate images to patterns of data.

Evidence: from assessor observations, documentation in portfolios.

Additional information and guidance
Candidates should be given a lot of opportunities to think of images in terms of patterns of dots. This can start with looking at printing images to paper at various resolutions, investigating pictures in magazines or newspapers using magnifying glasses and low power microscopes. Can they use a microscope to work out the resolution of an image by counting the dots? What happens if you move your eye further away from a grainy image? Use Inkscape www.inkscape.org or similar drawing program to make a 5 x 5 grid. Fill in squares to make letters. Some letters like L or E are easy to get a good representation. M and W are much more difficult. How could we make it easier? Use a grid with more squares. Note that saying use a bigger grid is ambiguous as it could mean just bigger squares which would not help. More squares gives us more information, bigger squares are just the same information magnified. This is why with telescopes and microscopes magnification is not as useful as resolving power. Resolving power lets us see the details, magnification just gives a bigger view of the same level of detail and keep magnifying and you just get a big blurred image. This can be related to the work on abstraction. More relevant information means clearer more specific results. It is a universal principle whether dealing with images, economics or the environment.

A challenge. Your friend has 4 pencils. One red, one blue, one green and one black. You have only a black pencil and you can only write the numbers 0, 1, 2, and 3. You have a 20 by 30 grid on a sheet of paper and you want to send your friend enough information for them to draw the Republic of the Gambia Flag.

Send you friend a grid with the information they need to create the flag. They will do the same for you and see if you both get an identical flag at the end. Can you think of any ways you could reduce the amount of information you need to send?

As an extension to this consider getting other colours. Since all colours are made up from red, green and blue we can combine red, green and blue in different amounts to get all the other colours. If we had 3 levels of red, 3 levels of green and 3 levels of blue, how many colours could we make? Make a 3 x 3 grid for R1, R2, R3 and G1, G2, G3. 9 possibilities. add another 3 making the grid a cube and its 27. 3 x 3 x 3. So how many colours from 255 levels of red, 255 levels of green and 255 levels of blue? This is getting well beyond what is required at level 1 but provides a good grounding for Level 2. Ideas of file compression can be opened up by an instruction to print “1” 30 times rather than writing “1” 30 times to print a red stripe. A way of doing that would be to say if there is a change of colour, the first number tells you how many of the next number to print. So 30, 1 would replace 111111111111111111111111111111. We are allowed to use 3 and 0 so this would work as long as the person at the other end knew how to decode it.

1.3 I can follow instructions to develop a software abstraction

Candidates should be able to follow a set of instructions accurately to get a working abstraction

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance
To achieve an abstraction in software a simple case would be to draw a box in logo with REPEAT 4 [FD L RT 90] The size of the box depends on the parameter L. We

could add more parameters to change the colour and texture of the box. At this level the simplest cases are sufficient. A software abstraction is using some code to make a simple model of something in the material world and usually it is is an approximation to the real thing achieved by eliminating some of the details. The simplest abstractions such as drawing a line to represent a road or a circle to represent a stick person's head or a triangle for a skirt can all be represented in simple code. If a set of instructions are provided for the candidate to follow in order to get a working program, these constitute an algorithm. We then have an algorithm to produce the code and the code itself is an algorithm to produce the abstraction. The success of the algorithm to produce the code depends on how much information the programmer needs and for sufficient detail to be provided to them that they can understand. Similarly the success of the code as an algorithm depends on its accuracy and the ability of the computer programming language to understand the code as specified by the programmer. If both algorithms are well designed, the output will be as expected.

1.4 I can use software abstractions that model real world systems

Candidates should be able to use software models of real world systems.

Evidence: from assessor observations, schemes of work, content of learner portfolios.

Additional information and guidance
Any use of a computer simulation of a real world system is a target for this criterion. Numpty Physics http://numptyphysics.garage.maemo.org/ is a free and appropriate example that should help learners of this age understand the principles of abstraction since it is a simplified representation of the physical world.

1.5 I can identify strengths and weaknesses in computer models

Candidates should be able to list strengths and weaknesses in models that they use.

Evidence: From content of learner portfolios.

Additional information and guidance
If we take the Numpty Physics model, strengths are that is fun and easy to use, weaknesses are that the representation of reality of real objects is visually very approximate. Of course that is also a strength in relating to general physical

behaviour in a fun way. In general, encourage debate about why things are considered strengths and weaknesses. A lot of unnecessary detail could provide little benefit and make the software a lot more expensive or demanding of the hardware and it might actually be less fun. The interesting issues are usually the ones where there can be disagreement. This is also an opportunity to review games and to develop descriptive language beyond "I like it" or its good to say why it is good and to see if there is consensus. Another aspect is to identify strengths and weaknesses in coded algorithms. For example, where code is badly documented, inefficient, or particularly elegant. These aspects are very much more difficult to assess except in superficial ways in controlled tests so encourage understanding in the course of normal activities through, for example, peer review.

2. The candidate will understand algorithms

2.1 I can write algorithms for everyday tasks

Candidates should be able to use ordered lists of instructions to define procedures for everyday tasks.

Evidence: Assessor observations, local testing, portfolios.

Additional information and guidance

Algorithms are step-by-step problem-solving procedures. It is really a "fancy" word for something everyone does every day if they have any routines. Get up, go to the bathroom, get dressed, go down stairs, put the kettle on. All that is required here is that candidates can list the steps in everyday tasks. They should appreciate that repetitive tasks that are simple to replicate lend themselves to algorithms. Complex unpredictable behaviour doesn't. For example riding a bike to school. Mount bike, repeat (pedal) until I'm at school, dismount, park bike. Of course this is very simplified since we are saying nothing about avoiding traffic or turning corners. In practice a full algorithm that took into account all the possible events that might take place on the journey is a whole lot more complicated. It would be very difficult if not impossible to write an algorithm to coincide with how an individual lives for a month.

2.2 I can identify different algorithms that target the same task

Candidates should be able to recognise at least two different methods of approach to a problem that lends itself to an algorithm

Evidence: Assessor observations, local testing, portfolios.

Additional information and guidance
A useful resource to underpin this learning outcome is at http://csunplugged.org/searching-algorithms

A bubble sort and a merge sort are both sort algorithms but they can result in different efficiencies in achieving the outcome. A linear search and a binary search are again different methods targeted on the same problem. At level 1 candidates would be able to determine that two methods are achieving the same result even though the methods might work differently.

2.3 I can compare algorithms

Candidates should be able to compare algorithms based on properties such as how easy they are to follow or understand, how efficient they are and the circumstances where they might work and not work.

Evidence: From local testing and portfolios

Candidates should be able to see that some algorithms are easy to follow and some are much more complex. They should be critical of algorithms that are not documented well enough to understand. They should be able to carry out simple tests comparing eg two sort algorithms to see which is the most efficient. Guidance should be provided on the need for controlling variables such as the number of items to be sorted or searched so that the test is fair. This would be a good aspect to relate to the science curriculum. A mixture of algorithmic games and activities away from a computer and some with code will help in developing transferable understanding.

2.4 I can apply logic to efficiency and effectiveness of algorithms

Candidates should be able to provide rational reasons why they would prefer to use one algorithm rather than another.

Evidence: From assessor observations and portfolios

Additional information and guidance
As part of their testing of algorithms, they should be able to provide reasons why one algorithm is more suited to a task than another. This might need reference to a

particular context such as search strategies in a game of "Battle Ships". http://csunplugged.org/searching-algorithms is a possible resource for this.

2.5 I can change variables in an algorithm and predict the effect

Candidates should use existing code and experiment with changing one variable at a time to see its effect.

Evidence: Assessor observations and portfolios.

Additional information and guidance

This is another opportunity to reinforce control of variables. Experimenting with variables in several different scenarios should enable candidates to make predictions about effects in simple but unfamiliar code.

2.6 I know how instructions and data are stored

The candidate should know that instructions are stored in programs in a particular sequence and executed one after another but very quickly so that often it appears as if several things are happening at the same time.

Evidence: Internal testing, portfolios

Additional information and guidance

Conditional statements in programs determine which instructions are executed and in what order. Modern processors can execute hundreds of billions of instructions in a second. If a display is refreshed 100 times a second (typical of modern screens), more than a billion instructions can be processed in that time. To the observer of the screen it could look as if several things have happened all at the same time whereas they were actually processed one after the other. In the early days of computing performance was governed by the processor clock speed. Make the clock faster and the computing power increased but so did the heat generated. In order to operate at faster speeds the components had to get smaller so processor components became more densely packed. This makes the heating problem even worse. Removing the heat fast enough without frying the processor requires large heat sinks and fans. Apart from the waste of energy, this situation is also totally useless for mobile technologies that are dependent on batteries because the battery life will be insufficient for practical use as the processor churns out heat. (Good opportunity here to link to science, environment and conservation of energy) Most of the effort is now to make processors more efficient and to give them multiple cores - effectively several processors on one chip. Of course writing

software more efficiently will also help. If I can find a way of making savings in the number of instructions executed in my program to get the same outcome it will be no different from improving the performance of the hardware.

Programs are normally executed from very fast memory actually on the processor itself (called a cache). So instructions and their associated data are stored in different places at different times. The program will be stored eg on a hard disk, pulled into the computer's main memory but the codes being executed will be in faster memory better matched to the speed of the processor. Why not just run all the memory faster? Cost. It is very much more expensive to manufacture faster memory so it is a trade off between capacity and speed at a particular price point. Hard discs are slow compared to RAM but 1000 GB of hard disc space is a lot less expensive than 1000 GB of RAM. With mobile technologies hard discs consume more power and are relatively bulky and the devices can store their information on the internet. At the time of writing there appears to be a transition taking place from desktop and laptop computers to mobile technologies based more on power efficiency and small energy efficient clients to internet based resources. These are all areas worth exploring as they will have an increasingly significant impact on learners in the coming years. The main requirement for learners for this criterion is to understand the basic concepts of storing instructions in a program and executing them in a program flow.

In a sense, writing any program code is using codes to represent instructions and data. The HTML tag <h1> is a code telling the browser to make the following text adopt a particular style. </h1> is telling it to stop. HTML is a good way of introducing these concepts because it is practical, simple and accessible. will make the text appear bold and switch this off. Characters between the tags are data. They are simply displayed as written. So the tags represent instructions and what is between the tags is data. HTML is a mark-up language rather than a programming language because it doesn't have structures such as loops and conditional statements. These are added by using Javascript. (Note Java script is nothing to do with Java!) For the purpose of this criterion it is sufficient for learners to understand tags are codes representing instructions and anything that isn't a tag is data.

Evidence: Assessor observations and portfolios.

2.7 I can identify situations where codes control events

The candidate should be familiar with machinery that is controlled by code and measuring instrumentation that is automated.
Evidence: Assessors observations, portfolios

Additional information and guidance
Typical examples are 3D printers, robots, CAD/CAM, working models such as Lego, Fischertechnik and similar kits. Candidates should preferably have some hands on experience of programming practical control systems where the code controls physical events. It is true to say that there is an element of this in general purpose computing since software controls mechanics in printers, disc drives and other peripheral devices, however, breadth of experience will help in transfer of learning to unfamiliar and new situations. This would be a good opportunity for links to science in terms of measuring and recording data through experimental investigation and in creating products in design and technology.

3. The candidate will use programming languages

3.1 I can originate useful code in a visual language

The candidate should be able to originate some useful code in a visual language such as Scratch or Blockly.

Evidence: Portfolios

Additional information and guidance
Candidates should be encouraged to code complete projects but given time constraints they could adapt and modify existing code as long as they can originate at least some of the code themselves. The challenges in Blockly at https://code.google.com/p/blockly/ are a good way to get started.

3.2 I can originate useful code in a text based language

The candidate should be able to originate some useful code in a text based language such as Logo, python, BASIC, Javascript or Java.

Evidence: From candidate's source code in portfolios.

Additional information and guidance
Candidates should be encouraged to code complete projects but can be provided with sufficient structured guidance as long as they can originate at least some of the code themselves. Blockly is free from the web and enables export of code to

Javascript and Python. This provides a good potential means of transition from visual programming in Blockly itself to programming in Javascript or Python.

3.3 I can identify structure in programs

The candidate should be able to identify variables, procedures, loops and conditional tests in existing programs.

Evidence: From assessor observations, internal tests.

Additional information and guidance

Candidates should be given opportunities to review source code that is sufficiently well documented for them to identify key structures and decide how they relate to the outcomes produced when the program is run. They should be encouraged to adopt good structural practices in their own work. They should be able to see how tables of data can be separated from program instructions and how a very large and complex program can be made up from many much simpler components. They should become aware that good structure and clarity are desirable eg by using peer review. Do other people understand their work and do they understand the work of others?

3.4 I can test code

The candidate should be able to use pauses in program code to identify the places where errors occur.

Evidence: From assessor observations and documentation in portfolios

Additional information and guidance

Being systematic in approach to finding and isolating bugs is the aim. Candidates at level 1 will need clear and concise instructions to support their work. This work could be related to the work on comparing algorithms and also to control of variables.

3.5 I can edit source code to fix a bug

The candidate should follow instructions to make simple edits to source code to fix bugs.

Evidence: From assessor observations and documentation in portfolios

Additional information and guidance
Level 1 candidates will need support and clear instructions in any but the very most straightforward cases. A key point is to immediately check any edit so that the effect of the edit is obvious. Avoid trying to fix several bugs at the same time since additional bugs can be introduced unintentionally and then it is not so obvious which edit was responsible. This might be a good time to introduce the concept of "many eyes making bugs shallow" and encourage working in pairs. They should also appreciate the importance of access to the source code if bugs are to get fixed, and also to really understand what a program is doing.

3.6 I can choose variable names that aid clarity

The candidate should spend time choosing variable names that are meaningful in the context of their code.

Evidence: From source code in portfolios

Additional information and guidance
This is all part of documenting source code to enable maintenance and development. Other people usually take over code from the original author and so it is important for them to be able to quickly understand the software. At one time there was an argument for short labels and names because the space available to run programs was very limited. This is no longer the case and the only reason for using short and cryptic variable names is laziness.

4. The candidate will understand Boolean Logic

4.1 I can predict the outcome of statements containing AND, NOT and OR

The candidate should be able to predict the outcomes of simple conditional statements containing each operator.

Evidence: From internal testing.

Additional information and guidance
Conditional statements are of the the form IF <condition> THEN <do something> eg IF 3 > 2 THEN PRINT "true". Involving the Boolean operator AND could result in IF 3 >2 AND 8 >6 THEN PRINT "true" AND requires both conditions to be true. If we replace AND with OR true will be the result of either condition being "true".

These conditions are more powerful when the numbers are variables. eg IF A > B AND X > Y THEN PROCEDUREgreaterthan. So if A is a bigger number than B and X is a bigger number than Y do some processing contained in a PROCEDURE called greaterthan. NOT effectively inverts a condition. IF NOT A>B PRINT "B is bigger than A". Candidates should be able to predict the results of simple statements of the type presented here. This will need some practice. Some clear supporting resources are at http://computer.howstuffworks.com/boolean1.htm and http://www.cut-the-knot.org/game_st.shtml

4.2 I can include AND, NOT and OR in information searches

Candidates should be able to use the equivalents of AND, NOT and OR in searches using a particular search engine.

Evidence: From assessor observations and internal tests.

Additional information and guidance
Modern search engines are very good at finding relevant information without much need to know about Boolean Logic however they normally provide ways of including operators in searches. As an example, Google provides the following information https://support.google.com/websearch/answer/136861?hl=en. The whole indexing of searches and the algorithms used to work out relevance is very complex. This link provides and overview http://www.google.com/intl/en/insidesearch/howsearchworks/thestory/. At this level candidates should realise that searching a list is easier if you sort it first. The activities in Computer Science Unplugged http://www.cut-the-knot.org/game_st.shtml on algorithms is relevant here.

4.3 I can identify reasons why some search results are likely to be more important than others
The candidate should know some factors that search engines use to decide which sites are the most important.

Evidence: Internal testing, portfolios.

Additional information and guidance
Although not published in detail, Google uses over 200 factors in ranking the importance of sites for searches. These include.

Links – links to and from the site, the quality of those links, and ratios between links and even links with pages on the site and how it interrelates and how often it changes and the rate of change.
Site content – the content of the site, keyword density and interrelationships of content on the page and content within the site itself and how it interrelates and how often it changes and the rate of change.

Visitor related factors – how many visitors return, how many visits the site receives and the rate of change (increase or decrease) of new visits.

Domain name factors – How long the domain name has been registered for and how long it has been owned. How many times it has changed ownership.

Why does Google not publish its search algorithms in any detail?

4.4 I can relate boolean logic to program flow

Candidates should be able to identify the use of Boolean Logic in existing code, saying broadly how it affects the routes of program execution.

Evidence: From assessor observation and portfolios

Additional information and guidance
The code studied should where possible have relevance to the candidate's interests, projects or other work. Conditional statements such as IF, WHILE, CASE, etc. More of this at
https://en.wikipedia.org/wiki/Conditional_(computer_programming)

4.5 I can use wildcards in searches

Candidates should be able to replace parts of words with wild card characters when performing searches.

Evidence: From assessor observations

Additional information and guidance
The most appropriate place to demonstrate this is likely to be searching for files on local systems. Wild cards tend not to be very useful in general search engine type searches because the number of matches is likely to be enormous.

4.6 I can represent numbers using binary patterns
Candidates should be able to represent decimal numbers by binary patterns and use codes to represent letters and characters.
Evidence: From assessor observations, local tests and portfolios,

Additional information and guidance
There is a good introduction to binary numbers in http://csunplugged.org/activities. More resources at http://www.convertbinary.com/
http://home.paulschou.net/tools/xlate/
http://www.mathsisfun.com/binary-decimal-hexadecimal-converter.html
http://nickciske.com/tools/binary.php

At the most fundamental level all instructions and data are stored as voltages. A 0 voltage is zero, and voltage significantly higher than zero is 1. All the sophistication and complexity of all computer systems boils down to this. The 1s and 0s are called binary digits or bits. 8 binary digits makes a byte. If we set 8 wires to each have 0 volts we have 0 and if we set each to say 5V we have 11111111 = 255. Why 255? Because there are 255 possible patterns using 1s and 0s on 8 wires. Every time we add another wire we double the number of possible combinations. So 9 wires will give 512 and 10 will give 1024 and so on. (See CS unplugged for binary activities) The original microcomputers popular in the early 80s were 8 bit. Now the norm is 64 bit. No great fundamental difference except that if each instruction is represented in 8 bits, a 64 bit processor could process 8 at the same time. That is quite apart from the clock speed increases to make them go faster.

8 bits has a special significance in computing because it is the fundamental unit for many codings. eg all the numbers, letters of the alphabet and characters such as £,*,$ etc each have a unique 8 bit code. A letter "A" is for example code 65, B code 66, the space bar code 32. We don't need to remember these because computers do the translations automatically although it is easy to find tables of them http://www.ascii.cl/ Computers are in fact translating the binary patterns to the numbers and letters we see on the screen. The decimal numbers are really just because most humans are more familiar with them. So a set of 8 wires representing the letter A or code 65 would be 01000001. where 0 is zero volts and 1 is a higher voltage. Storing the letter A in RAM or on a hard disk means there is a tiny area on the disc or in the chip with that pattern on it in some physical form. If we could make them say ionised and unionised atoms, each letter could be represented in the space of 8 atoms. Currently it takes about 10 million times as much space. The theory is a lot easier than the practical technology though!

Candidates should be able to tackle simple problems such as if I have the bit pattern for the letter A 01000001 how would it change to a letter B given that A is 65 and B is 66? We need the next number up so it is 01000010. They should appreciate how counting in binary works.

They can make secret messages in binary and use the converters to decode them. Of course not that secret if other people have access to the decoder. They could of course write some sort of binary encoder eg changing all the 1s to 5s and 0s to 4s so that a binary decoder would not work unless they first put the message through something to convert the 5s and 4s back to 1s and 0s.

A lot of scope here for coding games, secret messages and similar.

L1 Computing Unit 2
Using digital applications to support projects - 5 Credits - 40 GLH

1. Select use and combine applications	2. Create original works using digital applications	3. Be able to manage projects	4. Respect intellectual property
1.1 select suitable applications to support my work	2.1 originate digital information from my own imagination	3.1 structure a plan for a project supported by digital tools	4.1 identify licenses that are restrictive
1.2 collect and record data	2.2 use remix to create original digital information	3.2 carry out projects by linking a sequence of steps	4.2 identify licenses that are liberal
1.3 find patterns in data	2.3 use specific design techniques	3.3 evaluate a project in terms of its strengths and weaknesses	4.3 ensure my work contains only appropriately licensed content
1.4 present data effectively	2.4 match my work to a target audience.	3.4 apply e-safety principles to my projects	4.4 find open source equivalents for many proprietary software applications
1.5 meet the needs of other people		3.5 show courage in completing a project.	
1.6 use more than one application to solve a problem			

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 1 qualifications

1. QCF general description for Level 1 qualifications
2. Achievement at QCF level 1 (EQF Level 2) reflects the ability to use relevant knowledge, skills and procedures to complete routine tasks. It includes responsibility for completing tasks and procedures subject to direction or guidance.
3. Use knowledge of facts, procedures and ideas to complete well-defined, routine tasks. Be aware of information relevant to the area of study or work
4. Complete well-defined routine tasks. Use relevant skills and procedures. Select and use relevant information. Identify whether actions have been effective.
5. Take responsibility for completing tasks and procedures subject to direction or guidance as needed.

Requirements

1. Standards must be confirmed by a trained Level 1 Assessor or higher
2. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
3. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
4. When the candidate provides evidence of matching all the criteria to the specification, subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
5. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
6. This unit should take an average level 1 learner 50 hours of work to complete, with 40 hours of learning under specific teacher presence.

Assessment Method
Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award. Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate.

Expansion of the assessment criteria

1. The candidate will be able to select use and combine applications

1.1 I can select suitable applications to support my work

Candidates should be able to match some common applications to the specific tasks such as a drawing program for designing graphics, a text editor for editing text, a spreadsheet for making number models.

Evidence: from assessor observations, documentation in portfolios.

Additional information and guidance
Candidates should be encouraged not to just take every application on face value and experiment with some different tools, especially free resources from the internet and not restrict their experience to particular types of computer eg desktop, tablet, smartphone. There is really no need to spend money on licenses for most general productivity tools and this also enables students to legally use the same tools outside school as in school therefore contributing to inclusion. Two of the key changes taking place globally in technology is a shift to open standards related to the internet and the increasing takeover of mobile technologies. In relation to open source, a simple example is graphics. There are three fundamental open standards for graphic images. .jpg, .png and .svg. These cover nearly every possible requirement and should be encouraged as replacements to older and less efficient formats such as .bmp, .gif, .cdr, .ai and similar formats. Note that proprietary vector formats such as .ai tend to create monopolies by forcing use of the software that created them. .svg is the open internet (XML) based vector standard and Inkscape is a free and open source application for editing .svg files and exporting .png files from them. While .svg has taken some time to establish itself, it is in everyone's interest to promote open standards because it frees up competition in the market

and therefore reduces costs and increases convenience to end users. It is generally bad practice to design graphics in applications such as Word or Publisher even though at this level it is practically possible and in some cases might appear easier. It is better to learn a specific application that is designed for the purpose and produces files in the open standard. Where possible originate graphics as vectors and then produce raster graphics such as png and jpg from the vector. This is because the vector application is the best for designing in and it produces infinitely scalable images without problems of resolution and enormous file sizes. .png files are for displaying line diagrams where the eg browser software is not yet up to coping with .svg. A .png can have transparent objects and does not lose any data due to file compression to reduce the size of its files. .jpg can not have transparencies and trades off quality for low file size. Both .png and .jpg can be used for photographs but usually .jpg is the best format for these. .svg can produce photo-realistic drawings and can contain a photograph as part of a file but photographic images can not normally be converted to vectors. Similar arguments can be made for audio and video formats but at this level graphics are likely to be the most common scenario where some basic knowledge will make a significant difference to dealing with practical and unfamiliar circumstances.

1.2 I can collect and record data

Candidates should be able to use digital devices to collect and record data in useful situations

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance
The most commonly cited use of data recording is in experimental measurement in science. This is still a perfectly legitimate activity to support this criterion. An example might be recording the temperature of a liquid as it cools and freezes. Note that all data recording boils down to sampling a changing voltage and storing the samples as bytes of data. The device that converts the physical thing (temperature, sound intensity, brightness of light, etc) into a voltage is called a transducer. A microphone is a transducer for sound, a digital camera for light. The chip that converts a continuously changing electrical signal into digital data is called an ADC - Analogue to digital converter. A 16 bit ADC will divide up the signal into about 64,000 parts. If it was used with a transducer across 100 degrees a theoretical accuracy of 1/640th of a degree would be possible. A 8 bit ADC would divide into 255 parts so better than 0.5 degrees accuracy which would be good enough for a lot of general purpose temperature measurements. Level 1

candidates will not be expected to know about how data recording works but it could be useful background for some for Level 2. Using software such as Audacity to record audio data effectively and outputting it to appropriate file formats is typical of what is required. Being able to relate the size of the data file recorded to the length and quality of the recording will be useful too. Most technical problems arising from data capture are due to a lack of understanding of file sizes and file types. The more experience candidates can get of this, the more confident they will become in unfamiliar contexts.

1.3 I can find patterns in data

Candidates should be able to see patterns in their data and in simple cases relate them to physical effects.

Evidence: from assessor observation and content of learner portfolios.

Additional information and guidance In the case of audio recording candidates should see that the amplitude of the signal is related to the loudness of the sound and that shorter wavelengths are associated with higher pitch. Other patterns might include variations in brightness eg measuring light intensity over a day and night. The exact examples are up to the assessor to provide but candidates should gain enough experience to relate simple patterns to physical circumstances in unfamiliar settings.

1.4 I can present data effectively

Candidates should be able to present data in tables and graphical forms subject to guidance in keeping with level 1 qualifications.

Evidence: From content of learner portfolios.

Additional information and guidance
Candidates should be regularly reminded of how easy it is to misrepresent data. They should be guided to present simple data informatively with the emphasis on clarity and objectivity in straightforward situations. An example might be to present simple information in a web page by combining the output from a chart drawing program or spreadsheet with text in a content management system web page. The subject could be showing the time they spend each week in different lessons, the number of people in their class who have a birthday in a particular month, the results of a scientific investigation. Try to avoid stereotyping the word presentation

with particular proprietary software brands and giving the impression that one piece of software can be used to do everything. Part of the learning process is to develop flexibility in using and combining different applications and so even if it is possible to use a single software resource is is desirable to combine several simpler tools. Issues that arise in data transfer and compatibility will provide useful learning to make the candidates more able to transfer their learning to new and unfamiliar circumstances.

1.5 I can meet the needs of other people

Candidates should be able to present data in tables and graphical forms subject to the structure and guidance in keeping with level 1 qualifications.

Evidence: From assessor observations and learner portfolios

Additional information and guidance
Candidates should use a brief to produce something that is useful to other people. They should be encouraged to combine applications to do this and the work can include programming or scripting. This is an opportunity to undertake a small scale project that can support this and other learning outcomes. Software is becoming increasingly capable of "guessing" user needs. Mobile devices are increasingly "context aware" so for example, when you are standing next to a bus stop the device senses it and can automatically display the timetable on the screen along with how long until the next bus arrives. This can be related also to criteria for data logging as it is all the same principle. While at level 1 it is not realistic to expect candidates to program context awareness into their applications they should be aware of it as a sophisticated application of what is actually quite an old technological concept. It is simply enabled by much more powerful low cost and portable devices.

1.6 I can use more than one application to solve a particular problem

Candidates should be able to combine at least two applications in achieving a solution to a particular problem or task.

Evidence: From assessor observations and learner portfolios

Additional information and guidance
Candidates should be able to provide a solution to a problem supported by at least two and preferably more applications. An example might be to use a graphic design

program and an image editing program to design and prepare clip art for display in a web page. They could use noise removal in an application eg Audacity to clean up their sound track before adding it to their video. At this level candidates will require structured guidance in keeping with the general description of Level 1 qualifications. Other examples might be producing a newsletter using a text editor and imaging software to source the content and a different application to organise and print it.

2. The candidate will be able to create original works using digital applications

2.1 I can originate original digital information from my own imagination

Candidates should be able to originate original digital resources from a zero base.

Evidence: Assessor observations, local testing, portfolios.

Additional information and guidance
Candidates should create something original from a zero base. This could be an image designed using a vector program, rather than originating a bitmap eg from a camera, They might compose some original music or video film. The spirit of this criterion is creativity and while use of existing work is not banned where it is sensible to incorporate it, there should be a clear element of original work rather than exclusive remix of other people's work. Remix is a legitimate creative activity in its own right and it is assessed in the next criterion so the emphasis here should be on originating new material.

2.2 I can use remix to create original digital information

Candidates should be able to edit and combine existing information to create something new with an element of originality.

Evidence From portfolios

There are many good examples of remix on the web. Candidates should be aware of licensing and err on the side of caution although re-mix is an area that is not as clear cut about what is and isn’t infringing a copyright license.

2.3 I can use specific design techniques

Candidates should be able to incorporate specific design techniques in their work

Evidence: From assessor observations and portfolios

Additional information and guidance
In the case of images, specific techniques include perspective, lighting and shadows. They should combine learning from the computer science unit in handling colour and file sizes. In audio applications they should be able to remove noise and edit out unnecessary pauses in, for example speech.

2.4 I can match my work to a target audience.

Candidates should make clear the type of people on whom they are targeting their original work.

Evidence: Assessor observations and portfolios.

Additional information and guidance
Two clear possible audiences are their family and younger less experienced learners. If projects are originated to support learning in younger pupils, it helps reinforce their own learning and makes the target audience clear. They can also get evaluation feedback relatively simply. The best endorsement of work is for it to be taken up to be used.

3. The candidate will be able to manage projects

3.1 I can structure a plan for a project supported by digital tools

The candidate should be able to organise a plan for a project in keeping with the general level 1 description.

Evidence: Portfolios

Additional information and guidance
Candidates will need structured support with their planning in keeping with the general level descriptor for level 1 qualifications.

3.2 I can carry out projects by linking a sequence of steps

The candidate should be able to follow a logical sequence of steps to support the execution of their project.

Evidence: From portfolios.

Additional information and guidance
Candidates should be encouraged to become increasingly self-sufficient in solving their own problems as they go through the steps in their project. Working in a team is recommended. The main aim is to appreciate that projects require sequential steps and this could be related back to work on algorithms.

3.3 I can evaluate a project in terms of its strengths and weaknesses

The candidate should be able to identify strengths and weaknesses in the execution and/or outcomes of the project

Evidence: From portfolios

Additional information and guidance
Candidates should be able to identify strengths and weaknesses and it is a good idea to involve peer review in the process. Candidates should accept criticism graciously and provide constructive suggestions for improvements.

3.4 I can apply e-safety principles to my projects

The candidate should be aware of e-safety issues and be prepared to take action in keeping with the general description of level 1 qualifications.

Evidence: From assessor observations and portfolio

Additional information and guidance
Being safe online is the objective. At level 1 structured support will be necessary in some areas. Part of this criterion is the appreciation and willingness to take advice from more experienced people. E-safety is important and the best way to become safe is through guided practical experience.

3.5 I can show courage in completing a project.

The candidate should demonstrate courage in persevering and making an effort to overcome difficulties.

Evidence: From assessor observations and documentation in portfolios

Additional information and guidance
The spirit of this criterion is to recognise the fact that although at level 1 structured support will be needed, candidates are expected to make an effort to overcome difficulties themselves. Real life projects require courage to complete and this is an opportunity for candidates to demonstrate this quality.

4. The candidate will be able to respect intellectual property

4.1 I can identify licenses that are restrictive

The candidate should be able to identify copyright licenses that restrict re-use of the work

Evidence: From assessor observations, portfolios

Additional information and guidance
Try to establish the difference between copyright and licenses. It is the license that determines whether or not you can copy a work. Copyright free should be either public domain or licensed for free use. Whenever a candidate originates work technically they are the copyright owner and they can determine who can use the work and how. Many proprietary companies license work so that it can only be used if a fee is paid. These licenses are “restrictive” because they restrict the use of the work. Just to add more confusion, copyright rules are different in different countries. In general candidates should not use anything that causes them any doubt.

4.2 I can identify licenses that are liberal

Candidates should be able to identify licenses that are liberal. These are licenses where copying is allowed but there might also be some conditions.

Evidence: From assessor observations and portfolios

Additional information and guidance
The most liberal license is public domain. Work in the public domain can be freely copied. A good source of public domain clip art is www.openclipart.org. Your students can contribute and become famous artists! There are many liberal licenses for software too. The BSD license and Apache Software Foundation licenses allow you to do just about anything with the software as long as you respect the trademarks. The GPL is liberal but also requires you to use the same license for works you derive from GPL licensed work. Linux is probably the best known product licensed with the GPL. Creative Commons is another widely used

liberal license eg by Wikipedia. At this level it is sufficient for candidates to understand the broad license types and to be aware enough to start checking. it is safest to use sources such as the wikimedia commons and openclipart to be sure to be working legally. There is usually no need to “pirate” software because perfectly good free and legal applications are available for most major and popular tasks. Candidates need to appreciate this and be supported in finding suitable applications themselves.

4.3 I can ensure my work contains only appropriately licensed content

The candidate should use peer review and quality assurance review to identify risk in using inappropriately licensed information.

Evidence: Assessor judgements and portfolios.

Additional information and guidance

Whenever candidates get information - text, images, video, audio - to use as part of their work they should acknowledge the source and b) question whether or not what they are doing is legal. At level 1 they will need structured support and constant reminders. The objective here is to ingrain the questioning of the rights to use copyright material so that it becomes a routine part of working. They should appreciate that it is a lot less hassle to go to known sources of work that is licensed for free use. If they can’t find what they need there, is it worth paying for it? Assessors should be vigilant in ensuring candidates do not have inappropriately licensed material in their portfolios.

4.4 I can find open source equivalents for many proprietary software applications

Candidates should be able to identify open source equivalents to the most popular proprietary productivity tools.

Evidence: From assessor observation and portfolios

Additional information and guidance

The aim here is to engender informed choice. Mostly people use software applications that are popular because they have never tried anything else. There is no obligation to use Open Source Applications but if you have never done so how

do you know whether they are useful or not? The most obvious applications are OpenOffice.org/LibreOffice in place of MS Office, Inkscape as a replacement for Fireworks, Illustrator, Corel Draw, Serif Draw etc. GIMP as a replacement for Photoshop, Audacity for sound recording programs. There are also free resources on the internet that while free of charge are not Open Source. Google Docs is a good example of this. A list of popular open source applications is at http://sourceforge.net/directory/os%3Alinux/freshness%3Arecently-updated/?page=1&_pjax=true
Candidates should be able to name a few popular Open Source applications and how they can be acquired.

Moderation/verification

The assessor should keep a record of assessment judgements made for each candidate and make notes of any significant issues for any candidate. They must be prepared to enter into dialog with their Account Manager and provide their assessment records to the Account Manager through the online mark book. They should be prepared to provide evidence as a basis for their judgements through reference to candidate e-portfolios and through signed witness statements associated with the criteria matching marks in the online mark-book. Before authorizing certification, the Account Manager must be satisfied that the assessors judgements are sound.

L1 Computing

Unit 3 - Computer hardware systems and networks - 5 Credits - 40 GLH

1. Understand computer hardware	2. Understand the role of network servers	3. Be able to identify factors affecting network performance	4. Contribute to good network security
1.1 identify the main hardware components in computing devices	2.1 identify a server in a network diagram	3.1 compare the performance of cable and wireless connections	4.1 work to support an acceptable use policy
1.2 match discrete components in computing devices to purpose	2.2 identify a range of servers and services provided by servers to networks.	3.2 relate bandwidth to data transfer capacity	4.2 choose a strong network password and keep it secure
1.3 classify hardware on the basis of purpose	2.3 identify key services provided by internet servers	3.3 explain the term "contention"	4.3 identify encryption as a way of making information secure
1.4 compare hardware components on the basis of their properties	2.4 identify key factors that can affect server and network performance	3.4 identify potential bottlenecks in network designs	4.4 identify ways of minimising spam and eliminating malware
1.5 identify power consumption and performance as key limits on hardware	2.5 know about permissions and basic server security	3.5 distinguish between local and wide area networks	4.5 identify a firewall and explain its purpose
1.6 identify cost as an issue in performance		3.6 identify protocols used in networks	

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 1 qualifications

1. QCF general description for Level 1 qualifications
2. Achievement at QCF level 1 (EQF Level 2) reflects the ability to use relevant knowledge, skills and procedures to complete routine tasks. It includes responsibility for completing tasks and procedures subject to direction or guidance.
3. Use knowledge of facts, procedures and ideas to complete well-defined, routine tasks. Be aware of information relevant to the area of study or work
4. Complete well-defined routine tasks. Use relevant skills and procedures. Select and use relevant information. Identify whether actions have been effective.
5. Take responsibility for completing tasks and procedures subject to direction or guidance as needed.

Requirements

1. Standards must be confirmed by a trained Level 1 Assessor or higher
2. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
3. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
4. When the candidate provides evidence of matching all the criteria to the specification, subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
5. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
6. This unit should take an average level 1 learner 50 hours of work to complete, with 40 hours of learning under specific teacher presence.

Assessment Method

Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award. Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate.

Expansion of the assessment criteria

1. The candidate will understand computer hardware

1.1 I can identify the main hardware components in computing devices

Candidates should be able to identify CPU, micro and standard USB ports, audio and video ports, RJ45 network ports, SD Cards, Memory modules, USB memory, hard drive, keyboard, mouse, displays for commonly used computer devices.

Evidence: from assessor observations, internal testing and documentation in portfolios.

Additional information and guidance

Candidates should be familiar with commonly used hardware components through hands on use. Raspberry PI, building a PC or taking apart disused machines will all provide experience. A good little game is to provide a hardware specification for a computer and ask the candidates to use the web to source the parts at the best possible price. The winner is the one who can get the components to build a machine at the best price. If you want to make it more difficult take shipping costs into account and say you need 50 pieces. This will make it less likely that shipping costs will swamp the costs if components are bought from different suppliers.

1.2 I can match discrete components in computing devices to purpose

Candidates should be able to match a component to a description of its purpose

Evidence from internal testing and portfolios.

Additional information and guidance

Candidates should know the different purposes of common components. CPUs for processing instructions, USB ports for connecting peripherals, RAM for storing

programs and data that is in operation, SDRAM and hard discs for storing programs and data while not being used. A heat-sink is for taking heat away from active components to stop them being damaged by getting too hot. Heat-sinks might incorporate a fan. Power supplies to convert mains voltages to the lower levels needed in the devices, Batteries for portable power. Main board to hold and enable connections between the components.

1.3 I can classify hardware on the basis of purpose

Candidates should be able to group hardware devices that have common purposes.

Evidence: from internal tests and content of learner portfolios.

Additional information and guidance
Candidates should be able to recognise that for example, SD Cards, USB pen drives and hard drives all have the primary purpose of holding programs and data before use. They should be able to see that internal power supplies. external power supplies and batteries all provide the energy to make the computer work. Keyboards, mice and touch screens are all input devices, Screens, printers, plotters and CNC machines are all output devices.

1.4 I can compare hardware components on the basis of their properties

Candidates should be able to use the physical and performance properties of components to make comparisons.

Evidence: From internal testing and portfolios

Additional information and guidance
Candidates should be given many opportunities to compare components and devices carrying out testing where possible. Do all computers start up in the same time? If not why not? Are all USB ports equal when transferring data? Are differences in price justified? Does over-clocking a RaspberryPI really make much practical difference? Is it worth paying more for a hard drive for capacity that is unlikely to ever get used? These are opportunities to reinforce and develop numeracy with simple calculations to quantify differences. At Level 1 structured support will be needed in keeping with the overall level descriptor.

1.5 I can identify power consumption and performance as key limits on hardware

Candidates should appreciate the tension between computer performance and power consumption.

Evidence: From assessor observations and learner portfolios

Additional information and guidance
One of the most fundamental technical limits on technological progress is power management. Portable devices require light weight and long battery life but they also need increasing processing power and hi-resolution displays. If the speed of a processor doubles the energy it consumes doubles. If the voltage at which a processor operates doubles its power consumption goes up 4 times. So it is important to run processors at a low voltage and the processing power in every tick of its clock is also very important. Particular strategies to reduce power consumption include.

Variable speed processors so that the processor only runs fast when it is needed
Multi-core processors to reduce the need for increasing the clock speed in order to keep processing power up
Using low power cores in a multi-core processor design to handle some not so demanding tasks
Low voltage designs
Efficient chip designs with fewer transistors to get the same processing power.

It is worth noting that the ARM processor in the RaspberryPI, designed by technologists in Cambridge and originally at the heart of the Acorn Archimedes computers, is one of the most power efficient in the world. Similar designs are used in the vast majority of mobile 'phone and portable devices such as ipads. While there is probably more publicity given to the very power hungry Intel and AMD CPUs in Windows desktop computers, 4 times as many ARM processors are currently being sold and that looks to increase as people start to use mobile devices as their main computers.

Improving battery technology will also help as would improving the efficiency of software. This is another reason to learn to write efficient code. It is better for energy efficiency and therefore better for the environment.

Candidates should have the opportunity to explore power and energy considerations perhaps in conjunction with other assessment criteria and there are some excellent opportunities to link to the English, science and mathematics curriculum.

1.6 I can identify cost as an issue in performance.
Candidates should appreciate the tension between computer performance cost.

Evidence: From assessor observations and learner portfolios

Additional information and guidance
In general high performance components are disproportionately more expensive than low cost components. Add this to branding in a technically complex field and you have a potential for users to be at the mercy of salesmen! If a particular component is a limiting factor in a performance critical application it might be justified to pay a big premium on that component but often this is not the case. Salesman will use terms such as “future proofing” to persuade people to part with their money. Take a state of the art processor costing £500 and one with say 80% of the performance costing £100. There will be no obvious difference to the user in many applications and in time other factors will probably be just as important such as the amount of memory in the machine, its power consumption or the resolution of its screen. A similar situation applies to network switches and new products. New products often command a premium price as much because they are technology fashion accessories as because of their real functionality. Often in a year or two prices are half and functionality doubled. Smart users do the sums and work out cost benefits. In most cases costing is simple arithmetic. It is understanding the real benefits if technologically illiterate that is the problem. Of course some people will be happy to pay a premium for fashionable brands but at least young people should be educated to be aware of why they are deciding to make purchases. A useful debate would be “Is their school getting good value from its technology suppliers?” How would they know?

2. The candidate will understand the role of network servers

2.1 I can identify a server in a network diagram

Candidates should be able to appreciate the server in relation to other components in the network.

Evidence: local testing, portfolios

Additional information and guidance
Candidates should be able to identify a server in a network diagram by considering size, shape and position in relation to other components.

2.2 I can identify a range of servers and services provided by servers to networks.

Candidates should know that a server provides a range of services including running programs and presenting results to clients, storing client data and information, enabling communication between clients.

Evidence: From local testing and portfolios

Additional information and guidance
In the early days of microcomputers, servers were often called file servers because that was their main function. They stored files and shared them between clients subject to permissions to access them. They would provide shared printing services and perhaps email but they did not run general applications programs. Increasingly servers do both jobs. They run programs and the results are displayed on the client computer and they store files and handle e-mail. It is very expensive to have software applications stored and run individually on every network client, not only in the cost of multiple software licenses but in having to manage the software on every machine. Even though to an extent this management can be made more efficient using the server to update machines, in practice constantly upgrading hardware with different specifications that can not all cope with exactly the same software results in expensive complexity. Running everything from servers is potentially much more efficient and much less expensive but two things made this difficult. One is that the servers needed to be very powerful (expensive) to cope with running very large applications often designed at the limit of hardware capacity and the other is that the network connections have to be fast too.

The internet has changed the way we think of servers and the key is the web browser. Web browsers can run client side applications in the client eg in Javascript and also support transactions on the server side eg executing PHP code to process database information and then present it on the client through the browser. It is very much easier to manage a large server farm with consistent software than to manage many distributed client computers, scattered all over the world each running an unpredictable range of applications. The browser has effectively standardised the operating platform removing licensing fees and enabling competition based on service. At the time of writing we are in a transition to mobile

clients where power consumption is just as important as performance and perhaps more so when servers can provide almost unlimited storage and raw processing power. Clients can still run their own apps but the main productivity tools can be provided and managed centrally.

For this criterion, candidates need to be able to distinguish between servers processing data, storing and making information available and enabling communications.

The most obvious case of programs running locally is the client operating system such as Windows installed on the local machine. An example of a server running the program on behalf of the client is a search engine like Google. You make the query in the web browser and the search engine somewhere on the web then runs a program to find things linked to the query and returns the results in the local browser. An obvious data server is a file sharing application such as Dropbox. Dropbox enables the sharing of data files over the internet. The distinctions between running programs locally and running them on the server is now much less clear-cut than at any time in the past. Web pages use HTML files to tell the browser what to display but there is generally no interaction for the user. To provide that Javascript is built into the browser. Programs that run in the browser are running locally but these are usually small and could be downloaded into the browser from the server or they could be a plug-in on the local machine. The cooperation between server and client in running programs has become much more closely linked with the internet. Peer to peer systems are effectively making any machine on the network a potential server. The trend is to racks of many low cost machines, often just the main boards and components, sharing the tasks and so what is represented as a server by a box on a diagram might in fact be very many servers not just one machine.

2.3 I can identify key services provided by internet servers

Candidates should be familiar with internet services provided by servers, including web servers for sending out web pages, proxy servers for caching information locally, database servers and video servers.

Evidence: From assessor observations and portfolios

Additional information and guidance
Server based services is a complex area and at this level it is sufficient for candidates to know that web servers are responsible for hosting web sites. One

server can host many web sites sending out pages when requested. On the other hand a very busy site such as the Google search facility can be spread over many servers. Local proxy servers can store often used information locally so that it can be retrieved quickly rather than being limited to the slower and contended bandwidth of the wider internet. Most of the web is supported by databases. A web site of any complexity is a data base on a server with web pages through which information is presented in a web browser. Since the software protocols and associated technologies to link the data to the web page are free and open for all to use, the systems encourage competition between technology companies resulting in all web browser software being free of charge. There are commercially licensed applications built on these free and open technologies and the language for database software development (SQL) is common to both free and proprietary software. This generates a rich, varied and competitive market that has accelerated innovation and reduced costs.

Video is a sort of holy grail in that it is so data intensive that if a server can handle video streaming it can probably handle anything else. Google owns around 1 million servers at the time of writing. Probably a very significant proportion is used by You Tube. This is why it is better to make links to a site like You Tube than to host your own videos if these are likely to be used intensively. Google's servers run on Linux, imagine how much they save in license fees by using open source software on 1 million machines. Note that servers on the internet do not have to run any particular operating system as long as the information comes to them and leaves them in standard formats. This is the reason for HTTP (Hypertext transfer protocol) ftp (File transfer protocol) and smtp (Simple Mail Transfer Protocol.) They are standard ways of transferring information independent of particular server technologies.

2.4 I can identify key factors that can affect server and network performance

Candidates should be familiar with the following key factors. For servers, processor speed, RAM, and speed of getting data into and out of the machine. For networks the rate of data transfer and the way data is routed through the network.

Evidence: Assessor observations and portfolios.

Additional information and guidance
Three fundamental factors governing server performance are the speed of the processor, the amount of RAM in the machine and the capacity to get data into and out of the machine. It won't matter how fast the processor is if the machine runs out

of memory and starts trying to access information from its hard drive. This is because the speed of getting information from a hard disc is much slower than from RAM. Approximately 200ns (nanoseconds) to access RAM compared to 12,000,000 ns to access the hard drive. This is equivalent to what's normally a 3.5 minute task taking 4.5 months to complete! RAM is expensive and a lot of the time it is not used. This is why sharing RAM across a million servers is much more economic than having a million individual machines any of which might run out of RAM while several neighbours are empty. Load balancing across multiple servers minimises the chances of using their RAM inefficiently. A simple game to illustrate the point. Get 10 children to partner 10 others. One partner leaves the room the other holds as many sweets in one hand as they can. Now get them to put the sweets in a box. The sweets represent the full capacity of the children together. Now bring in the partners and say they have to get as many sweets from the box into the hand of their partner as possible, if they drop any the sweets are lost. It is likely that they will try to grab more sweets than their partner can hold so some sweets will get lost while others will have spare capacity. We know that if they are careful and work cooperatively they can all get the maximum amount of sweets but if they all come in a rush to one box and try to distribute to their partner they won't be able to cope with them even though some of their colleagues will have spare capacity. At the end say they can share equally the sweets that all have safe. If they knew that at the beginning would they have done things differently? This demonstrates the value of load balancing (and also human cooperation).

If the data coming into and out of the server is such that the connection of the server to the network is saturated this will also over-ride the speed of the processor or the amount of RAM in the machine. Let's say the machine has 4GB of RAM free and data is coming in at 100 MB per second. How long before the RAM is full and data has to be swapped to the hard drive? about 40 seconds. At this point the speed of transfer to the hard drive is likely to be the limit because this will be hundreds of times slower than taking the information into RAM. Of course if the entire Database is capable of fitting into RAM and that is all you are dealing with the hard drive might never need to be accessed and so the processor and the network connection would be the only things to consider. If the application required a lot of complex calculations the processor could be the limit. If not the connection speed could be the limit. Candidates should appreciate that it is impossible to say exactly what will be a limit unless you know exactly what the server is going to be doing. Simple games can be devised to illustrate these points. Get one candidate to bring books 10m across the class for three others to pick up and put on a shelf next to them. To speed up the process will it help to add a person to the three or to the one? The three children represent the processor working well within capacity.

Adding another will make no difference if the supply of books is not increased. Now if the shelf is full and the shelf stackers have to transfer books to the library at the other side of the school before any more can be accepted, this is the equivalent of memory being full and having to transfer data to the hard drive. If they can take 3 books at a time to the library it will be faster than taking one but still won't make much difference until the shelf can be refilled.

These principles also apply to routing data through network switches. If switches know where to send data specifically it is much more efficient than if they just broad cast it everywhere so the relevant data does reach its target device but also slows every other device down by having to check irrelevant data.

2.5 I know about permissions and basic server security

Candidates should know that servers usually provide a variety of permissions for users to enable them to have ownership of their information and to selectively share it. They should know the importance of secure passwords and the need to respect other people's information and privacy.

Evidence: Assessor observations and portfolios.

Additional information and guidance
At this level it is sufficient for candidates to know that there are roles for most server applications with each role having permission to access different subsets of the information on the server. The concept of a super user who can access everything should be understood as well as the responsibilities that go with that role. Two clear types of permission are read and write access. They should know that it is possible to provide read but not write access and why this might be useful. They should also realise that different applications can have different sets of permissions for the same user. The need for strong passwords and keeping them secure should be emphasised.

3. The candidate will be able to identify factors affecting network performance

3.1 I can compare the performance of cable and wireless connections

The candidate should be able to make comparisons between wireless and cable network connections and their appropriateness in different circumstances.

Evidence: Portfolios

Additional information and guidance

Candidates should be aware of the term bandwidth meaning the capacity to transfer information and that it is generally highest in fibre optic cables, then copper cables then wireless. The main advantage of fibre optic cables is that they can carry signals a long distance with very high bandwidths but they are expensive. Copper cables are inexpensive but become unreliable at high bandwidths at lengths over 100m. Wireless has the lowest bandwidth but is very versatile in that it spreads everywhere and is essential for mobile technologies. It should be easy to demonstrate that for a few clients wireless is a good solution but if many access the network all at the same time they only share the bandwidth and performance will fall. Mobile phones work because not everyone is using their phone at the same time. When there is an emergency and everyone tries to access the network is can fail to provide connections. Note that a mobile phone is a small computer and a mobile phone network is a computer network. A good practical exercise is for candidates to make up a fly lead using a piece of UTP cable, RJ45 plug and a crimp tool. They can see how easy it is to make up a cable network. Plugging the cable into a RJ45 socket on the network and their computer connects them to the network. A home network is easy to wire up. A switch plugged into a server and then the clients plugged into the switch. Wireless is easier but wireless performance reduces with distance from the wireless access point and also if there are walls and things in the way. In a house it is not likely to be a limiting factor.

3.2 I can relate bandwidth to data transfer capacity

The candidate should be able to use the term bandwidth in situations where data transfer is important..

Evidence: From portfolios.

Additional information and guidance

Bandwidth is commonly used as a generic term for data transfer in bits/second. This is because data bits/second represents a frequency similar to oscillations in analogue systems where frequency is measured in Hz. A direct example is in processor speed. A processor bandwidth of 2 GHz is 2 billion clock cycles in one second. If the processor has several cores it might well be possible to do several operations in one clock cycle and these could involve scores of bits. In a network with a bandwidth of 54 Mbits/second, (eg wifi 802.11g) the maximum possible data transfer rate is 54 Mbits/sec. In practice it is likely to be less than this. Since there are 8 bits in a byte, the maximum number of bytes that could be transferred would be 54/8 = 6.75 Mbytes. However, data transmission requires routing and other

information to go with the data so the actual throughput will always be less than this. The details are much too complex for this level but candidates should know that the standard wireless bandwidth of 54 Mbits/second is likely to transfer data more slowly than a 100 Mbits/second cable.

In general terms they should be able to associate bandwidth with network data transfer speed and processor speed in simple cases.

3.3 I can explain the term "contention"

The candidate should be able to explain contention as competition between many systems sharing the data transfer capacity of a system.

Evidence: From portfolios

Additional information and guidance

It is very common for internet services to be advertised based on the maximum bandwidth available when in fact the actual amount depends on how many other people are using the system. Where several people are using the same link to a service provider they are “contenders” for the available bandwidth. If for example the contention ratio is 50:1 it means there could be 50 people having to share that connection. If they all decide to download a video file at the same time the performance is likely to collapse! But on average over a 24 hour period this is unlikely and if one user happens to be the only one on the system at the time it will be very quick. It is possible to rent uncontended lines but they tend to be much more expensive. In a school where there is a wireless access point serving a class of laptops, the same problem arises. One way to solve this is to have several access points but then all the laptops might connect to just one of them so a system to balance out the connections is needed. This again adds cost. If we take the main server in a school and its connection to the internet we have effectively the whole network through one link that is a lot slower than the connections between the clients and the server. This is where a proxy server can be useful. If information that is regularly used is downloaded once on the proxy server all users can use it locally from the proxy server instead of having to keep getting it from that single internet connection that could also be contended with other schools and local businesses. Of course contention also takes place for the server. More people requiring high intensity services from the server can eventually reduce the performance. At level 1 the main thing is for candidates to know the word contention and its meaning so they recognise what it means when used in for example ISP sales and advertising literature.

3.4 I can identify potential bottlenecks in network designs

The candidate should be able to identify bottlenecks in networks in simple cases.

Evidence: From local testing, portfolios

Additional information and guidance
Obvious bottlenecks occur where many people are in contention for a limited amount of bandwidth in any part of a network. If the network speed between the client and a network switch is 100 Mbits/sec and the switch is connected to the server at 100 Mbits/sec there is no bottleneck if there is only one user. If there are 100 users each consuming 10 Mbits, their connection to the switch can handle this easily but the connection from the switch to the server will be saturated. This is why the fastest network speeds are needed closest to the server. Typically a level one candidate should be able to identify on a diagram where a bottleneck is likely to occur given the appropriate data on the components.

3.5 I can can distinguish between local and wide area networks

The candidate should be able to associate a local area network with a specific location such as a school or office building and a wide area network with links joining buildings at significant distances apart..

Evidence: From portfolios

Additional information and guidance
Usually local area networks have a server connected to clients through structured cabling built on fast switches with distances between nodes no more than 100m. They don't have to be confined to a single building but usually external building links are fibre optic cable a) because they can have greater distances without needing a switch or repeater to boost the signal and b) because metal cables are more vulnerable to lightning strikes. It gets difficult and expensive making these external links if they have to go over public roads or other people's property. Once buildings are spread out by more than a few hundred metres, it is usual to use existing infrastructure for carrying the signals eg an internet service provider. Networks that span large distances are called Wide Area Networks (WANs) those using entirely their own cables, switches and access points are Local Area Networks (LANs). LANs can carry data faster and the owner has freedom to customise it any way they want but this is also expensive in management and maintenance. WANs can be centrally managed and benefits from economies of

scale in principle reaching anywhere on Earth. The problem with WANs is simply the relatively slow connection between buildings separated by large distances. It is possible to get a fast connection but it tends to be expensive. The internet has driven wide area connection technology to become faster and less expensive. Another significant factor is designing software to work efficiently over a network using many smaller applications working together rather than one massive one. The internet is effectively a global wide area network with parts localised for specific uses.

Your home hub is connecting your computer directly to the service providers server(s). You don't need a server at home. Computers like the Google Chromebook are intended to work through a web browser. All of these changes are gradually chipping away at the original concept of a local PC connected for communications to being an network device that happens to be able to do some things locally. The traditional view of LANs and WANs might well change as more local needs can be satisfied by "cloud computing" where a client is connected to a website somewhere out on the internet. Of course that web site is hosted on a server or servers somewhere. There is commercial pressure as it is a lot less expensive to run eg a school's IT infrastructure from the "cloud" but there is also pressure from the rise in mobile computing where people expect to get their information anywhere any time. It will take time to change because many of the people with decision making power find changing the way they work and the associated technologies difficult but it is clear that the question is more how long will all this take rather than if it will. For younger learners we need to consider the world in 10 years time not now and one thing is for sure, things are going to keep changing so learning how to cope with change is important.

3.6 I can identify protocols used in networks

The candidate should know what a protocol is and be able to give some specific examples such as HTTP, FTP, TCP/IP and SMTP.

Evidence: From portfolios

Additional information and guidance

A protocol is a way or method of doing something. In life outside technology, protocols are used so people can work collaboratively without offending each other! For example, it is part of the protocol for meeting the Queen not to turn your back on her. When giving a business card to a Japanese business person you should hold it in two hands to pass it to them and when you receive their business card you should read it carefully and put it safely in your wallet. In technology protocols

enable different systems to communicate each other. Imagine you are a program and you need to send a message to another program. The other program needs to know there is a message, who it is from, where it starts, where it ends and so on. We do this ourselves with language all the time. One of the protocols of spoken communication is to use a language the two people talking to each other both understand. If you were talking to your boss at work you will automatically adjust the way you talk to be different to how you talk to your friends in a social setting. All of this is using protocols you have generally picked up growing up. Of course it is learnt because an immature toddler often gets the protocol wrong. This is often amusing and we make allowances for it. In fact these learnt human protocols are a lot more complicated than machine protocols but machine protocols have to be precise.

There are far too many protocols to learn about all of them so let us look at two that are at the heart of the internet. HTTP and TCP/IP. HTTP is Hypertext Transfer Protocol. You make an HTTP request when you put a web address into your web browser - http://www.gmail.com. This involves connecting to a port on the server using TCP (Transmission control protocol). An http server will be listening on that port for requests. This is where protocols come in. The http server has to know what it is listening for and distinguish it from any old random noise coming along. Once the connection is made information is sent in defined methods and received by a server that understands those methods. We won't get into all the details. The main thing is for candidates to understand why protocols are needed and in general terms, what they are. FTP, file transfer protocol is used for sending and receiving files and SMTP - simple mail transfer protocol is used for sending mail messages. In a nutshell all these protocols are about sending and receiving information so that sender and receiver both understand the message.

At level 1 it is sufficient to know a protocol is a way of providing information in a standardised format so that all devices that understand the format can send and receive the information reliably. They should recognise the names of some common protocols but do not need to know how they work.

4. The candidate will contribute to good network security

4.1 I can work to support an acceptable use policy

The candidate should show that they can work consistently to an acceptable use policy over a prolonged period.

Evidence: From assessor observations.

Additional information and guidance
The INGOT community learning site has a simple acceptable use policy and schools usually have one of their own. Either of these is suitable. If a candidate abuses the system they should be expected to show several months “good behaviour” before this criterion can be safely awarded. Assessors should relate this to e-safety and citizenship.

4.2 I can choose a strong network password and keep it secure

Candidates should know the characteristics of a strong password and apply these to their own passwords.

Evidence: From assessor observations

Additional information and guidance
Password strength depends on the number of characters and the variety of types of character. 8 characters or more and including upper and lower case letters, numbers and characters like $ and %. Passwords can be strong and memorable. eg MyDogSpot£75 or LeavesAre80%Green. Writing a password on a piece of paper is not a problem if you don’t leave the paper lying around since no computer can access that piece of paper. Candidates should not share their passwords with anyone else. This should also be part of the acceptable use policy.

4.3 I can identify encryption as a way of making information secure

The candidate should know what encryption is and some simple methods.

Evidence: Internal testing, portfolios.

Additional information and guidance
The simplest methods of encryption are to substitute the characters in a message for a different but related set of characters. eg This is a message replaced by Uijt jt b nfttbhf. This is just moving the letters on one place in the alphabet. This is not difficult to crack! In practical encryption such as GPG the computer uses random numbers to generate a key code which the user keeps secret. The message is encrypted to very complex patterns that can only be undone if you have the key code. You only give the key code to the people you want to be able to read your message. GPG is free so it is possible to try this out. This is a resource aimed at children and another. There are a lot! Just use a search!

4.4 I can identify ways of minimising spam and eliminating malware

Candidates should be able to identify basic ways of reducing spam and avoiding viruses and other malware.

Evidence: From assessor observation and portfolios

Additional information and guidance
Spam is unsolicited e-mail. If your e-mail address is unknown it can't be "spammed". A fundamental principle is not to leave your e-mail address in a machine readable format on a web site. Making an image of an e-mail address is a much better way of presenting it if it needs to go on a web site because it is much more difficult for a robot to realise that an image is actually an address. Internet searches will find many tips on reducing spam. An exercise might be to get children to work in pairs and use searches to find and then list say 5 actions to reduce spam in the order they think most important and present back to the rest of the class.

4.5 I can identify a firewall and explain its purpose

Candidates should be able to identify a firewall on a network diagram and say why it is important.

Evidence: Local testing and portfolios

Additional information and guidance
A firewall is a software or hardware network security system that controls the incoming and outgoing network traffic by analysing the data packets and determining whether they should be allowed through or not. This is in some ways related to protocols in that the order and nature of the data in the packet will determine what happens.

Moderation/verification

The assessor should keep a record of assessment judgements made for each candidate and make notes of any significant issues for any candidate. They must be prepared to enter into dialog with their Account Manager and provide their assessment records to the Account Manager through the online mark book. They should be prepared to provide evidence as a basis for their judgements through reference to candidate e-portfolios and through signed witness statements associated with the criteria matching marks in the online mark-book. Before

authorizing certification, the Account Manager must be satisfied that the assessors judgements are sound.

Annexe D - Level 2 Units

Unit 1- Computer Science - 5 Credits - 40 GLH

1. Design, use and evaluate computational abstractions	**2. Understand algorithms**	**3. Be able to use programming languages**	**4. Understand boolean logic, binary and hexadecimal numbers**
1.1 develop abstractions to make efficient code.	2.1 write complex algorithms that include conditional loops	3.1 modify an existing program to extend the scope of its use	4.1 show how NOT AND and OR gates can be made from NAND gates only.
1.2 use computational techniques to store patterns more efficiently.	2.2 describe different algorithms that target the same task	3.2 distinguish between a mark-up language and a programming language	4.2 add and subtract binary numbers
1.3 modify a software abstraction to serve a new purpose.	2.3 compare algorithms on the basis of efficiency	3.3 originate code to solve a problem	4.3 relate 4 bit binary to hexadecimal numbers
1.4 describe software abstractions that model real world systems	2.4 explain the relationship between instructions and data in an algorithm	3.4 test code using systematic methods	4.4 relate binary numbers to the voltage state of a connector
1.5 describe strengths and weaknesses in computational models	2.5 explain the words iteration and recursion	3.5 explain the difference between source code and executable code	4.5 explain analogue to digital conversion

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 2 qualifications

1. Achievement at QCF level 2 (EQF Level 3) reflects the ability to select and use relevant knowledge, ideas, skills and procedures to complete well-defined tasks and address straightforward problems. It includes taking responsibility for completing tasks and procedures and exercising autonomy and judgement subject to overall direction or guidance.
2. Use understanding of facts, procedures and ideas to complete well-defined tasks and address straightforward problems. Interpret relevant information and ideas. Be aware of the types of information that are relevant to the area of study or work.
3. Standards must be confirmed by a trained Level 2 Assessor or higher
4. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
5. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
6. When the candidate provides evidence of matching all the criteria to the specification subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
7. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
8. This unit should take an average level 2 learner 40 guided hours of work to complete.

Assessment Method

Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award.

Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate. Candidates that meet the requirements for all units achieve 30 marks and are then eligible to take the grading examination. Grades from the exam are A*, A, B, C. No grade can be awarded at level 2 without taking the examination with at least 40% of the marks coming from the examination.

Expansion of the assessment criteria

1. The candidate will design, use and evaluate computational abstractions

1.1 I can develop abstractions to make efficient code.

Candidates should be able to develop simple abstractions that can make code efficient.

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance

The candidate should be able to produce code that represents a simplified version of a physical object or system. This can be part of a larger program or it can be a smaller pieces of standalone code. The aim should be to produce something that is non-trivial ie something beyond drawing a simple shape that is produced once and has no particular purpose. An example would be to produce the code to represent something that is used repeatedly in a program in different circumstances. Key words in programming languages such as PRINT are ready made abstractions because the command PRINT invokes some code that causes a range of different possible printing effects. eg PRINTTAB(5) would use the PRINT abstraction together with the tabulation abstraction to start printing in a particular place. Note the word PRINT is causing the activation of a lot of hidden and complex code. Its just used so frequently it is an obvious part of the language to provide “ready made”.. In a procedural language, the student abstraction could be a Procedure that is used to do different things if different parameters are included. eg ProcedureDrawBox(5) might draw a box with side 5 units and ProcedureDrawBox(10) might draw a box with side 10 units. It is then possible to invoke ProcedureDrawBox whenever we need a box with a different side. We could get the effect of an expanding box by repeating the drawing with gradually increasing length parameter. For this criterion the aim is that the learner appreciates that if a piece of code can be given a name so it can be used used

many times just by calling that name it is much more efficient than having to keep repeating the code in slightly different forms each time it is needed.

1.2 I can use computational techniques to show how to store patterns more efficiently.

Candidates should be able to come up with methods for reducing the amount of data needed to store sequences of data where there is a pattern.

Evidence: from assessor observations, documentation in portfolios.

Additional information and guidance
Candidates should build on work in level 1 to consider how information is stored and how it can be compressed. If patterns repeat they can be compressed. Take the simple case of 5 red pixels in an image. This can be represented as RRRRR or it could be 5R. RRRRR takes 5 characters and 5R takes 2. If we think in terms of bytes, a byte of data can be any number from 0 to 255 so in 2 bytes we could store 1R, 2R..up to 255R or indeed 1B, 2B …..up to 255B (for blue) This is because the first character is just a number so it can be represented by a number and the second, a colour can also be represented by a number. The computer would have to know that the first byte was a number, the second byte was a colour and which colour in order to get the hardware to put that colour on the screen. This ordering and data representation is the file format. Try opening a small .jpg or .png file in a text editor. You will see a lot of characters some slightly weird because there are about half of the characters in the 255 available that are not normally used for text printing.

What would the limits be? First of all 0,1 and 2 colours don't give us any gain. 0R for no red would be a disaster because you would have 2 bytes for every pixel that wasn't a red one! That would make the file much bigger. 1R is worse than just R and 2R is no better than RR. The first byte is limited to 255 because that is the biggest number we can have in one byte. What if there are 256 Rs? We would have to start again with a new counter for each set of 255 Rs. Of course this is still a good saving because for every 255 Rs we use only 2 bytes. So a file that was all Rs could at best be 255/2 times smaller. A 127k file would then be just 1k. Or a 127MB file just 1 MB. For big files transferred over the internet this makes a big difference.

If a file has a lot of colour variation in it, the compression will work a lot less well. If every byte is different from the next one our system will not work well. To test this

use a program like Inkscape to draw a plain coloured circle and export the image to a .png file. .png files compress files in a similar but more complicated way to what we have been considering. Now apply a colour gradient to the image to make the colour tone change across the image. In this case there are many more different colours. Now export the png using a new name but everything else identical (the size and image resolution etc) to make it a fair comparison. Now go to the filer and check the size of each image. The one with the gradient will be significantly bigger.
.png files still contain all the information to reconstruct the original file. .jpg get even greater compression by throwing away some of the information if it is not going to make the picture look a lot better. This is more complicated but the quality of the image is traded off against the size of the file. Once you jpg a file, you can't get back to the original data. Best always to store an original in eg png if it is likely to be important and take jpg copies from it. For line diagrams, charts, cartoon style clip art etc it is best to design using a vector format like svg and produce png and jpgs from it as required.

1.3 I can modify a software abstraction to serve a new purpose.

Candidates should appreciate the power of an abstraction in terms of the way relatively small modifications can give it a whole new set of uses. They should have opportunities to demonstrate this in software.

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance
The candidate can take an existing piece of open source code and make modifications to parts of it to make it do something different. This could be making a procedure more general by adding a variable parameter. It could be adding to a structure to extend its purpose or it could be simplifying a structure to make it more general.

1.4 I can describe software abstractions that model real world systems

Candidates should be able to describe some typical software abstractions and say how they relate to real world systems.

Evidence: from assessor observations, content of learner portfolios.

Additional information and guidance

In the case of eg Numpty Physics http://numptyphysics.garage.maemo.org/ candidates should be able to say that the objects they draw on the screen are abstractions of real objects because they are limited to 2 dimensions whereas real objects are 3 dimensions. In the case of a violent computer game the abstraction is not real because no real people get killed.

1.5 I can describe strengths and weaknesses in computer models

Candidates should be able to describe the strengths and weaknesses in models that they use.

Evidence: From content of learner portfolios.

Additional information and guidance
This differs from level 1 in that the candidate should be able to describe strengths and weaknesses from a generic starting point and provide some detail beyond identification. eg In Numptyphysics, a strength is that you can experiment with how different objects behave in a gravity field in different environments. This can help understand how real objects behave even though the objects are not fully identical to real objects. A weakness is that you can't make it more realistic by providing wind or different materials. Plastic, wood and metal might make some of the situations different.

2. The candidate will understand algorithms

2.1 I can write complex algorithms that include conditional loops

Candidates should be able originate algorithms that have some complexity

Evidence: Assessor observations, local testing, portfolios.

Additional information and guidance
Algorithms are step-by-step problem-solving procedures. By complex we mean multiple components and some variation in the structure. This could be as an example, from a nested loop. eg generating a set of times tables with something like:

```
FOR mtable = 1 TO 10
 FOR number = 1 TO 10
   IF NOT(mtable = 5) THEN
       PRINT mtable "x" number "=" mtable*number
```

```
  ENDIF
 NEXT number
NEXT mtable
```

This will then print the multiplication tables minus the 5 times table.

Candidates should be encouraged not to make things more complex than necessary. It is best to break a program down into many small easy to understand parts and link these together. To further this process using a combination of their own and other people's code is perfectly legitimate and to be encouraged. Just make sure there is sufficient evidence of the candidate being able to meet the criterion with their own work.

2.2 I can describe different algorithms that target the same task

Candidates should be able to describe at least two different methods of approach to a problem that lends itself to an algorithm

Evidence: Assessor observations, portfolios.

Additional information and guidance
A useful resource to underpin this learning outcome is at http://csunplugged.org/searching-algorithms

A bubble sort and a merge sort are both sort algorithms but they can result in different efficiencies in achieving the outcome. A linear search and a binary search are again different methods targeted on the same problem. At level 2 candidates would be able to outline some fundamental reasons why although two methods are achieving the same result one might be a better choice.

2.3 I can compare algorithms on the basis of efficiency

Candidates should be able to compare algorithms based on how efficient they are in solving a particular problem.

Evidence: From local testing and portfolios

Candidates should be able to see that some algorithms can achieve a task more quickly than others or with less lines of code. They should always be looking to reduce the amount of code they need to achieve a task. (Code as opposed to

documentation. Note that it is a common mistake to assume documentation and comments slow programs down. There will be no discernible difference) They should appreciate that in some cases execution of a program with more code could be faster than one with less. By level 2 candidates should be thinking about how many iterations of an algorithm are needed and how altering an algorithm could make it operate more efficiently. https://fiftyexamples.readthedocs.org/en/latest/algorithms.html

2.4 I can explain the relationship between instructions and data in an algorithm

Candidates should be able to recognise the inputs and outputs of algorithms as data and the instructions as operators on the data.

Evidence: From assessor observations and portfolios

Additional information and guidance
Generally algorithms take input data and do some operations on it and then provide some output data. The input data might have to be qualified first through a "precondition". Without qualified data the algorithm could fail to give a valid result so data is often validated before it can be input into the algorithm. For example, an algorithm to find square roots of numbers might check to see if all the input numbers are positive since finding the square root of a negative number is not possible (at least not with real numbers). Instructions need data on which to operate. An instruction such as ADD is not much use without knowing what it is to ADD and where it must put the result. ADD N1,N2,R is more useful if it adds two numbers in N1 and N2 and puts the result in R. Algorithms of just about any complexity can be built up from simple instructions and data like this. Indeed this is how modern digital computers work. They do billions of simple operations like this in a second and a billion simple operations can be combined and configured into very complex algorithms. Fortunately, most of the common simple instructions are defined for us and even much more commonly used complex algorithms are provided by key words in programming languages. The HTML tag is effectively an instruction to make all the text after it appear in a bold type face. That will be achieved by different methods in different browsers on different computers with many steps between the tag and what actually appears on the screen. We don't have to code all these steps each time just putting in the tag is enough.

2.5 I can explain the words iteration and recursion

Candidates should be able to explain the words and recognise examples of them in algorithms
Evidence: Assessor observations and portfolios.

Additional information and guidance
Iteration means the act of repeating a process usually to converge to a result. Recursion is a process in which a function calls itself as a subroutine. Recursion is really a special case of iteration. At this level it is sufficient to be able to explain iteration in terms of loops.

Iterations happen with loops. Each time a loop is executed an iteration takes place. A program can specify a fixed number of iterations eg FOR iteration=1 TO 100:PRINT iteration:NEXTiteration will execute 100 iterations. Alternatively a condition might be set to end the iteration.

Recursion allows a function or procedure to be repeated several times, since it calls itself during its execution. Recursion is often seen as an efficient method of programming since it requires the least amount of code to perform the necessary functions. However, recursion must be incorporated carefully, since it can lead to an infinite loop if no condition is met that will terminate the function.

3. The candidate will use programming languages

3.1 I can modify an existing program to extend the scope of its use

The candidate should be able to modify an existing useful program to extend its scope of use.

Evidence: Portfolios

Additional information and guidance
Candidates should take an existing application that is open source and modify it to produce something different. This could be an extension of the program, an improvement or a change in its function. As an example there are Javascript games at https://theingots.org/community/LinkPuzzles Take the game Pairs 1 and increase the number of pairs to match and make the subject of matching different. This is just an example. There is flexibility to to find and change anything that the candidate has as an interest.

3.2 I can distinguish between a mark-up language and a programming language

The candidate should able to use an example of each to illustrate the difference.
Evidence: From Portfolios.

Additional information and guidance
Candidates should be able to give examples such as HTML as a mark-up language and Javascript as a programming language. HTML uses tags to display information in different ways. It does not have loops, structures and logical constructs that a programming language has. Mark-up languages can be used for file formats eg XML as the basis of OpenDocument and docX. On the Web, Javascript is used on the client side when programming is needed to make web pages interactive. Server side programming languages such as PHP can provide database processing that can then be displayed in the web page using HTML tags.

3.3 I can originate code to solve a problem

The candidate should be able to solve a non-trivial problem using their own code.

Evidence: From portfolios

Additional information and guidance
Candidates should be given opportunities to solve simple problems in the subjects of the curriculum at a level they have mastered using code. They do not have to originate all the code themselves but at least 50 lines of the code should be their own. Examples might be to program a tune to play within an application, to program a control system to simulate automated machinery, a program in science to simulate simple circuits, a program in geography to test knowledge of sustainable development.

3.4 I can test code using systematic methods

The candidate should be able to use systematic methods including control of variables and breaking the code into smaller sections.

Evidence: From assessor observations and documentation in portfolios

Additional information and guidance
Showing practical competence in systematic debugging in keeping with the overall level 2 descriptor is the aim. Candidates at level 2 will need some pointers but

should be showing consistent techniques to fault finding with a degree of self-sufficiency.

3.5 I can explain the difference between source code and executable code

The candidate should be able to recognise source code and executable code from the contents of files and explain the difference.

Evidence: From portfolios

Additional information and guidance
Candidates should know that source code is designed to be easily understandable by humans and executable code is understandable by machines. This can be related back to abstraction. A hardware abstraction layer is software that provides a means for applications to access hardware resources. The source code of an application is an abstraction further from the hardware to make things more humanly friendly. Source code is what humans produce in programming languages. Languages like Python are designed to make them more like the language humans are used to. At the other end of the scale Assembly languages are much closer to what the machine understands. To get from source code to executable code requires translation. This can be done through an interpreter which is a program that converts the source code to executable code as the program is run. The other more common method with large modern applications is to use a compiler that converts all the source code to executable code so that it is ready to run. The disadvantage of compiling is that it takes time to compile large amounts of source code eg Apache OpenOffice takes several hours to build. If you need to compile the code you can't easily just change a few lines of code and immediately see the effect. The advantage is that the executable code will be a lot more compact and most people don't need the source code so it makes distribution easier and for owners of the source code prevents other people from seeing how the program works. Open Source software makes the source code freely available so that other people can see the source code and help improve it.

4. The candidate will understand Boolean Logic, binary and hexadecimal numbers

4.1 I can show how NOT AND and OR gates can be made from NAND gates only.

The candidate should be able to show how combinations of NAND Gates can produce the other three fundamental gate types.

Evidence: From internal testing and portfolios

Additional information and guidance
Diagrams and explanations are freely available from
http://www.instructables.com/id/Use-NAND-gate-to-make-NOT-gate/
http://luishernandezengineeringportfoli.weebly.com/nandnor-gates.html

Some practical electronics projects from
http://www.dummies.com/how-to/content/electronics-projects-how-to-use-nand-gates-to-crea.html

Candidates should be familiar with simple truth tables and the symbols for NOT, AND, OR and NAND gates. Also know the name Inverter for a NOT gate. The importance of NAND gates is that they can be used to make any other gate so in practice only one type of logic gate is needed in electronic engineering.

4.2 I can add and subtract binary numbers

Candidates should be able to perform simple arithmetic operations on binary numbers,

Evidence: From internal testing and portfolios.

Additional information and guidance
http://www.cimt.plymouth.ac.uk/projects/mepres/book9/bk9i1/bk9_1i2.html

The above link shows how to do this and provides exercises. Note that at a fundamental level in a computer all the operations are with binary numbers, these are just abstracted to higher levels so that humans can directly recognise them. eg the binary number 1000001 = 65 in our more familiar decimal numbers. The ASCII code 65 is the letter A in the text you see on the screen, so somewhere in your computer there is the pattern 1000001 in any computer displaying the letter A. B is 66 so 1000010 Imagine trying to read this page if all the codes were converted to binary. This is why we translate from binary codes to decimal numbers and characters. The computer does all its calculations in binary, specialised chips and software convert from binary to our more familiar number systems and mathematics based on this so we don't need to learn to think in binary just to understand the principles.

4.3 I can can relate 4 bit binary to hexadecimal numbers

The candidate should be able to recognise the relationship between 4 bit numbers and hexadecimal.

Evidence: Internal testing, portfolios.

Additional information and guidance
In some ways it is unfortunate that we have 10 fingers because that is why we count in lots of ten. It is so ingrained into us from being little children anything else seems alien. Computers lend themselves much better to counting in 2s, 4s, 8s. 16s etc because these relate better to binary numbers. A lot of computer numbers are based on 4 and 8 bits. (A bit is a binary digit) in binary 0=0 10 = 2 100 =4 1000=8 and 10000=16. So 15=1111. its all based on the number of possible unique patterns possible from the number of bits. Using 4 bits we can have all the numbers from 0 to 15 - 16 patterns including 0000 through to 1111.. To store these in a single place value they are 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F. The letters are used because there is no single character to represent 10, 11, 12, 13, 14 and 15 because single place value in decimal numbers only requires 0-9. This is really just the same as if we had 16 fingers, we would count them as individual units up to 15 and for 16 we would say 10 but mean sixteen not ten. In computers you will see numbers like &FF, or &10 or #FF or %FF. The &,# and % all mean it is a hexadecimal number following, not a decimal number. If there are letters in it it is easy but of course some hex numbers look like decimal numbers. This is actually true of binary too. 10 in binary is two not ten. Why bother with Hex numbers? It simply makes it more compact to store numbers and relates better to the number systems best suited to machines. &FF is the same as decimal 255. &FFFF is 65535 or 64K. Notice that if we have a file size of 64K it is actually a bit bigger than 64 thousand bytes in decimal because of the different number systems.

&F is 1111 ie the maximum 4 bit number
&FF is 11111111 ie the maximum 8 bit number
&FFFF is 1111111111111111 - 16 bits
&FFFFFF is 111111111111111111111111 - 24 bits as in colour 8 bits for each of red, green, blue (In HTML you will see
&FFFFFFFF is 11111111111111111111111111111111 - 32 bits

If you think of those 1s as wires, how many possible locations could be connected to 8 wires - answer &FF in hexadecimal or 255 in decimal. What about 32?

&FFFFFFFF or 4,294,967,295 so about 4.3 billion. (There is a converter at http://myhandbook.info/table_hex.html?original=1&finaltext=FFFF%0D%0A)

This is why a 32 bit computer is much more than just 4 times the power of an 8 bit computer. Now we have 64 bit computers. The maximum decimal number with 64 bits is 9,223,372,036,854,775,807. Very big! 1111111111111111111111111111111111111111111111111111111111111111 If we can make instructions in a computer with 8 bits we can process several at once in 64bits and directly address many more memory locations.

The main aim here is to give an insight of why number systems are important and how they might relate to the physical electronics in a computer. We are not expecting average Level 2 candidates to fully grasp everything or remember all the details. If some can so much the better. They should recognise hex numbers by the &,#,% or Hex. know that 1111 in binary is 15 and F in hexadecimal, that 10 could represent many different numbers in different number systems.

4.4 I can relate binary numbers to the voltage state of a connector

Candidates should be able to relate states of wires, LEDs etc to bit patterns.

Evidence: From assessor observation and portfolios

Additional information and guidance
Digital electronics works by settings that are high or low, on or off. High or on represents a 1 and low or off a zero. Back to abstraction again. 1 is an abstraction of a wire raised to a potential of 5 volts. 0 is an abstraction of a wire at 0 volts. In fact as long as there is a measurable difference between two states they can represent 1 and 0. The smaller we can make the physical representation of 1 and 0 the more data we can pack into a given space. We could make a computer with light bulbs as memory locations but it would be massive and consume a lot of power. On the other hand humans have to be able to communicate with computers so we have to be able to connect big things like keyboards to very little things like memory locations. If I push the key with a letter A on it, it will connect to a physical pattern 1000001 etched microscopically in silicon via a series of steps and that pattern will also be sent back through a series of steps to the screen. It happens so quickly it seems instantaneous.

Practical applications can be explores eg using the RaspberryPI http://www.cl.cam.ac.uk/projects/raspberrypi/tutorials/robot/morse_code/

There are many simple applications of bit patterns being used to control things. Take a 7 segment display. It is based on representing numbers and letters by 7 lines. If all lines are present we get a number 8

How can you take away 2 lines to make a 3?

How many bits does it take to control the display? Answer 7 because there are 7 lines that can be switched on or off. What number corresponds to 1111111 ? Answer 127 or &F7. It depends on which bit controls which line as to what specific bit pattern displays which number or letter. All we know for certain is 1111111 which include allof them so sending the number 127 to the display as a binary pattern produces what looks like a number 8 on the 7 segment display.

4.5 I can explain analogue to digital conversion

Candidates should be able to explain the basic principles of sampling analogue signals to produce digital data and reconstructing an analogue signal from digital data.

Evidence: From portfolios

Additional information and guidance
A good concrete example is in music. Sound we hear is analogue. It is a continuous series of pressure changes in the air caused by a mechanical oscillation. Vocal chords, guitar strings or vibrating reeds all cause continuous sound waves. when the sound wave wobbles tiny bones in our ears they send the sound signal to our brains and we hear things. A microphone picks up sound and converts it to an electrical signal. So how can we record this signal and store the recording in a computer? Computers can only store 1s and 0s so we need a way of converting the electrical signal produced by the sound wave into patterns of 1s and 0s. This is where an analogue to digital converter is used. This is a chip that can sample a varying voltage very rapidly. More details at http://en.wikipedia.org/wiki/Analog-to-digital_converter

The key thing with audio is that the samples have to represent the level of the voltage (amplitude) - effectively the loudness of the sound - and the frequency that the voltage changes to get the pitch of the note or frequency. A simpler example is to make a digital thermometer. If you have a device where it's electrical properties change with temperature we can use it to measure temperature. As the temperature rises and falls the voltage across the device will change. This is again a continuous analogue signal. Sampling the voltage with an analogue to digital converter (ADC) will provide numbers corresponding to the voltage and hence the temperature. Let's say we put the device in pure melting ice at normal pressure. The number generated from the ADC is then 0^0C put it in steam at normal pressure and that number is 100^0C. Now divide into 100 parts and we have a digital thermometer. If the ADC uses 8 bits what is the smallest temperature the thermometer can measure. If 0^0C happens to coincide with the lowest possible sample for the ADC and 100^0C the highest, there are 255 possible readings in 8 bits so 2.55 for each degree. It is very unlikely that zero and a hundred will be at the two extreme measurements but certainly an 8 bit ADC should be able to be made to 1 degree of precision. A 16 bit ADC would divide the scale into 64,000 parts and so it would probably be far more precise than needed. With audio a 16 bit ADC will sample sound so well that there will be no real discernible gain by going to higher values. Sample frequency (how fast the sound wave is sampled) is also important though. With a thermometer, if the reading is up-dated every second it is probably good enough, with a sound wave the oscillations causing the sound are at tens of thousands per second. If the sample rate is not fast enough a lot of information will simply be missed. In general the sample rate should be at least double the highest frequency. For standard CDs this was set at 44KHz because humans don't hear much above 20KHz. On modern electronics this is easy to achieve so it is possible to go to much better rates. Whether or not the ear and brain can tell the difference is moot. Once a sound is converted to numbers is is easy to do mathematical operations on the numbers and produce a lot of effects. Echo, noise removal, pitch shifting can all be done using software. Its so fast we can even deaden sound by sampling an incoming sound wave working out its exact opposite wave form and then playing it back before the original sound wave (vibrating 10s of thousands of times a second and moving at the speed of sound) has have time to change its form or position appreciably. This is the principle of expensive headphones that remove all external noise.

Digital to analogue conversion is the reverse process, creating a sound wave in a speaker from a set of numbers stored in the computer.

Students should be familiar with the basic concept of ADC/DAC in terms of sampling analogue signals to produce sets of numbers. Getting hands on experience eg via RaspberryPI or similar is desirable.

L2 Computing

Unit 2 - Using digital applications to support projects - 5 Credits - 40GLH

1. Select, combine and evaluate applications	**2. Create original works using digital applications**	**3. Be able to manage projects**	**4. Respect intellectual property**
1.1 compare suitable applications to support my work	2.1 originate original digital information from my own imagination	3.1 devise a project plan to explain my intentions	4.1 describe my preferred license for my project
1.2 organise and classify data and information	2.2 use remix to create original digital information	3.2 set deadlines on the way to reaching my project goal	4.2 compare liberal and restrictive licenses
1.3 format data for different applications	2.3 consider digital technology issues to inform my design techniques	3.3 meet deadlines on the way to reaching my project goal	4.3 describe the 4 freedoms of Free and Open Source Software.
1.4 explain interoperability	2.4 match my work to a target audience.	3.4 apply e-safety principles to my projects	4.4 explain the difference between copyright and license
1.5 I can use collaborative technologies safely	2.5 compare my work to acknowledged good practice	3.5 show courage in completing a project.	4.5 explain the terms Creative Commons and DRM
		3.6 evaluate a project in terms of its strengths and weaknesses	

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 2 qualifications

1. Achievement at QCF level 2 (EQF Level 3) reflects the ability to select and use relevant knowledge, ideas, skills and procedures to complete well-defined tasks and address straightforward problems. It includes taking responsibility for completing tasks and procedures and exercising autonomy and judgement subject to overall direction or guidance.
2. Use understanding of facts, procedures and ideas to complete well-defined tasks and address straightforward problems. Interpret relevant information and ideas. Be aware of the types of information that are relevant to the area of study or work.
3. Standards must be confirmed by a trained Level 2 Assessor or higher
4. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
5. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
6. When the candidate provides evidence of matching all the criteria to the specification subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
7. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
8. This unit should take an average level 2 learner 40 guided hours of work to complete.

Assessment Method

Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award.

Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate. In the case of the L2 Award, 2 units are required. For a certificate 3 units are required. Certificate candidates that meet the requirements for all units achieve 30 marks and are then eligible to take the grading examination. Grades from the exam are A*, A, B, C.

Expansion of the assessment criteria

1. The candidate will be able to select, combine and evaluate applications

1.1 I can compare suitable applications that can support my work

Candidates should be able to make comparisons between similar applications that they have used as a basis for selecting an application for a particular task or project..

Evidence: from assessor observations, documentation in portfolios.

Additional information and guidance

The aim is for candidates to make objective and informed decisions about the tools they use rather than just using those that are popular or have the biggest marketing budget. Build on Level 1 work to become more sophisticated in decision making. In the adult world their is often strong partisan alignment with particular brands that is often only based on experience of that brand. Candidates should consider the wisdom of this and this also relates to open standards and interoperability. It is in company interests to lock users into their technology, it is in user interests to be able to change technologies without too much hassle. Things like non-standard connectors for power supplies and other peripherals is environmentally damaging and serves no other purpose except for the owner to charge a premium for the connector because customers can't get it from a different supplier. There is an argument for non-standard features when they really are innovative and provide some specific benefit but that is increasingly rare as computer technologies become commodities. Often the benefits are marginal at best.

1.2 I can organise and classify data and/or information

Candidates should be able to organise their data files and the information within them as well as information shared on the web.

Evidence from assessor observations, content of learner portfolios.

Additional information and guidance
The main purpose of this criterion is to encourage candidates to organise their work so they can find things. By implication, candidates should be familiar with common file types and their relationship with particular applications. Strictly speaking data are just unorganised facts, statistics and such-like. Data become information when organised to provide meaning. Some of this could be grouping similar items but using meaningful titles is also important. This is because searches and sorts often make it less necessary to group files by type because you can just search for them when needed. This does require some discipline when naming files. As an example, Google drive labels items so they can be organised by search rather than in a conventional filing system.

Assessors should be flexible in awarding this criterion. Ff there is clear method and a systematic approach, even if it isn't always 100% effective this is sufficient. Organisation does not have to be complex and it is often better to keep things simple. Information in web pages should be structured clearly and in logical order. It is more difficult in web pages to position images and so at this level it is sufficient to provide clear logical order. It might be worth linking the classification of information here with work on eg keys in biology. It could also help in understanding classes in object orientated programming.

1.3 I can format data for different applications

Candidates should know that applications expect their data in particular forms and act appropriately when preparing data and information for others. .

Evidence: from assessor observation and content of learner portfolios.

Additional information and guidance
This is similar to work on protocols. The way data files are organised internally is critical as to whether an application can access them. Even changing one byte can prevent an entire file from being accessed. Some applications are more tolerant than others. This could be related back to 1.1. As a specific example, MS Word will usually reject a corrupt .doc document that might have only a minor error. Apache OpenOffice can often open such files with only a few corrupted characters. It depends on the programmers as to how they deal with errors. Clearly if you have a 100 page document that has two or three words that are corrupt, it is a lot better to be able to open it and fix the problems than to just get an error message saying "go away the file is corrupt".

There is potential to relate this work to both 1.1 and 1.2 above. There are many different file formats for very similar and overlapping tasks. This has arisen through the natural growth and competition on a new market but now there is an increasing tendency to standardise on open formats because then software can be developed to translate the data between different formats so it is usable in more than just one application. (See 1.4 below)

The important things for candidates is to be able to find and use the “Save as” and “export” options usually under the file menu and try to use open file formats such as .jpg, .png and .svg whenever possible. Try to avoid applications where there is no export to an open standard.

1.4 I can explain interoperability

Candidates should be able to recognise the term interoperability and associate it with being able to use applications from different providers to originate, edit and exchange information.

Evidence: From content of learner portfolios.

Additional information and guidance
Candidates should understand that it is usually in the user’s interests to support open data formats because they prevent them being locked into particular applications. All should appreciate that open formats enable interoperability. Not always, but at least it provides the possibility.

Web browsers and W3C standards are a good illustration. To start with HTML, the language to present information in a web page, was made freely available to everyone. Two browsers emerged, Netscape and Internet Explorer. IE was given away with Windows so Netscape was presented with an increasing distribution disadvantage. Microsoft provided tools that made web sites that could not be viewed well in Netscape and so IE became an almost total monopoly with over 90% of the market. The result was a stagnated browser development because there was no competitive drive for improvement. FireFox offered a better and Open Source alternative with innovative “tabbed” browsing followed by another open source based browser in Google Chrome. Now there are 3 dominant browsers, Chrome, Firefox and Internet Explorer with other significant players such as Safari and Opera. IE has been improved beyond all recognition recently as many people rejected it even though it was per-installed on their desktop. The dominance of IE is likely to decline further with smartphones that don’t run windows or IE becoming

used increasingly for web access. Now all browsers need to keep to the standards or risk being isolated. The latest version of HTML at the time of writing is HTML 5. This promises to further standardise information formats on the web. You can test your browser's compliance with HTML 5 at http://html5test.com/.

The point of all this is that it is highly desirable to have an internet that is interoperable. We don't want to have to buy all mobile phones from a single monopoly supplier so why would we want to buy all computers from one source? All software? All peripherals? We can already see the benefits of freeing up web based competition. A lot of the applications on the internet are legal and free or very low cost and we take it for granted that we can choose our smartphone and expect it to work compatibly with any other devices on the web. Interoperability is almost taken for granted on the web whereas on desktop computers even using a computer without Windows has until very recently been seen as a big compatibility risk.

1.5 I can use collaborative technologies safely

Candidates should be able to work as part of a group sharing information, its production and concurrent editing.

Evidence: From assessor observations and learner portfolios

Additional information and guidance
Examples of collaborative technologies include:

1. Google Docs on Google Drive
2. Google Hangouts/Skype/Flash Meeting
3. TLM evidence management system
4. Social networking sites
5. Smartphones
6. E-mail

This list is not exhaustive. Candidates should use one or more collaborative technology to make a positive contribution to their work. They should be encouraged to combine applications to do this and the work can include programming or scripting. This is an opportunity to undertake a small scale project that can be supported by collaborative technologies especially where it would be difficult or impossible to carry out the project. An example might be to manage a project with non-English speakers using translation software and an e-mail list. At level 2 the use should go beyond simple exchange of messages eg by e-mail.

Safety issues should be considered and a risk assessment would be a reasonable way of doing this before any collaborative projects commence.

2. The candidate will be able to create original works using digital applications

2.1 I can originate digital information from my own imagination

Candidates should be able to originate digital resources from a zero base.

Evidence: Assessor observations, local testing, portfolios.

Additional information and guidance
Candidates should create something original from a zero base. Building on Level 1, Level 2 candidates should be more self-sufficient and produce resources with several dimensions eg by having two distinct design elements eg sourcing an image with a camera, editing it in and image editing program and combining it with vector objects in a drawing program. Another similar activity might be to make a video by recording their computer desktop and adding captions or a commentary recorded separately. The spirit of this criterion is creativity and while use of existing work is not banned where it is sensible to incorporate it, there should be a clear element of original work rather than exclusive remix of other people's work. Remix is a legitimate creative activity in its own right and it is assessed in the next criterion so the emphasis here should be on originating new material.

2.2 I can use remix to create original digital information

Candidates should be able to edit and combine existing information to create something new with an element of originality.

Evidence From portfolios

At level 2 candidates should be able to ensure that their work is legal from an intellectual property point of view and acknowledge their sources. They should be able to choose sources so that the remixed outcome looks reasonably coherent as a new item rather than obviously just unconnected items pushed together. There are many good examples of remix on the web. While remix is normally associated with music and video, it doesn't have to be and it is up to the assessor and candidate to decide on the exact nature of the evidence. There is some useful video information at http://everythingisaremix.info/watch-the-series/

2.3 I can consider digital technology issues to inform my design techniques

Candidates should be able to relate technical knowledge to specific design techniques in their work

Evidence: From assessor observations and portfolios

Additional information and guidance
For level 2, candidates should build on the Level 1 requirements in keeping with the overall level statement. They should be increasingly aware of fundamental digital principles when designing information artifacts or systems for other people to use. File size, interoperability, legal issues.

2.4 I can match my work to a target audience.

Candidates work should include features that are obviously appropriate to the target audience..

Evidence: Assessor observations and portfolios.

Additional information and guidance
Two clear possible audiences are their family and younger less experienced learners. If projects are originated to support learning in younger pupils, there should be obvious characteristics in the context of what they present that will appeal to the younger audience. Adults, even teachers are not that good at removing themselves from what appeals to them as opposed to what appeals to a very young child. This was demonstrated in Sesame Street for example, by repetition eg with the Count, that the original program designers did not plan because of the advice of educational psychologists. The repetition emerged from empirical evidence observing what did and did not engage the children. The best evidence will always come from “customer feedback”.

2.5 I can compare my work to acknowledged good practice

Candidates work should find examples of similar work to their own that is considered good and make comparisons.
Evidence: Assessor observations and portfolios.

Additional information and guidance

Finding professional standard work in just about any field is straightforward using the internet. Candidates should take at least one of their extended pieces of work, find something similar and make objective comparisons. For example they might make a short digital video to explain how to do something and search You Tube for similar videos. They might have produced a program for a web based game and compare it with a similar game. They might design a logo and compare with some company brand logos.

3. The candidate will be able to manage projects

3.1 I can devise a project plan to explain my intentions

The candidate should be able to put together a simple structured plan to explain what they intend to achieve and how.

Evidence: Portfolios

Additional information and guidance
Candidates can build on level 1 supported planning to move onto self-sufficiency. Plans do not need to be elaborate. They should be plausible summaries of what the candidate intends to do and why this will secure the outcome. In general plans should explain the aim or aims of the project, a time schedule with milestone goals, any other resources needed and a clear set of SMART steps along the way.

3.2 I can set deadlines on the way to reaching my project goal

The candidate should set deadlines and justify their inclusion in their project planning.

Evidence: From portfolios.

Additional information and guidance
Candidates should be encouraged to consider the targets and deadlines they set in the light of how likely they are to be achieved. They should realise that setting a target and a deadline mean they are committed to them and need to do what it takes to be reasonably sure of achieving them.

3.3 I can meet deadlines on the way to reaching my project goal

The candidate should be able to demonstrate that they have met deadlines by providing appropriate evidence.
Evidence: From portfolios

Additional information and guidance
Candidates should understand that if they have set themselves a challenge it might turn out to be more difficult than they anticipated. In such cases they should not give up, they should look for ways of getting back on schedule by either revising the original goal, modifying their actions or putting more time in. This is partly about courage and capacity to take responsibility in keeping with the general level 2 descriptor.

3.4 I can apply e-safety principles to my projects

The candidate should be aware of e-safety issues and be prepared to take action in keeping with the general description of level 2 qualifications.

Evidence: From assessor observations and portfolio

Additional information and guidance
Being safe online is the objective. At level 2 candidates should be building on the structured support necessary in some areas for level 1 to build greater self-sufficiency in keeping with the level 2 descriptor. Part of this criterion is still the appreciation and willingness to take advice from more experienced people but the aim should be to become at least basically safe without the need for supervision. http://www.safenetwork.org.uk

3.5 I can show courage in completing a project.

The candidate should demonstrate courage in persevering and making an effort to overcome difficulties.

Evidence: From assessor observations and documentation in portfolios

Additional information and guidance
The spirit of this criterion is to recognise the fact that at level 2 candidates are expected to make an effort to overcome difficulties themselves. In some cases they will still need help but real life projects require courage to complete and this is an opportunity for candidates to demonstrate this quality.

3.6 I can evaluate a project in terms of its strengths and weaknesses.

The candidate should provide at least one reasonably detailed evaluation of a project.

Evidence: From portfolios of evidence.

Additional information and guidance
The evaluation should focus on strengths and weaknesses and provide a commentary on what went well, what went wrong and what could be improved. This could be in writing but video and audio are perfectly legitimate media as long as the main characteristics of an evaluation are reported.

4. The candidate will respect intellectual property

4.1 I can describe my preferred license for my project

The candidate should be able to describe the licensing they prefer for at least one project that has copyrightable outcomes.

Evidence: From assessor observations, portfolios

Additional information and guidance
The implication is that candidates will have considered more than one license for their work and that they can state the reasons for the particular license they choose.

4.2 I can compare liberal and restrictive licenses

Candidates should be able to make an objective comparison of at least one liberal and one restrictive license.

Evidence: From assessor observations and portfolios

Additional information and guidance
See also the level 1 guidance. For this criterion, some more in-depth consideration is required. Licensing is a very complex field and the main aim is to get candidates to understand this together with the importance of licensing in the world of work. While at home people often get away with copyright infringements it is a wholly different situation at work (and in school) because of corporate responsibilities and

interdependence of people and their businesses. In the end, any work they originate is their own copyright unless they signed some sort of agreement with eg an employer assigning their copyright to them. Some companies will only employ people if they effectively sign over their "intellectual property rights" while in that employment. Candidates might like to consider the fairness of someone originating and idea at home outside working hours and then having it owned by the company.

4.3 I can describe the 4 freedoms of Free and Open Source Software.

The candidate should be able to describe the basic gist of the 4 freedoms conveyed by free and open source software and understand the general implications.

Evidence: Assessor judgements and portfolios.

Additional information and guidance
The 4 freedoms were first proposed by Richard Stallman a computer scientist from MIT who founded the GNU organisation to try and prevent corporate and commercial interests from being too dominant. The 4 freedoms are

1. The freedom to run the program, for any purpose (freedom 0).
2. The freedom to study how the program works, and change it so it does your computing as you wish (freedom 1). Access to the source code is a precondition for this.
3. The freedom to redistribute copies so you can help your neighbour (freedom 2).
4. The freedom to distribute copies of your modified versions to others (freedom 3). By doing this you can give the whole community a chance to benefit from your changes. Access to the source code is a precondition for this.

Later some people though the term Free software was confusing because people interpreted it in the same sense as "freeware" ie software that is free of charge and the term Open Source was proposed as a replacement. Now we hear FOSS (Free and Open Source Software) FLOSS (Free Libre, Open Source Software) as well as just plain Open Source. "Commercial Open Source" has also been invented as it became obvious that the Open Source label was useful branding. If we use the OSI definition of Open Source software, most Commercial Open Source Software is not Open Source as it is often only a subset of the characteristics in the definition.

At this level it is easier for candidates to remember the 4 freedoms in what is a complicated field and these provide a good idea of what it is all about. The main

criticism of Free and Open Source software is that there is no business model to fund development. This is obviously not the case since there are many large open source software projects that are thriving. Selling services around an open source "ecosystem" seems to be the most sustainable. If you like coding, contributing to an Open Source project can convey social status and satisfaction that transcends financial rewards. The internet has made a huge difference because people from all over the world can share collaborative interests and it takes relatively few from the 7 billion to provide the necessary resources. In addition, the whole point of FOSS is to share code so libraries are getting steadily larger and large projects then take relatively little human resource to build and maintain. On the proprietary megalithic model an individual company has to build everything and compete with lots of other also replicating similar effort. The FOSS model is cooperative and shares the resources building on existing resources and is likely to be long term much more efficient as all the previously developed real estate is there to build on. Re-mix is a similar concept and it is no coincidence that big changes are taking place in both the software and content industries.

4.4 I can explain the difference between copyright and license

Candidates should know the nature of what is appropriate to have a copyright assigned to it and how licensing then comes into play.

Evidence: From assessor observation and portfolios

Additional information and guidance
Whenever you create a work such as a book, software, music or video you own the copyright which means you have the right to say who can and can not use the work and in what way. The means of doing this to provide a license. Although there are many ready made licenses the copyright owner can use, they can also make up their own if they want to. A lot of people say copyright free when they mean a copyright work that is licensed for free use. Work in the public domain has no copyright assigned to it. This is the most convenient situation for end users because they can do anything they like with the work without having to make acknowledgements.

4.5 I can explain the terms Creative Commons and DRM

Candidates should be able to explain Creative Commons as a class of licenses and DRM as a way of preventing illegal copying against the terms of a license.

Evidence: From assessor observation and portfolios

Additional information and guidance

Creative Commons is a whole set of licenses that provide different conditions for use of a work. Licenses are designed to enable sharing but with some restrictions such as no commercial. The idea is to enable creative people to share their work on terms they feel is best for them. The term Copyleft is used for licenses that encourage sharing of resources by specifying that work derived from copyleft licensed works has to be licensed with the same terms. This is another example of recursion. It is usual to use Creative Commons licenses for works other than computer software. Licenses such as the GPL GNU Public license are more used for software.

DRM is digital rights management is a class of technologies used with the intent to control the use of digital content, after licenses to use the content have been sold. It is controversial because some people say that the inconvenience to users outweighs the need for the owners of the content to protect it. The reasons it is inconvenient to users is that it prevents them from making backups or using the work on a different device. It also means that the formats used for the content are not generally the normal open ones. In principle all mobile devices could use HTML to display information. We can convert HTML screens to pdf or print them directly should they need to go on paper. Then any ebook could simply be displayed in any web browser on any device. The snag with HTML is that it is an open format that would make DRM difficult if not impossible to implement. DRM goes beyond books and can be used to control video, audio and pretty well any media.

Some people say DRM won't work in any case because it will "get hacked" and once someone knows how to do it that will quickly spread. DRM adds to the complexity of the technology and therefore increases costs. In some cases DRM is probably counter-productive because it puts a barrier to entry in the way of take up. Its arguable that You Tube and Wikipedia would not have taken off if it had DRM forcing users to pay to watch the videos. On the other hand, services like You Tube need revenue to pay for their operation. Advertising is the alternative to charging subscriptions. We are in the middle of a very turbulent shift from a time when just about all content was controlled by large corporate publishing organisations to much greater scope for individuals to do it themselves. An individual might think getting their work seen more important than trying to make a lot of money from it.

Digital technologies enable individuals to be much more self-sufficient and less dependent on large and expensive bureaucratic structures so perhaps the demise of those structures is inevitable or perhaps they will just have to reform. No-one really knows.

L2 Computing
Unit 3 Computer hardware systems and networks

1. Understand computer hardware	2. Understand the role of network servers	3. Understand network design related to performance	4. Contribute to good network safety and security
1.1 describe the function of the main hardware components in computing devices	2.1 describe a server in terms of its functions	3.1 describe network design features	4.1 describe features of a good acceptable use policy
1.2 explain performance criteria for key components	2.2 explain the performance criteria for servers	3.2 explain component choice based on cost and performance	4.2 describe the features of a strong password
1.3 relate computer hardware to computational thinking	2.3 explain backup strategies for servers	3.3 explain how networks communicate to transfer data	4.3 describe a method of data encryption
			4.4 identify examples of unsafe practice on networks

Assessor's guide to interpreting the criteria

General Information

QCF general description for Level 2 qualifications

1. Achievement at QCF level 2 (EQF Level 3) reflects the ability to select and use relevant knowledge, ideas, skills and procedures to complete well-defined tasks and address straightforward problems. It includes taking responsibility for completing tasks and procedures and exercising autonomy and judgement subject to overall direction or guidance.
2. Use understanding of facts, procedures and ideas to complete well-defined tasks and address straightforward problems. Interpret relevant information and ideas. Be aware of the types of information that are relevant to the area of study or work.
3. Standards must be confirmed by a trained Level 2 Assessor or higher

4. Assessors must at a minimum record assessment judgements as entries in the online mark book on the INGOTs.org certification site.
5. Routine evidence of work used for judging assessment outcomes in the candidates' records of their day to day work will be available from their e-portfolios and online work. Assessors should ensure that relevant web pages are available to their Account Manager on request by supply of the URL.
6. When the candidate provides evidence of matching all the criteria to the specification subject to the guidance below, the assessor can request the award using the link on the certification site. The Account Manager will request a random sample of evidence from candidates' work that verifies the assessor's judgement.
7. When the Account Manager is satisfied that the evidence is sufficient to safely make an award, the candidate's success will be confirmed and the unit certificate will be printable from the web site.
8. This unit should take an average level 2 learner 40 guided hours of work to complete.

Assessment Method

Assessors can score each of the criteria N, L, S or H. N indicates no evidence and it is the default setting. L indicates some capability but some help still required to meet the standard. S indicates that the candidate can match the criterion to its required specification in keeping with the overall level descriptor. H indicates performance that goes beyond the expected in at least some aspects. Candidates are required to achieve at least S on all the criteria to achieve the full unit award. Once the candidate has satisfied all the criteria by demonstrating practical competence in realistic contexts they achieve the unit certificate. Candidates that meet the requirements for all units achieve 30 marks and are then eligible to take the grading examination. Grades from the exam are A*, A, B, C.

Expansion of the assessment criteria

1. The candidate will understand computer hardware

1.1 I can describe the function of the main hardware components in computing devices

Candidates should be able to describe the function of the CPU, USB ports, audio and video ports (HDMI), RJ45 network ports, SD Cards, Memory modules, USB memory, hard drive, keyboard, mouse, display for commonly used computer devices.

Evidence: from internal testing and documentation in portfolios.

Additional information and guidance
Candidates should be familiar with commonly used hardware components through hands on use. Raspberry PI, building a PC or taking apart disused machines will all provide appropriate experience. There should be descriptions in the portfolio of the components using diagrams - a good exercise for using a vector drawing program such as Inkscape. Work here can be related to criteria on interoperability, standards and costs of specific components to make it real. A focus on building their own PC could be a worthwhile context http://lifehacker.com/how-to-save-money-when-you-build-your-own-pc-511195742 or making a really objective comparison between Smartphones. If you don't understand what is in them you are not in a strong position to say why one is better than another apart from aesthetics and subjective considerations.

1.2 I can explain performance criteria for key components

Candidates should be able to explain CPU processing power and heat generation/energy consumption, Storage cost/byte and speed of access, data transfer rates as key performance issues.

Evidence from internal testing and portfolios.

Additional information and guidance
Candidates should know that CPU processing speed is complicated! To begin to understand it they need to know the prefixes, Mega - Giga and Tera. Mega is 1 million, Giga 1000 million and Tera a million million or 1000 Giga. They will probably be familiar with terms like Megabytes and Gigabytes. Now they need to know the significance of these prefixes - they need this for their work in science and maths too so talk to colleagues in those departments.

In its simplest form digital processing is done by taking instruction codes and data one at a time and passing them through the CPU. A clock is used to keep this sequence ordered. A program is effectively a set of instructions and associated data that are clicked through the processor in time with the clock. The faster the clock goes the faster the program runs. The first microcomputers ran with clock speeds of about 1 MHz. That is 1 million clicks per second. (1 Hz is one click per second) If an instruction could be processed each clock tick we can then process 1 million instructions per second. So two factors are involved with the speed the processor

can execute the program. The first is how fast the clock can run and the second is how many clock ticks are needed on average for each instruction. For this reason simply comparing the clock speed is not necessarily going to be a fair comparison unless the processors are identical in all other respects (a good illustration of the need for control of variables in fair tests to link to the science curriculum) Why not just make the clock speed higher and higher? Firstly the smaller the component size in the processor the faster the clock speed can be. Small things can generally vibrate faster than large things. Small tuning forks have a higher pitch than large ones because the prongs vibrate faster. As designers have been able to make smaller and smaller components on silicon, they have been able to raise the processor clock speed. Unfortunately higher frequency generates more heat and it gets harder and harder to remove the heat. This heat also has to come from an energy source and while that is easy if it is mains electricity it is a big problem if it is from a battery because the battery will have to be big or it will quickly go flat. This is why completely different and more energy efficient CPU designs are needed in Smartphones compared to desktop computers. Clock speeds now are typically around 3 GHz, around 3000 times as fast as those early microcomputer clocks at 1 MHz.

Clock speed is not the only factor. In the early computers the CPUs were 8 bit. This meant that they could only cope with a 1 byte instruction at a time. Handling any numbers bigger than 255 required at least two clock cycles. Now CPUs are 64 bit so in theory they could hold eight 8 bit instructions all at the same time. In 64 bits in theory 8 times as much could be processed per clock cycle as in an 8 bits so apart from the speed of the clock ticks, the number of bits in the CPU registers matter too. In addition to the number of bits in a single CPU we now have processors with multiple cores. This is like having more than one CPU. 4 cores is currently common with 8 cores becoming more common. This enables processor manufacturers to increase processing power without increasing the clock speed and therefore hitting heat problems. In addition there is a limit to the size of components in the processor itself so we can’t keep making them smaller in silicon forever.

In general purpose devices, raw processing power is a lot less important than it was. In mobile devices power consumption is probably more important. You can’t have a massive processor with a heat sink and fan in a smartphone or slimline tablet.
In summary, all of the following can have an effect on the speed of execution of a program. The CPU clock speed, the bit-width of the registers in the CPU ie 8 bit, 16

bit, 32 bit, 64 bit etc. The number of cores in the CPU, the way the CPU is structured and the design of the software itself.

There is now the issue of storing programs and data before and after it is processed. If we could have storage space that could run at the same clock speed as the processor it would make things relatively simple. In one clock tick the processed data is stored and its job done. Unfortunately any storage capable of running at that speed would be extremely expensive. There is therefore a trade off between capacity and speed. A hard drive can store terabytes of data but in simple terms can only transfer about 1 Gigabit per second. The processor can process 64 bits at a 3 Ghz clock speed. That is about 200 times faster so if the hard drive was directly coupled to the processor the processor would be constantly waiting for the hard drive. (If your desktop computer ever runs out of RAM and starts using the swap file you will see the effect) To get round this problem there are smaller faster (and more expensive) storage steps in between. RAM is where programs are loaded for actual execution then between RAM and the processor are caches which are smaller bits of fast memory to hold parts of programmes that are currently being executed. Writing software loops so they fit entirely in Cache will make the program run much faster and more efficiently. Data is moved between storage devices by buses. A data bus is effectively a set of parallel wires 8, 16, 32, 64, 128 etc bits wide. A 64 bit bus can transfer 8 bytes at the same time so for the same clock speed it would be 8 times as fast as an 8 bit bus. It is easy to see from this that the binary number system that generates the numbers 2,4, 8, 16, 32, 64, 128, 256 etc is of fundamental importance in computer technologies.

The average candidate is not expected to know all of the quantitative details presented here. They should understand the basic principles of trade offs between cost, speed and power consumption. They should be familiar with the names CPU, register, Bus, RAM, Cache, Hard drive, Clock, and the prefixes Kilo, Mega, Giga, Tera used with bits, bytes and Herz.

1.3 I can relate computer hardware to computational thinking

Candidates should be able to relate hardware speeds and capacities to binary numbers, algorithms and abstractions.

Evidence: from internal tests and content of learner portfolios.

Additional information and guidance

Candidates should be able to recognise that for example, memory and bus speeds have capacity patterns related to the numbers 8, 16, 32, 64, 128, 256, 512, 1024. 1k is actually 1024 not 1,000. They should be able to see the link between clock ticks or cycles and processing the instructions in an algorithm. Each iteration will take a number of clock cycles and passing data through the system means synchronising the clocks of the various components. The actual details of the hardware electronics is very, very complicated but we can abstract simplified versions so we can do things without knowing all the details. The program they write has to go through the CPU as 1s and 0s but they only need to deal with an less complex bigger scale system of key words and numbers that are much more what they are used to seeing.

2. The candidate will understand the role of network servers

2.1 I can describe a server in terms of its functions

Candidates should be able to appreciate that servers serve clients with access to centralised resources and information.

Evidence: local testing, portfolios

Additional information and guidance

Candidates should know that there are a wide variety of server services that can be provided to network clients. These range from serving web pages to managing e-mail. The services could be provided by a single machine or they could be spread over many machines. Racks of blade servers are now common. Since servers generally work automatically they don't need individual screens, keyboards, cases, power supplies etc. This reduces costs and space. Peer to peer networks transfer data directly between users and don't need servers although in practice a network can have server(s) and peer to peer functions too. File sharing between peers became very popular with Napster for sharing music but ran foul of copyright law.

2.2 I can explain the performance criteria for servers

Candidates should know that most of the criteria that apply to computers in general also apply to servers. Getting data into and out of servers and running many programs concurrently are of particular relevance to servers.

Evidence: From local testing and portfolios

Additional information and guidance

The main differences between the needs of servers and the needs of a general purpose computer are related to multiple users. In general a server has three key functions for clients. 1. It can host storage for the clients programs and information, eg Drop box on a cloud server or space in Google Drive. 2. It provides shared information or access to shared information eg You tube servers, Wikipedia server. 3. It provides processing services on demand to its users over the network, eg Google search engine, Google Spreadsheet. All of this means in general that servers usually need more storage and more space (RAM) to run programs but there are specialist tasks that will make some aspects more important than others. Another trend is to spread the load over several servers so racks of servers or server blades is a common method for internet servers. For local networks it is more common to find the server as one powerful computer hosting the accounts of many clients with other servers such as mail and web proxy as separate boxes but there is a lot of variation. Cloud computing is growing and it could well be that local servers become increasingly rare. It is a lot less expensive to manage very complex servers centrally rather than having that complexity replicated in every locality. The main limit to this technically is simply getting sufficient bandwidth to run all the services reliably.

The performance criteria for servers depends largely on the use but speed of data in and data out, processing power, RAM and storage are the main considerations. Which of these is the limiting factor depends very much on the particular application. A good exercise for candidates would be to research eg the difference between rack servers and blade servers. There is plenty of scope on the web for material for this.

2.3 I can explain backup strategies for servers

Candidates should be able to explain backup strategies and why they are necessary.

Evidence: From assessor observations and portfolios

Additional information and guidance
Digital information can be lost if the hardware devices fail. Information in RAM is lost as soon as power is switched off. Hard drives and solid state storage such as SDcards can store information without power but they can still be physically destroyed. For this reason information on servers is copied so that if the server fails there is always a backup somewhere else. The snag is that the amount of data is massive and copying it takes time. To copy an entire drive on a desktop computer

can take hours. To copy large server storage shared by perhaps millions of users could take days or more. The fastest way to backup data is to transfer it by the fastest connection possible and that means having it not too far away. Unfortunately backups that are in the same physical place as the original are vulnerable to eg fires or other similar disasters. Any backup strategy has to take into account the risk and the circumstances. Candidates should know:

Full System Backup which saves every file and directory that is stored to the server. Since it takes a while to perform such a sizeable transfer of files, it is generally done on only a weekly or monthly basis. Full backups are the best in data security, as they create a duplicate of the server, which allows the server to be completely restored.

Incremental backup saves only the files that have been changed since the previous backup of your server. This takes considerably less time and requires less space than a full backup. Differential Backup

A differential backup is similar to an incremental backup but saves only the files that have had changes since the last full backup. A differential backup takes longer than an incremental backup and uses more disk space. The same data may be backed up more than once. It does provide a safety net in case a file was somehow missed during a previous backup.

One issue with backups is that a hardware failure would take the system off-line while the hardware was fixed and if a backup had to be restored it would then take a long time to get back up and running. Solutions to this are RAID 5 and 6 where data is distributed across several discs in such a way that if one (or 2 in the case of RAID 6) fail the system slows a little but can carry on until the data is rebuilt across a new replacement disc. Of course if the RAID controller hardware fails all of the discs will stop until that component is fixed. So the ultimate would be to have one or more identical servers so that if one failed the other could carry on. When you have a million servers, distributing multiple copies of data across them and managing it automatically means you can have entire server failures and the system will not be affected. It also means you can remove servers and add new servers and let the system rebuild itself. This is the type of strategy for very large service providers such as Google.

3. The candidate will be able to understand network design related to performance

3.1 I can describe network design features

The candidate should be able to describe some particular design features of networks that make them fit for purpose.

Evidence: Portfolios

Additional information and guidance

Candidates should be able to relate general concepts such as bandwidth, interpreted as capacity for data transfer, to a network design. They should appreciate that if data traffic from hundreds of clients all goes from them to point A and then from point A to point B through a single connection increasing the bandwidth between them and point A might have very little effect. In the best case scenario where they are the only user it will make a difference, but in the worst case where they are sharing the link between point A and B with many others it won't. One of the goals is to achieve transferable concepts and speed and efficiency of data transfer is an important issue in all aspects of digital technologies. It is usually a trade off between speed and cost. Fibre optics has huge capacity but is relatively expensive. Wireless has relatively low capacity but is inexpensive and very flexible. Copper cable is somewhere in between.

Switches and routers are the key components in networks. They channel data to where it needs to go as efficiently as possible. In Ethernet networks (by far the most common local networking system) the aim is to reduce "collisions" between packets of data in the network. A collision is the result of two devices on the same Ethernet network attempting to transmit data at exactly the same time. The network detects the "collision" of the two transmitted packets and discards them both and they have to re-transmit. This can slow the network down, especially bad for things like streaming video where continuity is important.

Distance is another key issue for networks. In local area networks, 100m is a key distance because the UTP copper cable is designed to be an inexpensive way of carrying data that distance. As long as there is a switch between 2 100m runs, everything is ok because switches act as repeaters, repeating the transmission as if it was a new signal. Longer connections can be done with fibre optic cable which can go for miles without needing signal boosting but it is a lot more expensive.

Wireless is increasingly used. It generally supports lower bandwidths and the speed of data transfer depends on distance from the wireless access point. Usually the wireless access point is connected to a switch using UTP cable. With multiple wireless access points on a site with many mobile users it is easy to see how the load could become unbalanced eg by a lot of people connecting to one access point and none connected to another. It is possible to get access points that are intelligent and can optimise connections. For example, although the bandwidth falls away with distance it might be better to connect to an unoccupied access point further away if the nearest one is saturated with connections. Wireless is at the heart of cell phone networks. Typically these connection speeds are much lower than wifi and if available a wifi connection is used in preference. Nevertheless it is perfectly possible to stream video to a cell phone over a 3G connection, it just depends on how far you are from a transmitter and how many other people are using it. Cell phone access points can be tens of miles apart or a a few hundred metres in Cities. It is fairly clear that distance and bandwidth are trade offs for wireless.

Practical networking components are inexpensive. To provide practical networking experience candidates should be given some hands on experience. This can be done inexpensively using older computers or RaspberryPI type machines. Candidates can use the internet to find information and ask questions to get a simple working network. They would need say 1 RaspberryPi to act as the server, an ethernet switch and some UTP cable with one or more Pis as clients. Once they got that working they could try adding eg a wireless access point.

3.2 I can explain component choice based on cost and performance

The candidate should be able to relate component choice to the fitness for purpose rather than simple all out performance since costs can vary a lot.

Evidence: From portfolios.

Additional information and guidance
Candidates are not required to know the cost of specific items but should understand principles that might be best learnt through specific case studies. “Future proofing” is as much a marketing term as it is a useful reason on its own for buying top end equipment. Take simple cable as an example.

Cat 5e £70 - 305m
Cat 6 £112 305m

Cat 6a £283 - 305m

Fibre optic £460 - 250m

A salesman says Fibre optic is future proof use it to connect a room with 40 clients to a 48 port switch 50 metres away.

So we need 2000m of cable.

Do it with CAT 5e and it's 7 reels of cable at a cost of £490
Do it with fibre and it is 6 reels of cable at a cost of £3680

There is also the issue of connectors. Cat 5e uses RJ45 plugs which cost pence each. To convert fibre to a UTP switch connector is about £30 per connection so add 40 x 30 =£1200.

So the fibre optic route is around 10 times more expensive. What would the gain be?

At speeds up to 1 Gb, exactly nothing! Remember your broadband internet connection is probably around 20 Mb so 50 times less than this and it can stream high quality video. Where you need possibly higher than 1 Gb is to connect the server to the whole network and even then UTP cable can be used. The main reason for fibre is distance and going outside. Why outside? Lightning strikes! Copper is a conductor, fibre optic cable isn't. More and more wireless is replacing desktop connections. Why? more flexible and less expensive even though less bandwidth. You can buy a 300 Mbit access point for under £50 then 1 50m UTP connection to your switch which of course then needs only 1 not 48 ports. Question is will one access point be enough for 40 users? On wireless N its 300 Mbits so in principle about 8 per user. Not huge but it really depends on use. If all 40 try to stream video at once it could be a problem but if that video is coming from the internet, probably the server connection to the internet will be unable to cope anyway. If it is intermittent use of 40 users who are mainly doing some web searches, typing some text and reading e-mail it will probably be fine. Since £50 is worth a gamble, try it. If it works you just saved several thousand! You could of course have a few cable connections for those that have particular priority for high bandwidth and the rest on wireless.

It would be a good exercise to get candidates to use the web to research such scenarios and decide what actions to take to get best value. Remember its a

salesman's job to get you to spend as much as possible, its your job to make sure you spend the least needed to get the job done.

3.3 I can explain how networks communicate to transfer data

The candidate should understand the concept of protocols to enable data transfer.

Evidence: From portfolios

Additional information and guidance
Please refer to the Level 1 guidance. TCP/IP is the protocol at the heart of the internet. It stands for transmission control protocol and internet protocol. it is another example of abstraction - a simplification of some very complicated technological details to implement it in the physical world. The TCP/IP protocol is divided into 4 layers

1. Application layer
2. Transport layer
3. Network layer
4. Data link layer

Each of these is an example of an abstraction from the actual technology.

The applications layer has a number of protocols related to it, for example:

1. HTTP (Hypertext transfer protocol)
2. FTP (File transfer protocol)
3. SMTP (Simple mail transfer protocol)
4. SNMP (Simple network management protocol)

HTTP will be most familiar as it is used for web page requests from web servers.

TCP is the key protocol for the transport layer. It divides the data (coming from the application layer) into chunks and then passes these chunks onto the network. It acknowledges received packets, waits for the acknowledgements of the packets it sent and sets time-out to resend the packets if acknowledgements are not received in time.

IP is the key protocol for the network it routes data over the network and between connected networks to get it ot the intended destination.

The data link layer is made up of device drivers in the OS and the network interface card attached to the system. Both the device drivers and the network interface card take care of the communication details with the media being used to transfer the data over the network, cables, wireless etc.

4. The candidate will contribute to good network security and safety

4.1 I can describe features of a good acceptable use policy

The candidate should be able to describe features and say why they are important.

Evidence: From portfolios

Additional information and guidance
An appropriate exercise would be for candidates to research acceptable use policies on the internet and identify common features. Then come to an agreement about which features are essential, which desirable and which not needed and why.

4.2 I can describe the features of a strong password

Candidates should know the characteristics of a strong password and why they make the password strong.

Evidence: From portfolios

Additional information and guidance
See the notes for level 1. At level 2 candidates should be able to relate the characteristics of a strong password to work on binary numbers and the number of possible combinations presented to someone trying to hack in.

4.3 I can describe a method of data encryption

The candidate should be able to describe a simple method of data encryption.

Evidence: Internal testing, portfolios.

Additional information and guidance
Please refer to the level 1 notes. The difference between a Level 2 candidate and a level 1 is that the Level 2 will be able to describe a method whereas at level 1

they are only expected to be able to identify examples having taken part in some encryption activities.

Moderation/verification

The assessor should keep a record of assessment judgements made for each candidate and make notes of any significant issues for any candidate. They must be prepared to enter into dialogue with their Account Manager and provide their assessment records to the Account Manager through the online mark book. They should be prepared to provide evidence as a basis for their judgements through reference to candidate e-portfolios and through signed witness statements associated with the criteria matching marks in the on-line mark book. Before authorizing certification, the Account Manager must be satisfied that the assessors judgements are sound.

4.4 I can identify examples of unsafe practice on networks

Given practical working scenarios, the candidate should be able to identify unsafe practices.

Evidence: from assessor dialogue and portfolios.

Additional information and guidance
Typically the candidate should be able to identify actions such as making their home location or immediate location publicly available is potentially unsafe. They should not take conversations with strangers on a network on face value and they should not arrange to meet anyone they meet through network communications alone. They should use strong passwords and keep passwords secure and understand the implications of identity theft. Illegal activities such as hacking networks can also be considered unsafe practice.

Annexe E – Summary of the units and their assessment.

Level 1

Unit 1 - Computer Science - 5 credits - 40GLH
Unit 2 - Using digital applications to support projects - 5 credits - 40GLH
Unit 3 - Computer hardware systems and networks - 5 Credits - 40 GLH

120 GLH in total for the full certificate. Units can be assessed concurrently or consecutively enabling the school to decide how to organise teaching.

There is a unit certificate available for each unit and all units must be assessed as satisfactory through coursework at level 1 or higher for a level 1 pass and before and exam entry is permitted. The exam will then differentiate pass with merit, pass with distinction and pass with distinction*.

Level 2

Unit 1 - Computer Science - 5 credits - 40GLH
Unit 2 - Using digital applications to support projects - 5 credits - 40GLH
Unit 3 - Computer hardware systems and networks - 5 Credits - 40 GLH

120 GLH in total for the full certificate. Units can be assessed concurrently or consecutively enabling the school to decide how to organise teaching.

There is a unit certificate available for each unit and all units must be assessed as satisfactory through coursework at level 2 or higher before an exam entry is permitted. The exam will then differentiate grades A*, A, B, C.

Annexe F - Useful links and supporting information

The INGOT community learning site www.theINGOTs.org has a wealth of supporting information and practical tools for managing evidence, progress tracking and reporting. These are all free for participating schools. Contact TLM for further details or training if required. We will update and add to supporting materials as time goes on.

The INGOT web site supports multiple languages and it is not very difficult to provide new translations. If you want to teach in the context of a modern foreign language it is possible and we will provide support where we can.

Making the transition from existing qualifications

It is rarely necessary to abandon all of the courseware of existing courses. The flexibility of the TLM approach means that most centres find they can map a great deal of their current learning to the assessment criteria and avoid major upheaval. This means that you can start gently and at more or less any time in the year. All we are interested in is the assessment outcome, the process to get there is up to the Principal Assessor and colleague assessors in the centre. So we can start by using evidence already available or in existing systems and you can decide for yourself how quickly you transition to TLM's evidence management if at all. We are not a software company trying to sell you technology, we are simply providing tools to make administration of our quality assurance service more convenient to users. If you think a different system is better for you, you are free to use it. All we need is ready access to evidence supporting the assessment criteria.

Annexe G - Coursework assessment flowchart