The synthesis of a unified pedagogy for the design and evaluation of e-learning software for high-school computing.

Vol 3 of 3 - Appendices

by

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Appendices document submitted in partial fulfilment for the requirements for the degree of Doctor of Philosophy at the University of Central Lancashire

June / 2019

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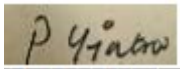
Signature of Candidate 

Type of Award Doctor of Philosophy

School Computing, Engineering and Physical Sciences

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F PHASE2-CYCLE2 PEDAGOGY EVALUATION DOCUMENT

As discussed in section 6.2.1 of the thesis, a pedagogy evaluation feedback document was used in Phase2-Cycle 1, Cycle 2 and Phase 3 to collect feedback from teachers and experts on the e-learning pedagogy. In Phase 2-Cycle 2, the document was updated to version two. For reference, this appendix contains the Phase 2-Cycle 2 version, which was completed by a teacher with over ten years of experience in key stages 3, 4, and 5 computer science, and with additional experience as a moderator for OCR GCSE computing.

Document Name:	GCSE Computer Science E-Learning Pedagogy v1.5	
Document Date:	05/06/2016	
Evaluator Name:	DXXXXXi KrisXXXXXXXXthy	
Evaluator Role:	Education Expert	**Teacher**
Evaluation Date:		
Name of any Other Feedback Documents:		

Appropriateness of heuristics for 15 to 18 years olds (Key Stages 4 & 5)	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
	☐	☐	☐	☐	☑

Feedback Comments:

In my opinion Problem based learning provides more opportunities for exploring and not focusing on just a fixed answer. Make expert and learner thinking processes explicit is the key for KS5 student esp. in relation to accommodate new learning. I feel with higher order thinking is developed more by Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).

Appropriateness of heuristics for Computer Science education	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
	☐	☐	☐	☐	☑

Feedback Comments:

I strongly agree Computer Science education focuses more on Problem based learning and prompt reflective practice to support learning. It is very important to build foundation on Computational thinking before using it. I would like to use Les Brown's (Motivational Speaker) quote that necessity is not the mother of invention refusing to accept things as they are is the mother of invention beautifully summarises why Computer Science seems to have taken more importance in education.

Feasibility of heuristics to be implemented in a High School environment	**Strongly Disagree**	**Disagree**	**Neither Agree nor Disagree**	**Agree**	**Strongly Agree**
	☐	☐	☑	☐	☐

Feedback Comments:

I could evidence that many of the heuristics are already implemented in high school environment. All schools focus on results oriented learning so even though they implement many of the suggested heuristics I think new learning happens only when students carry out projects on their own or practical activities.

There is very little time provided for student- content which deepens learning and this is one of the key area being ignored when considering why progression of students taking computer science from KS4 to KS5 is not 100%.

Student-content in schools refer to revising the content for exam or reaching solutions.

Is there balanced pedagogical coverage? (are there any gaps, weak areas or areas with too much focus)	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	☐	☐	☐	☐	☑

Feedback Comments:

Yes there is a very good balance of different pedagogical approach and in my opinion more focus given to computational thinking and on gamification elements.

The education benefits of each heuristic are clearly described.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	☐	☐	☐	☐	☑

Feedback Comments:

I could clearly see education benefits of each heuristic approach has been clearly explained.

The interrelationships between heuristics are clearly described.	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	☐	☐	☐	☑	☐

Feedback Comments: I agree interrelationships between heuristics are explained in many cases. I find it very interesting to read through the heuristics and evaluate my own teaching style. I have to admit I try to use visual learning style more as this is the way I learn. I employ other forms of learning activities but not sure how many times I have measured the effectiveness of the resources I created.

Are there new heuristics that are not considered in current version of the pedagogy?	Yes	No
	☑	☐

Feedback Comments: Computer Science is a subject where as a student/teacher/programmer I enjoyed correcting mistakes and never gave up. This is covered in pedagogy document briefly but in my opinion I start my every year of teaching by saying you must make mistakes and correct it by yourself.

Mistakes – find why it happens and how to correct it – deeper learning

Alternate solutions -- I can definitely say in my opinion students who tried many ways to solve problems were positively motivated and will be highly confident believer of their skills.

Feedback on structure and readability.

Feedback Comments:

Extremely clear and very well structured. As I have mentioned earlier very detailed description and I have already started to evaluate my teaching. Clear references to the different heuristic technique made it easier for me to look at the different approaches.

Summary Comments:

Feedback Comments:

Truly exceptional research and since I am currently exploring more about computational thinking I personally found this as a very useful addition to my other books and documents on this subject. Thank you for giving me an opportunity to evaluate heuristic approach and I am grateful for this.

G PHASE2-CYCLE1 PEDAGOGY EVALUATION DOCUMENT

As discussed in section 6.2.1 of the thesis, a pedagogy evaluation feedback document was used in Phase2-Cycle 1, Cycle 2 and Phase 3 to collect feedback by teachers and experts on the e-learning pedagogy. For reference, this appendix contains the Phase 2-Cycle 1 version, which was completed by Education Expert 2, an expert in computer science and educational media.

Document Name:	GCSE Computer science e-learning pedagogy (version1.2)	
Document Date:	2/12/2015	
Evaluator Name:	IXXXe PXXXXXXXXu Education Expert 2	
Evaluator Role:	**Education Expert**	Teacher
Evaluation Date:	29/1/2016	
Name of any Other Feedback Documents:	None for the current review	

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Appropriateness of heuristics for 15 to 18 years olds (Key Stages 4 & 5)	☐	☐	☐	☐	x

Feedback Comments:

I find the heuristics identified appropriate for the target age. Students of the ages between 15 and 18 should be able to carry out most of the learning activities identified and suggested. The document appropriately identifies any weaknesses (potential challenges) for cases that may pose some implementation difficulties for the specific age group.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Appropriateness of heuristics for Computer Science education	☐	☐	☐	☐	x

Feedback Comments:

The heuristics are appropriate for Computer Science education (as well as other STEM subjects). Many of the heuristics, especially the ones related to problem solving are important for fields such as computer science where students are expected to develop skills in problem identification, analysis, solution design etc. as well as evaluation skills drawing on supportive evidence. Also, other heuristics are focusing on the development of more generic skills which are of equal importance to computer science, such working under guidance, working as part of a team and as an individual. Some studies have also suggested the multimodal learning can be more effective in areas such computer science, especially the way the material is presented to the students and the blend of the different delivery modes, which is something also taken into consideration in the heuristics.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
Feasibility of heuristics to be implemented in a High School environment	☐	☐	☐	x	☐

Feedback Comments:

Although the majority of the heuristics can be easily implemented in a High School environment, there are a few which may be more challenging. Such challenges are already reported and well documented in the pedagogy document.

Is there balanced pedagogical coverage? (are there any gaps, weak areas or areas with too much focus)	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
	☐	☐	☐	x	☐

Feedback Comments:

The general pedagogical coverage is comprehensive and balanced.

There may be some heuristics which can relate to each other (may be they can become sub-heuristics, e.g. 4, 5 and 6) in terms of pedagogical synergies.

Also, some heuristics, such as heuristic 25, are completely based on other defined heuristics. It seems that these are direct consequences of the other heuristics. Are these necessary to be included even if they are supporting a different pedagogy? Do they add any value to the list of heuristics?

The only section that can be seen as not directly related to learning pedagogies in general is the last one (Computational Thinking). Although computational thinking is important for computer science and it should be considered, it is not clear how it fits with the other sections.

Are there new heuristics that are not considered in current version of pedagogy?	Yes	No
	☐	x

Feedback Comments:

Nothing I can think of.

Feedback on structure and readability.

Feedback Comments:

This version of the pedagogy document is much better than the previous version, with good reading flow and structured organisation. The way each pedagogy is presented (the structure of each section) is beneficial to a novice reader, since they can get familiar with the concepts through the Description, look at the Design Evaluation Criteria and also be informed of the Educational Benefits and Potential Challenges. At the same time, for an expert reader, the document may be too long, providing "unnecessary" information, since the reader will already be familiar with the presented concepts.

With regards to the structure, one minor suggestion will be to look into re-structuring the summary table to provide an easy reference for the reader. I am not sure how it can be done, but it may worth looking into separating the heuristics in categories. Such categories can be for example, "delivery of material" (how the material can be delivered – e.g. collaborative learning), "design of material"

(approaches to be used when designing the material – e.g. PBL), "presentation of material" (e.g. multimodal approach), etc.

Summary Comments:

Feedback Comments:

Overall, the pedagogical heuristics are comprehensive and very well presented/justified.

Some minor general comments:

- In the description of some heuristics there are references to teachers, or e-learning software or both (in most of the cases there is a reference to both). For heuristics that there is a reference only to the teacher, it will be beneficial if the role of the teacher in relation to the e-learning software is clear. For example, if there is a heuristic that only relates to the work of the teacher, how can this be applied to an e-learning software or why this should be considered in an e-learning software? Similarly, in some heuristics (e.g. heuristic 5) information is presented on the learning methodology, but there is no reference to the e-learning software and how the learning methodology relates to it. The inclusion of such heuristics should be justified. Throughout the document, in most of the heuristics, this is done through the implementation tips or potential challenges.
- I believe that heuristic 17 may need re-phrasing (e.g. form a sense of community?)
- I believe that heuristic 22 may need re-phrasing (mainly the second half – "instead of words alone".

H PHASE 3 SURVEY INSTRUMENT

As discussed in section 6.2.4 of the thesis, after each observation study, an online survey was administered to collect student rating and opinion on the e-learning software prototype; this was then used to extrapolate towards the underlying pedagogical heuristics used in the design of the software. In preparation for each phase/cycle, the instrument was refined, based on previous findings and the objectives of the phase/cycle. For reference, the final instrument used in Phase 3 is included in this appendix.

Phase 3 - Student Questionnaire

Dear Student,

Thank you for supporting this research; together we are trying to identify a set of educational guidelines for creating E-Learning software for Computer Science.

Your feedback is critical in order to understand what helps your learning and keeps you interested.

Please take the time to read carefully, think and then respond to the questions in this questionnaire. Your feedback is very important, so please don't rush.

Your feedback is anonymous so be as honest as possible.

If you have any other comments or questions feel free to contact the researcher (Peter Yiatrou) at pyiatrou@uclan.ac.uk

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1. Which browser and browser version did you use to access the E-learning software?

Before you started using the E-Learning software you took a quiz, then after you completed the 4 levels of the E-Learning software you took the same quiz again.

* 2. **During the period between taking the quiz the first time and again the second time, did you use any other learning material on the topic of Algorithms and Computational Thinking, other than the E-Learning software and the websites it links to?**

- ◯ YES
- ◯ NO

3. If you answered yes above, please explain your answer.

4. To what extent do you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A) All things considered, the E-Learning software is easy to use.	◯	◯	◯	◯	◯

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
B) The graphical parts (symbols, logos, diagrams, pictures and illustrations etc.) and design of the E-Learning software is appealing.	○	○	○	○	○
C) The graphical parts (symbols, logos, diagrams, pictures and illustrations etc.) of the E-Learning software are meaningful.	○	○	○	○	○
D) The navigation and program controls of the E-Learning software are logically arranged and consistent.	○	○	○	○	○
E) It is easy to use the navigation and program controls of the E-Learning software.	○	○	○	○	○
F) Sometimes I felt that I didn't quite understand what the E-Learning software was doing.	○	○	○	○	○
G) I found errors (bugs) in the E-Learning software that were difficult to recover from.	○	○	○	○	○
H) The E-Learning software felt speedy and responsive to my interactions.	○	○	○	○	○
I) The E-Learning software gave accurate feedback in response to my interactions.	○	○	○	○	○
J) The E-Learning software is reliable (i.e. does not contain bugs or errors).	○	○	○	○	○
K) The various instructions and prompt messages are understandable.	○	○	○	○	○

5. Please describe any significant usability issues that need attention.

Phase 3 - Student Questionnaire

6. To what extent do you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A) The learning content in the E-Learning software was represented in a clear and understandable way.	○	○	○	○	○
B) The learning content in the E-Learning software prepared me for the quiz questions (assessment activities).	○	○	○	○	○
C) The use of different methods to represent the same learning content helped my understanding.	○	○	○	○	○
D) The practice activities (problem solving) in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
E) The quiz questions (assessment activities) in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
F) The visual material in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
G) The audio material in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
H) The text material in the E-Learning software helped me understand the subject matter.	○	○	○	○	○

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I) The collaborative activities (forum discussions, group or pair work) helped me understand the subject matter.	○	○	○	○	○
J) The "extend your knowledge" learning material in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
K) The videos in the E-Learning software helped me understand the subject matter.	○	○	○	○	○
L) I supplemented, or needed to supplement, the learning material in the E-Learning software with further textbook reading.	○	○	○	○	○
M) I asked, or wanted to ask, my teacher for support in understanding the learning material in the E-Learning software.	○	○	○	○	○
N) After completing the 4 levels of the E-Learning software, I was confident that I would be able to pass a test on it.	○	○	○	○	○

7. Please rank the following educational components with regards to their benefit to your learning.

(1 is the most beneficial and 10 is least beneficial)

- Text
- Audio
- Video
- Extended Knowledge (non examinable material)
- Quizzes
- Games
- Pictures / Photos / Diagrams
- Animations / Simulations
- Collaborative Activities (forum discussions, group or pair work)
- Practice Activities (Problem Solving)

Phase 3 - Student Questionnaire

8. Please evaluate the level of difficulty of the following parts of the E-Learning software.

	Too Easy	A Little Easy	At the right level	A little difficult	Too difficult
A) Overall, at what difficulty level do you believe the learning material represented in the E-Learning software was at?	○	○	○	○	○
B) Overall, at what difficulty level do you believe the practice activities (problem solving) were at?	○	○	○	○	○
C) Overall, at what difficulty level do you believe the quiz questions (assessment activities) were at?	○	○	○	○	○

9. Please rank the following educational components on whether they positively influenced your enthusiasm and interest in Computing.

(1 has the most positive influence and 10 has the least positive influence)

- ⠿ [ ] Text
- ⠿ [ ] Audio
- ⠿ [ ] Video
- ⠿ [ ] Extended Knowledge (non examinable material)
- ⠿ [ ] Quizzes
- ⠿ [ ] Games
- ⠿ [ ] Pictures / Photos / Diagrams
- ⠿ [ ] Animations / Simulations
- ⠿ [ ] Collaborative Activities (forum discussions, group or pair work)
- ⠿ [ ] Practice Activities (Problem Solving)

10. To what extent do you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A) It is more interesting to use the E-Learning software to learn Computing than the textbooks.	○	○	○	○	○
B) I could use the E-Learning software for independent study to learn Computing.	○	○	○	○	○
C) The E-Learning software has increased my overall enthusiasm and interest in Computing.	○	○	○	○	○

Phase 3 - Student Questionnaire

11. Engagement and Motivation (IMMS)
How true are the following statements for you.

	Not True	Slightly True	Moderately True	Mostly True	Very True
A) When I first looked at this lesson, I had the impression that it would be easy for me.	○	○	○	○	○
B) There was something interesting at the beginning of this lesson that got my attention.	○	○	○	○	○
C) This material was more difficult to understand than I would like for it to be.	○	○	○	○	○
D) After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	○	○	○	○	○
E) Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.	○	○	○	○	○
F) It is clear to me how the content of this material is related to things I already know.	○	○	○	○	○
G) Many of the screens had so much information that it was hard to pick out and remember the important points.	○	○	○	○	○
H) These materials are eye-catching.	○	○	○	○	○
I) There were stories, pictures, or examples that showed me how this material could be important to some people.	○	○	○	○	○
J) Completing this lesson successfully was important to me.	○	○	○	○	○

	Not True	Slightly True	Moderately True	Mostly True	Very True
K) The quality of the writing helped to hold my attention.	○	○	○	○	○
L) This lesson is so abstract that it was hard to keep my attention on it.	○	○	○	○	○
M) As I worked on this lesson, I was confident that I could learn the content.	○	○	○	○	○
N) I enjoyed this lesson so much that I would like to know more about this topic.	○	○	○	○	○
O) The screens of this lesson look dry and unappealing.	○	○	○	○	○
P) The content of this material is relevant to my interests.	○	○	○	○	○
Q) The way the information is arranged on the screens helped keep my attention.	○	○	○	○	○
R) There are explanations or examples of how people use the knowledge in this lesson.	○	○	○	○	○
S) The exercises in this lesson were too difficult.	○	○	○	○	○
T) This lesson has things that stimulated my curiosity	○	○	○	○	○
U) I really enjoyed studying this lesson.	○	○	○	○	○
V) The amount of repetition in this lesson caused me to get bored sometimes.	○	○	○	○	○
W) The content and style of writing in this lesson convey the impression that its content is worth knowing.	○	○	○	○	○

	Not True	Slightly True	Moderately True	Mostly True	Very True
X) I learned some things that were surprising or unexpected.	○	○	○	○	○
Y) After working on this lesson for a while, I was confident that I would be able to pass a test on it.	○	○	○	○	○
Z) This lesson was not relevant to my needs because I already knew most of it.	○	○	○	○	○
A.1) The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	○	○	○	○	○
B.1) The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.	○	○	○	○	○
C.1) The style of writing is boring.	○	○	○	○	○
D.1) I could relate the content of this lesson to things I have seen, done, or thought about in my own life.	○	○	○	○	○
E.1) There are so many words on each screen that it is irritating.	○	○	○	○	○
F.1) It felt good to successfully complete this lesson.	○	○	○	○	○
G.1) The content of this lesson will be useful to me.	○	○	○	○	○
H.1) I could not really understand quite a bit of the material in this lesson.	○	○	○	○	○
I.1) The good organization of the content helped me be confident that I would learn this material.	○	○	○	○	○
J.1) It was a pleasure to work on such a well-designed lesson.	○	○	○	○	○

Phase 3 - Student Questionnaire

12. To what extent do you agree or disagree with the following statements.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
A) Overall, the E-Learning software was difficult to use.	○	○	○	○	○
B) The use of different methods to represent the same learning content made me feel overloaded.	○	○	○	○	○
C) After completing the 4 levels of the E-Learning software, my understanding of the subject matter had not improved.	○	○	○	○	○

13. The frequency I use the Internet and the Web to support my learning of the Computing subject is:

	Never	Less than Once a Month	Monthly	Weekly	Daily	Several times per day
The frequency I use the Internet and the Web to support my learning of the Computing subject is:	○	○	○	○	○	○

14. Please explain your above answer

15. To what extent do you agree or disagree with the following statement.

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
I would prefer using the Internet and the Web to support my learning of the computing subject, rather than this E-Learning software.	○	○	○	○	○

16. Please explain your above answer

17. The frequency I use other E-Learning software to support my learning of the Computing subject is:

	Never	Less than Once a Month	Monthly	Weekly	Daily	Several times per day
The frequency I use other E-Learning software to support my learning of the Computing subject is:	○	○	○	○	○	○

18. Please explain your above answer

19. Describe briefly in your own words what you like and dislike about this E-Learning software.

I VARK SURVEY INSTRUMENT

As discussed in section 2.4.7 and 6.2.3 of the thesis, with regards VARK learning styles, the student's preferred learning style(s) are identified by a short multiple-choice questionnaire that places them in several situations within their experience and asks them to specify their preferred action(s); this in turn indicates their favoured modal preference(s) (V, A, R, K). For each question, the respondent can select one or more options, or can even omit questions where they find no suitable option. The same questionnaire was used throughout the research study and is listed for reference in this appendix.

http://vark-learn.com/the-vark-questionnaire/the-vark-questionnaire-for-younger-people/

Accessed 10/03/2015

VARK Questionnaire version 7.1

This questionnaire helps identify if you have any preference in the way educational material is communicated to you.

Choose the answer which best explains your preference and click the box next to it. Please click more than one if a single answer does not match your perception. Leave blank any question that does not apply.

You are about to hook up your parent's new computer. You would:

- ☐ phone, text or email a friend and ask how to do it.
- ☐ unpack the box and start putting the pieces together.
- ☐ read the instructions that came with it.
- ☐ follow the diagrams that show how it is done.

A
K
R/W
V

You are going to make something special for your family. You would:

- ☐ find written instructions to make it.
- ☐ decide from pictures in magazines.
- ☐ talk it over with my friends.
- ☐ make something I have made before.

R/W
V
A
K

You want to plan a surprise party for a friend. You would:

- ☐ invite friends and just let it happen.
- ☐ make lists of what to do and what to buy for the party.
- ☐ draw a map and make a special design for the invitation.

- [ ] talk about it on the phone or text others.

K
R/W
V
A

A new movie has arrived in town. What would most influence your decision to go (or not go)?

- [ ] you read what others say about it online or in a magazine.
- [ ] hear friends talking about it.
- [ ] you see a preview of it.
- [ ] it is similar to others you have liked.

R/W
A
V
K

You need to give directions to go to a house nearby. You would:

- [ ] walk with them.
- [ ] draw a map on a piece of paper or get a map online.
- [ ] write down the directions as a list.
- [ ] tell them the directions.

K
V
R/W
A

Do you prefer a teacher who likes to use:

- [ ] class discussions, online discussion, online chat and guest speakers.
- [ ] a textbook and plenty of handouts.
- [ ] field trips, case studies, videos, labs and hands-on practical sessions.
- [ ] an overview diagram, charts, labelled diagrams and maps.

A
R/W
K
V

A website has a video showing how to make a special graph. There is a person speaking, some lists and words describing what to do and some diagrams. You would learn most from:

- [ ] seeing the diagrams.
- [ ] reading the words.

- ☐ listening.
- ☐ watching the actions.

V
R/W
A
K

You have to present your ideas to your class. You would:

- ☐ gather examples and stories to make it real and practical.
- ☐ make diagrams or get graphs to help explain my ideas.s to help explain your ideas.
- ☐ write out my speech and learn it by reading it again and again.
- ☐ write a few key words and say them again an again.

K
V
R/W
A

You are learning to take photos with your new digital camera or mobile phone. You would like to have:

- ☐ a chance to ask questions and talk about the camera's features.
- ☐ clear written instructions with lists and bullet points.
- ☐ examples of good and poor photos and how to improve them.
- ☐ diagrams showing the camera and how to use it.

A
R/W
K
V

You have a problem with your knee. Would you prefer that the doctor:

- ☐ gave you an article or brochure that explained knee injuries.
- ☐ showed you a diagram of what was wrong.
- ☐ described to you what was wrong.
- ☐ demonstrated what was wrong using a model of a knee.

R/W
V
A
K

You want some feedback about an event, competition or test. You would like to have feedback:

- [ ] that used examples of what I have done
- [ ] that used a written description or table of my results.
- [ ] from somebody who discussed it with me.
- [ ] that used graphs showing what I achieved.

K
R/W
A
V

I like websites that have:

- [ ] things I can click on and do.
- [ ] audio channels for music, chat and discussion.
- [ ] interesting design and visual effects.
- [ ] interesting information and articles in print.

K
A
V
R/W

Remember when you learned how to play a new computer or board game. You learned best by:

- [ ] clues from the diagrams in the instructions.
- [ ] listening to somebody explaining it and asking questions.
- [ ] watching others do it first.
- [ ] reading the instructions.

V
A
K
R/W

You are about to buy a new digital camera or mobile phone. Other than price, what would most influence your decision?

- [ ] the salesperson telling me about it.
- [ ] trying it.
- [ ] reading the details about its features.
- [ ] it is the latest design and looks good.

A
K
R/W

V

You have been selected as a tutor or a leader for a holiday program. This is interesting for your friends. You would:

- ☐ describe the activities I will be doing in the program.
- ☐ show them the map of where it will be held and diagrams about it.
- ☐ show them the list of activities in the program.
- ☐ start practising the activities I will be doing in the program.

A
V
R/W
K

After reading a play you need to do a project. Would you prefer to:

- ☐ draw or sketch something that happened in the play?
- ☐ read a speech from the play?
- ☐ act out a scene from the play?
- ☐ write about the play?

V
A
K
R/W

J PHASE 3 PRE-, POST-TEST AND MARKING SCHEME

As discussed in section 6.2.6 of the thesis, the pre-, post-test was developed to accurately measure student learning performance in relation to usage of the e-learning software prototype. The test is based on specimen exam papers from Paper 2: Application of computational thinking, of the new Computer Science GCSEs. The exam questions were taken from the following examination boards: EDEXCEL, OCR and AQA. For reference, the pre-, post-test and marking scheme are contained in this appendix.

Student Name:…….. **RESEARCH ID……..**

GCSE Computer Science

Computational Thinking and Algorithms Quiz

Time allowed: 35 minutes

Date: ……

Instructions

- Use black ink or black ball point pen. Use pencil only for drawing.
- Answer all questions.
- You must answer the questions in the spaces provided.
- If you make a mistake cross through the incorrect answer.
- Do all rough work in this book. Cross through any work that you do not want to be marked.
- You are free to answer questions that require a coded solution in whatever format you prefer as long as your meaning is clear and unambiguous.
- You must not use a calculator.

Information

- The marks for questions are shown in brackets.
- The maximum mark for this paper is 31.
- You are reminded of the need for good English and clear presentation in your answers.

Q1 (OCR – J276-02)

The area of a circle is calculated using the formula $\pi \times r^2$, where π is equal to 3.142 and r is the radius.

Finn has written a program to allow a user to enter the radius of a circle as a whole number, between 1 and 30, and output the area of the circle.

```
01      INTEGER radius
02      REAL area
03      SET radius TO 0
04      SET area TO 0.0
05      RECEIVE radius FROM (INTEGER) KEYBOARD
06      IF radius < 1 OR radius > 30 THEN
07          SEND 'Sorry that radius is invalid' TO DISPLAY
08      ELSE
09          SET area TO 3.142 * (radius ^ 2)
10          SEND area TO DISPLAY
11      END IF
```

(a) Identify **two** variables used in the program.

.....

.....[2]

(b) Identify **one** item in the program that could have been written as a constant.

.....[1]

(c) Give **one** reason why you have identified this item as a constant.

.....[1]

Q1 (OCR – J276-02) - ANSWER

b		• radius • area	**2** **(AO1 1b)**	
c	**i**	• 3.142 • 2 • 1 • 30	**1** **(AO2 1a)**	Maximum of 1 mark
c	**ii**	• The number does not need to be changed while the program is running • The number can be updated once and it updates throughout	**1** **(AO1 1a)**	Maximum of 1 mark

Draft

Q2 (AQA-85201-SQP)

```
FUNCTION TotalOut(a, b)
BEGIN FUNCTION
    SET c TO a + b
    WHILE (a < c) DO
            SET a TO a + 1
            SET b TO b - a
    END WHILE
    RETURN b
END FUNCTION
```

(a) Complete the trace table below when the function call `TotalOut(3, 4)` is made (you may not need to use all of the rows in the table):

a	b	c

[4]

(b) What value is returned by the subroutine call `TotalOut(3, 4)`?

.....[1]

(c) What value is returned by the subroutine call `TotalOut(x, 0)` where `x` is any positive integer?

.....[1]

Q2 (AQA-85201-SQP) ANSWER

02	1	**4 marks for AO2 (apply)** **Mark as follows:** **1 mark** for a always incrementing by 1 (at least twice); **1 mark** for a starting at 3 and ending at 7; **1 mark** for b starting at 4 and ending at -18; **1 mark** for c starting at 7 and not changing; The completed trace table should have these values although the candidate may have entered the values on different rows (do not penalise as long as the order of the values is correct). a | b | c 3 | 4 | 7 4 | 0 | 5 | -5 | 6 | -11 | 7 | -18 | | |	4

02	2	**Mark is for AO2 (apply)** -18; Follow on for the last value of b given in the trace table in (1a). R. b	1

02	3	**Mark is for AO2 (apply)** 0;	1

Q3 (AQA-85201-SQP)

A programmer is developing a website that allows users to upload small bitmap images. They want to create a subroutine that checks if an image is greater than the allowed upload size of 16,000 bits (ignoring metadata), based on its width, height and colour depth.

Develop a subroutine, using either pseudo-code or a flowchart, which checks if an image is greater than the allowed upload size of 16,000 bits. Your subroutine should:

- have the name Checker
- return true if the image file size is acceptable and false otherwise.
- have three parameters that are the image's width, height and colour_depth, all in bits.

.....

.....

.....

.....

.....

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.....

.....

.....

.....

.....

.....

.....

.....[6]

Q3 (AQA-85201-SQP) - ANSWER

	2 marks for AO2 (apply) **4 marks for AO3 (2 marks design, 2 marks program)** **Mark as follows:** **1 mark (AO2)** for clearly calling the subroutine `Checker` (**I.** spelling errors); **1 mark (AO2)** for including in the subroutine signature/interface the parameters `width`, `height` and `colour_depth` (different parameter names are allowed but must obviously refer to these values); **1 mark (AO3)** for multiplying the three input parameters together (the answer does not necessarily have to be stored in a variable);
	1 mark (AO3) for using an `IF-ELSE` statement (**A.** alternative correct logic such as two `IF` statements); **1 mark (AO3)** for checking that the product of the input is less than or equal to 16,000 (**R.** just less than **A.** alternative correct logic such as > 16,000); **1 mark (AO3)** for returning true and false in different parts of the `IF-ELSE` (**A.** the condition is incorrect);

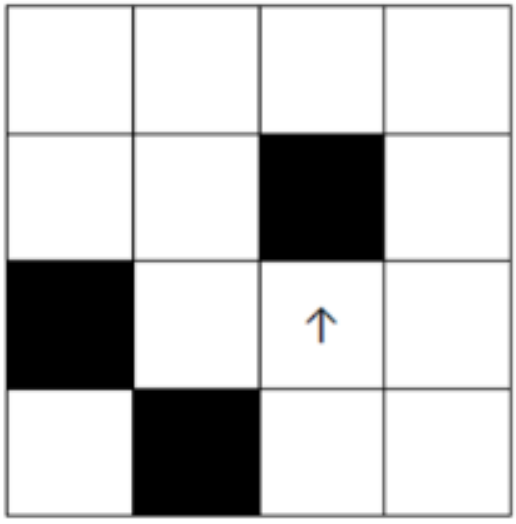
Q4 (AQA-85201-SQP)

Four separate subroutines have been written to control a robot.

- `Forward(n)` moves the robot **n** squares forward.
- `TurnLeft()` turns the robot 90 degrees left
- `TurnRight()` turns the robot 90 degrees right
- `ObjectAhead()` returns `true` if the robot is facing an object in the next square or returns `false` if this square is empty.

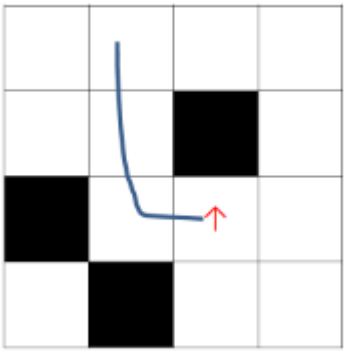
Draw the path of the robot through the grid below if the following program is executed (the robot starts in the square marked by the ↑ facing in the direction of the arrow). If a square is black then it contains an object.

```
WHILE ObjectAhead() = true
  TurnLeft()
    IF ObjectAhead() = true THEN
      TurnRight()
      TurnRight()
    ENDIF
  Forward(1)
ENDWHILE
Forward(1)
```



[3]

Q4 (AQA-85201-SQP) - ANSWER



Q5 (EDEXCEL 2016_1CP1_02_Specimen_Paper)

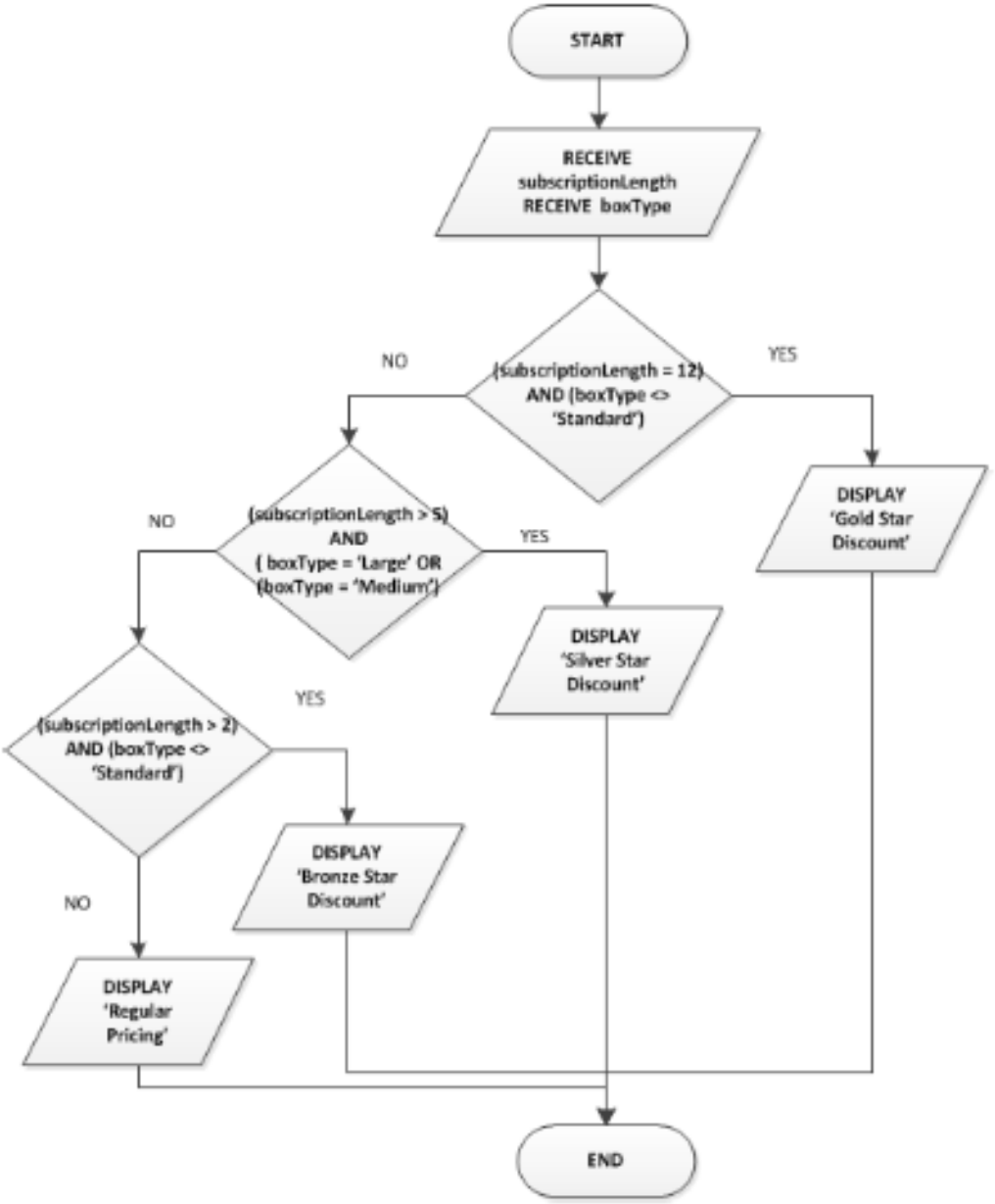
Scenario – The HappyPetBox Company

The HappyPetBox Company sells boxes for cats and dogs. The boxes contain healthy treats, toys, supplements, and grooming products.

The boxes are supplied monthly and are purchased online by subscription. The subscriptions are for one, three, six or 12 months.

There are four types of box: cat; and standard, medium and large for dogs.

The HappyPetBox Company offers discounts based on the type of box ordered and the length of the subscription selected.



(a) Complete the table to show the output of the discount algorithm, based on the given inputs.

(3)

Input		Discount
subscriptionLen	boxType	
12	Standard	
6	Large	
1	Medium	

(b) The algorithm needs to be tested thoroughly.

Complete the table to show boundary test data to meet the requirements.

(3)

Requirements	Input	
	subscriptionLen	boxType
A condition generating a bronze star discount		
Smallest subscription qualifying for a gold star discount		
Largest subscription qualifying for no discount		

Question Number	Answer	Additional Guidance	Mark
2(a)			**3**

Input		Discount
subscriptionLen	boxType	
12	Standard	Regular pricing / none (1)
6	Large	Silver star (1)
1	Medium	Regular pricing / none (1)

Question Number	Answer	Additional Guidance	Mark
2(b)	One mark for each correct row:	• Question asks for boundary conditions only.	**3**

Requirements	Input	
	subscription Len	boxType
A condition generating a bronze star discount	3 / 5	Medium
Smallest subscription qualifying for a gold star discount	12	Medium
Largest subscription qualifying for no discount	5	Standard

Q6 (EDEXCEL 2016_1CP1_02_Specimen_Paper)

The HappyPetBox Company uses a software application to calculate staff wages and produce payslips. Sample input data for this system is shown.

National insurance (NI) number	Standard format LL123456L
Full time	Y or N Full-time = maximum of 40 hours per week Part-time = maximum of 20 hours per week
Hours worked	Integer Hours worked in current week Maximum of 10 hours overtime in one week for full-time only
Pay rate	Real Hourly pay rate

(a) The input data needs to be validated.

(i) Complete the validation rules in the pseudo-code.

Write your answers in the boxes provided.

(6)

```
# Validate NI number
STRING NInumber
INTEGER hoursWorked
CHARACTER fullTime

# Validate National Insurance number
IF LENGTH (NInumber) [          ] THEN

    SEND "Error message" TO DISPLAY
END IF

# Validate hours worked this week
IF hoursWorked < 0 [          ] THEN

    SEND "Error message" TO DISPLAY
END IF

# Validate part-time worker's hours
IF fullTime = 'N' [          ] THEN

    SEND "Error message" TO DISPLAY
END IF
```

Question Number	Answer	Additional Guidance	Mark
6(a)(i)	3 # Validate NI number 4 STRING NInumber 5 INTEGER hoursWorked 6 CHARACTER fullTime 7 8 # Validate National Insurance number 9 IF LENGTH (NInumber) <> 9 THEN 10 11 SEND "Error message" TO DISPLAY 12 END IF 13 14 # validate hours worked this week 15 IF hoursWorked < 0 OR hoursWorked > 40 THEN 16 17 SEND "Error message" TO DISPLAY 18 END IF 19 20 # Validate part-time worker's hours 21 IF fullTime = 'N' AND hoursWorked > 20 THEN 22 23 SEND "Error message" TO DISPLAY 24 END IF		6

K PHASE 3 TECHNICAL SPECIFICATION

As discussed in section 6.2.5 of the thesis, during each observation study the students' accessed the e-learning software and the collaborative learning environment. Although both are cloud-based, there remain some technical pre-requisites and checks that need to be carried out in the schools' computer labs by the admin staff, and by the students before home use. These pre-requisites and technical checks were documented in the technical specification document which was tailored towards the objectives and technical requirements of each phase and cycle. For reference, the technical specification document for Phase 3 is included in this appendix.

Phase 3 Technical Environment Specification and Preparatory Steps

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1 DOCUMENT DETAILS

1.1 Document Version

Version	Date	Changes
0.1	20/11/2016	Phase 3 Technical specification is based on v0.6 of the Phase2-Cycle 1 specification and Phase 2-Cycle 2 Technical specification v0.2.

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3 INTRODUCTION

The E-Learning software and Collaborative Learning Environment (Google Apps for Education) used in Phase 3 are cloud based and will be accessed via a web browser. You will access both from your home and from the School's Computer lab. This document describes the necessary environment setup for both School and home. The setup at School be carried out by the ICT Administration team, **you are requested to check your home computer.**

4 CLOUD BASED E-LEARNING SOFTWARE

The E-Learning software is based on a number of cloud based applications:

Software Type	Chosen Software	URL
E-Learning Software	Hosted on SCORM Cloud	https://cloud.scorm.com/
Collaborative Learning Environment	Google Apps for Education	https://accounts.google.com/ https://mail.google.com https://classroom.google.com https://drive.google.com/ http://www.google.com
Visual Programming	Pencilcode	http://pencilcode.net/edit/new
Questionnaire Distribution	SurveyMonkey	https://www.surveymonkey.com/

Table 1: Cloud Based software used by the E-Learning Software.

4.1 Internet and Network Connectivity

Since this is cloud based software, internet connectivity is necessary.

If working with the software from home, you will need a broadband internet connection and if working from a wireless access point a strong and stable connection. If multiple students are accessing the software simultaneously from a Computer Lab, then a wired network is preferred with high capacity broadband.

4.2 Supported Web Browsers

1. Microsoft Internet Explorer 11 (11.0.9600.17843) (Preferred browser)
2. Mozilla Firefox (43.0.4)
3. Google Chrome (Version 51.0.2704.84 m)

In case you do not have either of these browsers installed you can download the latest version from the below links.

http://windows.microsoft.com/en-us/internet-explorer/download-ie

https://www.mozilla.org/en-US/firefox/new/

https://www.google.com/chrome/browser/desktop/

IMPORTANT: Microsoft Edge is not supported. The E-Learning software will not work correctly in this browser.

In the supported browsers, Popups should be enabled for the websites listed in Table 1, or manually allowed when the browser requests.

4.3 Flash

The E-Learning Screens require Adobe Flash, therefore ensure that Flash is installed and enabled on the web browser. In case you do not have Adobe Flash installed you can download the latest version from the below link.

https://get.adobe.com/flashplayer/

4.4 Research Email Accounts

You will be allocated an email account from google with the following domain **@research.uclancyprus.ac.cy**. This email account will be used to communicate with you regards the research and will be used to send you links to online surveys and the E-Learning software.

4.4.1 Accessing to the E-Learning Software

To launch the E-Learning software access your google research email account and find the email similar to the below (Subject: Level 3 Orange Flowcharts V0.3):

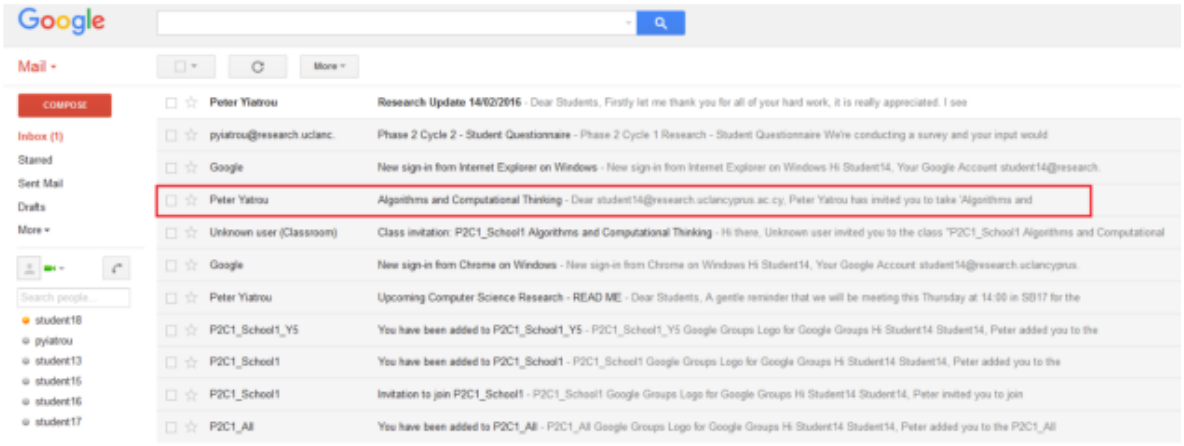


Figure 1: Email to access the E-Learning software.

Click on "Play Course" to launch the E-Learning Software.

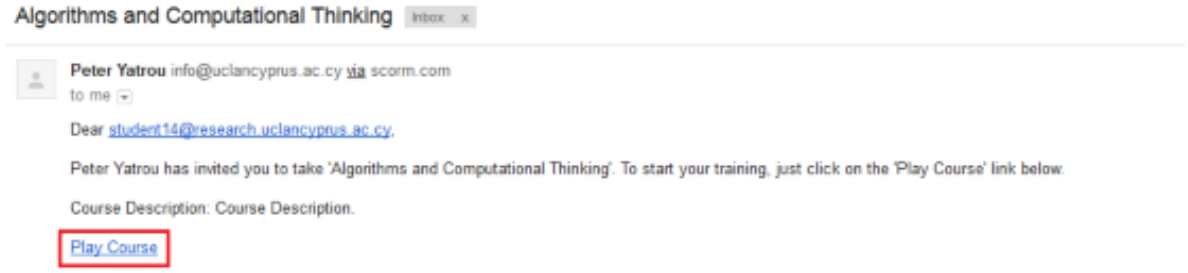


Figure 2: Link to launch E-Learning software.

6

5 COLLABORATIVE LEARNING ENVIRONMENT

Google Apps for Education is used as the Collaborative Learning Environment; it can be accessed from the google login.

https://accounts.google.com/

The collaborative tools can be accessed from your email:

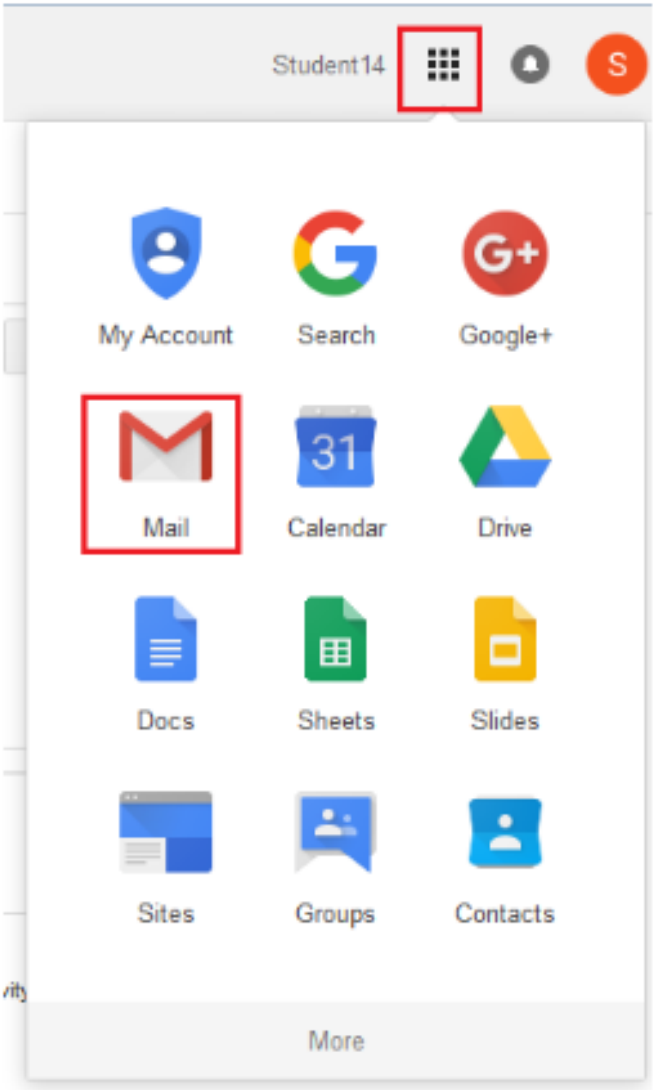


Figure 3: Accessing your Email and Collaborative tools.

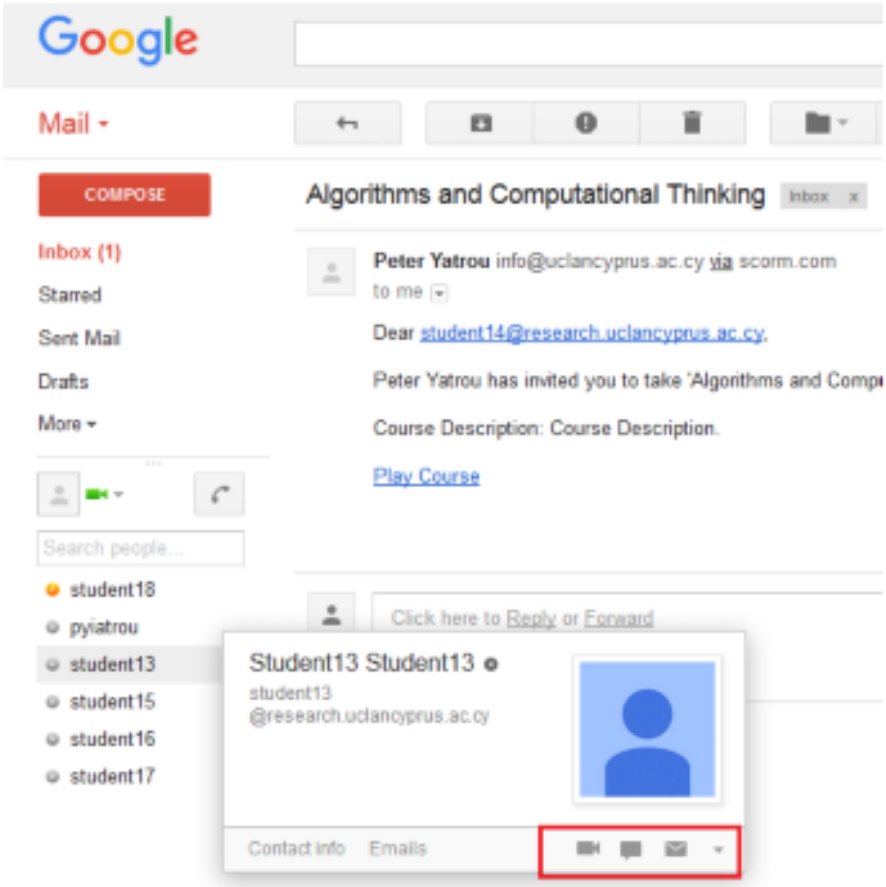


Figure 4: Accessing voice, video and chat tools.

You can then select one of your Contacts to chat, talk or video conference with.

5.1 Additional Hardware Requirements for Collaborative Learning

- Microphone
- Speakers
- Headphones
- Web Cam.

5.2 Additional Steps needed to setup the collaborative tools

The collaborative tools mentioned previously need to installed and given security access to run. To enable these tools please download and install the following plugin.

https://www.google.com/tools/dlpage/hangoutplugin

You may need to take additional steps in your browser to allow the plugin. Please see the below example from Firefox.

Please note you may need to repeat this step multiple times for the browser to remember the configuration change.

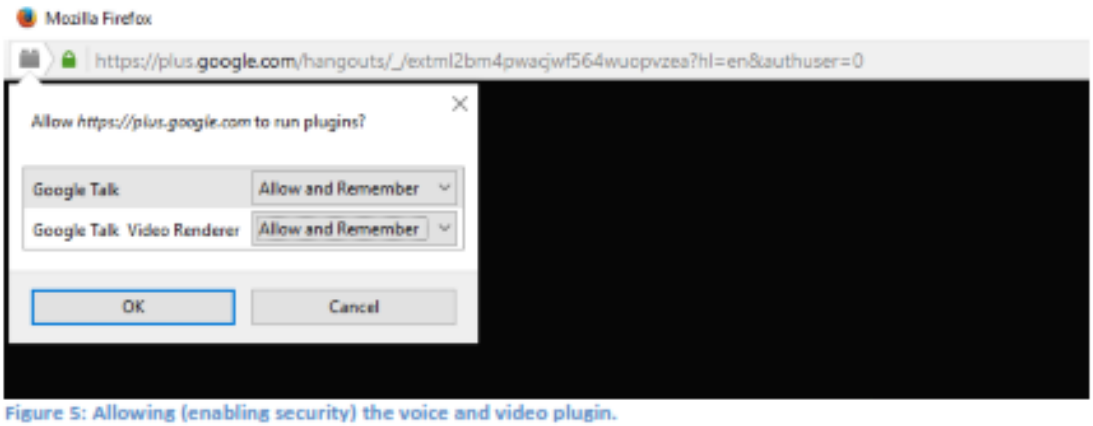
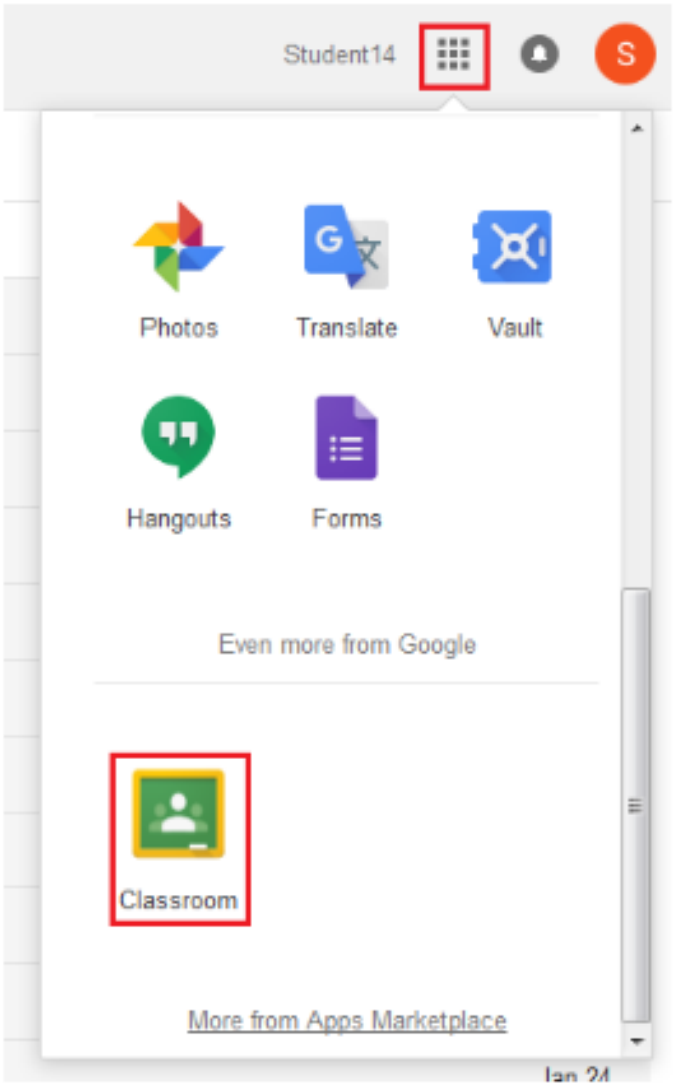


Figure 5: Allowing (enabling security) the voice and video plugin.

5.3 Accessing the Classroom and the Assignments

You can access the classroom and the assignments by clicking on the apps icon, then scrolling down to the Classroom.



You then click on the classroom to access the assignments.

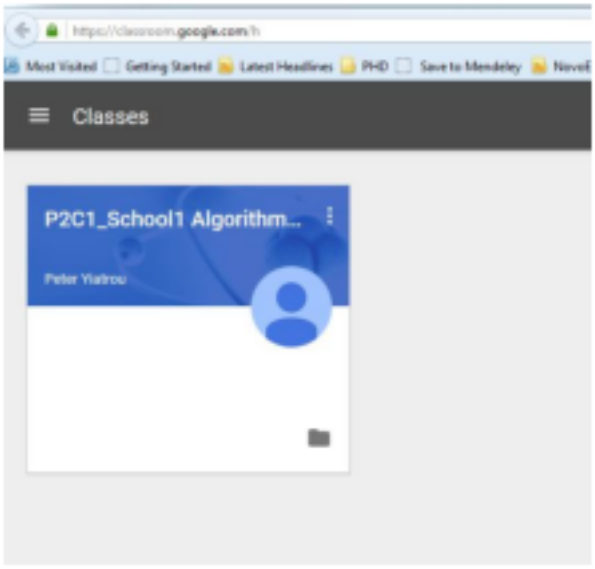


Figure 6: The Classroom, where your assignments are.

Click on each assignment to work on it.

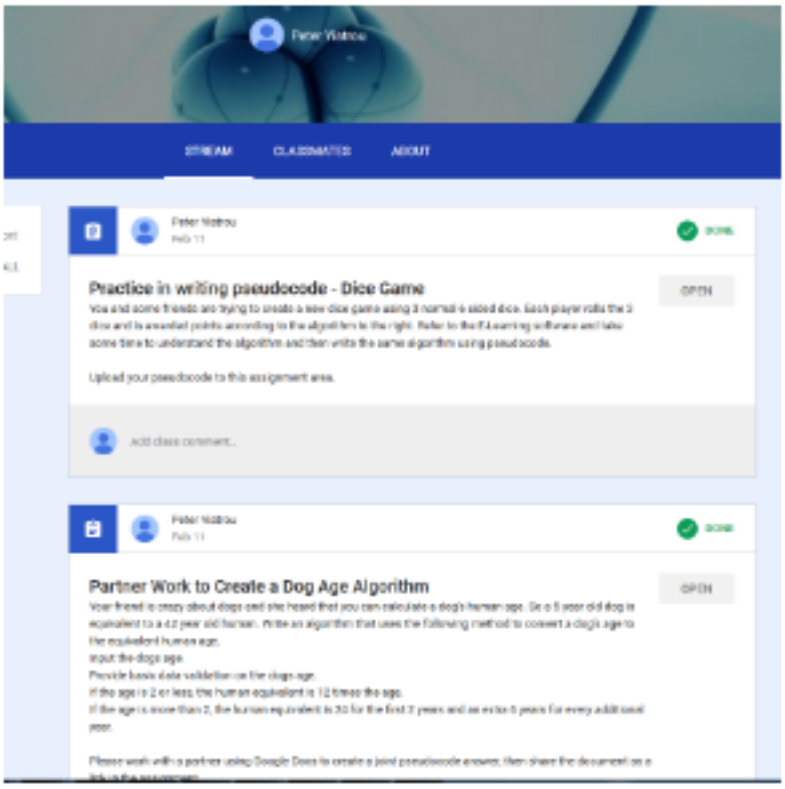


Figure 7: Accessing your assignments.

These assignments can also be accessed by clicking on the links within the assignment emails sent to your email address.

5.4 Forum Question

There are some forum based questions; this can be accessed from the apps and then clicking on Groups.

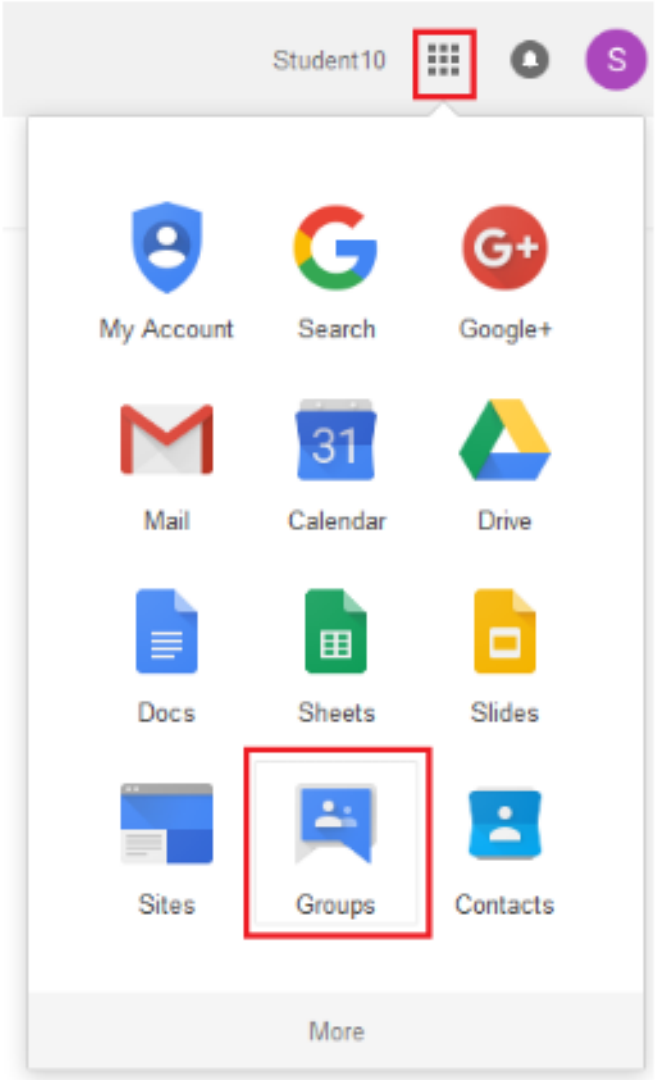


Figure 8: Groups are where forum questions can be found.

Then Navigate to MyGroups -> P3_All

6 ADDITIONAL WEBSITES

The following websites are linked to by the E-Learning software. They should be accessible from your web browser.

- http://edition.cnn.com/2011/TECH/web/04/25/amazon.price.algorithm/
- http://www.csmonitor.com/Business/Saving-Money/2013/1104/Everything-you-need-to-know-about-dynamic-pricing
- http://www.investopedia.com/articles/active-trading/101014/basics-algorithmic-trading-concepts-and-examples.asp
- http://www.wired.com/2013/08/qq_netflix-algorithm/
- http://www.huffingtonpost.com/2013/08/07/netflix-movie-suggestions_n_3720218.html
- http://www.google.com/insidesearch/howsearchworks/algorithms.html
- http://www.technologyreview.com/view/528836/forget-the-shortest-route-across-a-city-new-algorithm-finds-the-most-beautiful/
- http://www.accuweather.com/en/weather-blogs/weathermatrix/why-are-the-models-so-inaccurate/18097
- http://cb.cornell.edu/
- http://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/computational-chemistry.html
- http://www.acs.org/content/acs/en/careers/college-to-career/chemistry-careers/computational-chemistry.html
- http://www.theguardian.com/technology/2013/mar/02/amazon-withdraws-rape-slogan-shirt
- http://money.cnn.com/2013/03/05/smallbusiness/keep-calm-and-carry-on/
- http://visualgo.net/sorting.html
- https://www.youtube.com/
- http://www.bbc.co.uk/schools/gcsebitesize/maths/number/orderoperationrev1.shtml

7 KNOWN BUGS

- When clicking on a button to show a dialog (such as the hint or the Computational Thinking buttons), sometimes it may require to click more than once.
- Sometimes the audio for a dialog box does not play to the end. Clicking on the button again will resolve this.

- To access the acknowledgements screen, you need to click the next button multiple times.
- **Tip** if you are thrown out of the E-learning software for any reason, close that browser window, then open a new browser instance and go to the link to the E-Learning software. You will resume the E-learning software from the last slide.

L PHASE 3 RESEARCH PROTOCOL CONFIRMATION DOCUMENT

As discussed in section 6.2.7 of the thesis, since the Phase 3 study was executed in two schools with three teachers, it was essential to ensure each teacher and group followed the same detailed procedures, thereby safeguarding reliability and validity. A Phase 3 research protocol confirmation document was distributed to the teachers ahead of the study, which documented the steps and activities to be followed during the study. The document acted as a checklist for the teachers to confirm they followed the procedures, and to document any potential events or disruptions that could have affected study results. For reference, a completed research protocol confirmation document is included in this appendix.

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RPC V0.1 22 January 2018

The synthesis of a unified pedagogy for the design and evaluation of E-Learning software for high-school computing.

Phase 3 Research Protocol Confirmation

Researcher: Peter Yiatrou

Purpose: This document is a checklist of the steps and activities carried out by teachers during the school based research study. It documents which steps and activities from the research protocol have been followed to ensure uniformity between participating schools and identify any potential events or disruptions that could affect research reliability and validity. Please respond openly and honestly.

ID	Activity	Completion	Date	Additional Comment
1	Provide scans of head teacher and teacher consent forms.	YES☒ NO ☐		
2	Provide scans of parent and student consent forms.	YES☒ NO ☐		
3	Return Participant excel with requested information.	YES☒ NO ☐		
4	Confirm the appropriateness of the Phase 3 Quiz (Phase 3 Quiz V0.3).	YES☒ NO ☐		
5	Using the Technical checklist document (Phase 3 Technical Specification V0.1), check the School's computer lab.	YES☒ NO ☐		
6	Provide Technical checklist document (Phase 3 Technical Specification V0.1) to students to make sure they can use the software and collaborative environment for homework.	YES☒ NO ☐		

To be signed in duplicate: 1 copy for Teacher and 1 copy for the researcher.

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ID	Activity	Completion	Date	Additional Comment
7	Walk through with the students the Quick Tips v0.1 Tutorial to familiarise them with the e-learning environment	YES☒ NO ☐		
8	Supervise Phase 3 Quiz V0.3 under exam conditions as **pre-test.** (i.e. Before students use the e-learning software)	YES☒ NO ☐		Please outline any challenges or disruption during the supervision of the quiz as a pre-test.
8.1	Mark the Phase 3 Quiz V0.3 according to Phase3 Quiz Marking Scheme V0.1.	YES☒ NO ☐		Please check Yes, if you took on the role as marker and the researcher the role of moderator.
8.2	Moderate the Phase 3 Quiz V0.3 according to Phase3 Quiz Marking Scheme V0.1.	YES☒ NO ☐		Please check Yes, if the researcher took on the role as marker and you took the role of moderator.
8.3	Provide scans of completed pre-test quiz papers.	YES☒ NO ☐		
9	Using the below table please provide a high-level breakdown of how you incorporated the e-learning software into lesson time and homework.			

Class Session	Date	Duration (minutes)	High-Level Lesson Plan (Research activity, Learning focus, homework set, any significant disruptions)
1	9/01/2017	120	We started with level 1. Students were briefed on what to do and how to use this. Students were given email accounts and were asked to add all the students for collaborative learning
2	10/01/2017	120	Students worked through Level 2 and completed collaborative learning tasks
3	16/01/2017	120	Students worked through Level 3 and completed collaborative learning tasks
4	17/01/2017	120	Students worked through Level 4 and completed collaborative learning tasks
5			

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ID	Activity	Completion	Date	Additional Comment
10	Supervise Phase 3 Quiz V0.3 under exam conditions as **post-test.** (i.e. After students use the e-learning software)	YES☒ NO ☐		Please outline any challenges or disruption during the supervision of the quiz as a post-test.
10.1	Mark the Phase 3 Quiz V0.3 according to Phase3 Quiz Marking Scheme V0.1.	YES☒ NO ☐		Please check Yes, if you took on the role as marker and the researcher the role of moderator.
10.2	Moderate the Phase 3 Quiz V0.3 according to Phase3 Quiz Marking Scheme V0.1.	YES☐ NO ☒		Please check Yes, if the researcher took on the role as marker and you took the role of moderator.
10.3	Provide scans of completed post-test quiz papers.	YES☐ NO ☐		
11	Provide evaluation of Pedagogy document.	YES☐ NO ☒		
12	Confirm spelling of full name and school title of involved teachers. (For the purpose of letter and certificate of participation)	YES☒ NO ☐		ra h ed
13	Confirm spelling of full name of student participants. (For the purpose of letter and certificate of participation)	YES☒ NO ☐		
14	Please outline any significant information, events or disruption that may have affected the research study in your school.			

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Name of Teacher: .... br Ah ed ..... Signature: ..... Date: .....

Name of School: ..... S tfor ch Ac emy .....

To be signed in duplicate: 1 copy for Teacher and 1 copy for the researcher.

M PHASE 3 CODEBOOK

As discussed in section 3.6.5 of the thesis, as standard practice in quantitative analysis, a codebook was created to keep a meticulous log of any pre-treatment, variable coding, decisions, and statistical tests taken in Phase 3. For reference, the Phase 3 codebook is included in this appendix.

Phase 3 Statistical Analysis Codebook.

by

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1 PRE-TEST POST-TEST ANALYSIS

1.1 Data Cleaning Instructions

1. Remove from pre-test / post-test, all students who did not get a result for both tests.
2. Remove from pre-test / post-test, all students who answered yes in the survey instrument to using other learning materials.
3. Remove all students from pre-test / post-test, who spent zero time on both Level 3 and Level 4.

1.2 Data Cleaning and Transcription Verification Actions

1.2.1 School 1

At time of study the following excel was created. UserData-research.uclancyprus.ac.cy-20161115-SCHOOL1_Completed_21_01_2017 – Copy

This was used as basis and adjusted accordingly to create "School1 Verified Data (Complete) v0.1":

- E:\OneDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School 1
- The following columns were deleted:
    - Last Name (contains pseudonym)
    - Email Address
    - Password
    - First Name (contains student first name)
    - Surname (contains student surname)
    - Survey
    - PIC
    - SIC
- The following columns were added:
    - Exclude
    - Other Learning Material
    - %Pre-test
    - %Post-test
    - %Change
- SCORMCloud Data was downloaded again and split between schools:
    - C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\ScormCloud Extracts\2017-09-13\School 2
    - C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\ScormCloud Extracts\2017-09-13\School 1
- Level 1 to Level4 usage time was verified.
- Pre-test and post-test results were verified against the marked and moderated results excel: "UserData-research.uclancyprus.ac.cy-20161115-SCHOOL1 (1)" in folder: C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School 1

- Added values (3) to “Other Learning Material” based on survey results from “Sheet_1” in folder: C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results\School1\Response Data\Schookl1Data_All_Responses_Numeric170308.zip\Excel
- Remove from pre-test / post-test, all students who did not get a result for both tests.
    - Student 5, Student 9 and Student 21.
- Remove from pre-test / post-test, all students who answered yes in the survey instrument to using other learning materials.
    - Student 2, Student 4 and Student 7
- Remove all students from pre-test / post-test, who spent zero time on both Level 3 and Level 4.
    - Student 1, Student 5 and Student 19,
- Created new tab “Cleaned”, in which all data marked as excluded due to the above rules were removed.

1.2.2 **School 2**

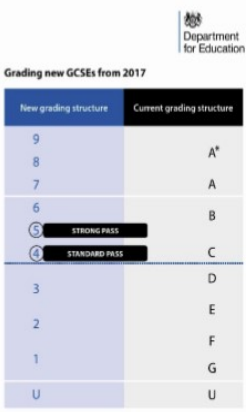
At time of study the following excel was created. UserData-research.uclancyprus.ac.cy-20161115-SCHOOL2_COMPLETED_19-02-2017 (Completed)

This was used as basis and adjusted accordingly to create “School2 Verified Data (Complete) v0.2”:

- E:\OneDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School2
- The following columns were deleted:
    - Last Name (contains pseudonym)
    - Email Address
    - Password
    - First Name (contains student first name)
    - Surname (contains student surname)
    - Survey
    - PIC
    - SIC
- The following columns were added:
    - Exclude
    - Other Learning Material
    - %Pre-test
    - %Post-test
    - %Change
- SCORMCloud Data was downloaded again and split between schools:
    - C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\ScormCloud Extracts\2017-09-13\School 1
    - C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\ScormCloud Extracts\2017-09-13\School 2
- Level 1 to Level4 usage time was verified.

- Pre-test and post-test results were verified against the marked and moderated test pdfs in: C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School2
- Added values (10) to "Other Learning Material" based on survey results from "Sheet_1" in folder: C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results\School2\Response Data\School2_All_Responses_Actual170308.zip\Excel
- Remove from pre-test / post-test, all students who did not get a result for both tests.
    - Student38
- Remove from pre-test / post-test, all students who answered yes in the survey instrument to using other learning materials.
    - Student36, Student39, Student 41, Student 43, Student 44, Student 46, Student48, Student49, Student51 and Student55.
- Remove all students from pre-test / post-test, who spent zero time on both Level 3 and Level 4. – no students removed
- Created new tab "Cleaned", in which all data marked as excluded due to the above rules were removed.

1.3 Coding Responses in SPSS

Variable	SPSS Variable	Coding Instructions	Comments
First Name	StudentID	None	Student Identifier of the form "P3Student1" - Phase 3 - Student 1.
Gender	Gender	Male Female	Gender of student.
Last GCSE Grade (KS4 Prediction)	KS4Prediction	1-9 according to the below 	
VARK		Not transferred into SPSS	Flag on whether student has undertaken VARK Questionnaire.
Exclude		Not transferred into SPSS, since all violating records are already removed.	Flag whether record has violated a data cleaning rule and therefore it has been excluded.
Other Learning Material		Not transferred into SPSS, since all violating records are already removed.	Flag whether student has accessed other learning material and therefore needs to be excluded from pre-test post-test analysis.
Level 1 (Avg Time)	Level1Time	Positive Integer value	

Variable	SPSS Variable	Coding Instructions	Comments
Level 2 (Avg Time)	Level2Time	Positive Integer value	
Level 3 (Avg Time)	Level3Time	Positive Integer value	Level 3 contains learning material directly relevant for test
Level 4 (Avg Time)	Level4Time	Positive Integer value	Level 4 contains learning material directly relevant for test
Level 2 and 4 Combined Time	L3L4	Positive Integer value Calculated variable summation of Level 3 and 4.	
All Levels Combined Time	L1L2L3L4	Positive Integer value Calculated variable summation of all levels.	
Pre-Test	PreTest	Integer value between 0-31	Pre-Test moderated raw mark from 31.
Post-Test	PostTest	Integer value between 0-31	Post-Test moderated raw mark from 31.
%Pre-Test	%PreTest	% value with 2 decimal places	%value of Pre-Test
%Post-Test	%PostTest	% value with 2 decimal places	%value of Post-Test
%Change	%Change	% value with 2 decimal places	%Change = %PostTest - %PreTest

1.3.1 SPSS Data Files

C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\Adjusted 26-10-2017

- Both Schools Test (No Outlier) – defunct.
- Both Schools Test (All)
- Both Schools Test (All - VARK)
- Both Schools Test (All - Survey)
- Both Schools Test (All - IMMS)

1.4 Descriptive Statistics

For the following variables, descriptive statistics will be produced:

Level1Time	KS4Prediction
Level2Time	PreTest
Level3Time	PostTest
Level4Time	%PreTest
L3L4	%PostTest
L1L2L3L4	%Change

The following descriptive statistics are produced:

```
DESCRIPTIVES VARIABLES=Level1Time Level2Time Level3Time Level4Time
PreTest PostTest PCTPreTest
    PCTPostTest PCTChange
  /STATISTICS=MEAN STDDEV MIN MAX KURTOSIS SKEWNESS.

EXAMINE VARIABLES=Level1Time Level2Time Level3Time Level4Time PreTest
PostTest PCTPreTest
```

```
  PCTPostTest PCTChange
/PLOT BOXPLOT HISTOGRAM NPPLOT
/COMPARE GROUPS
/STATISTICS DESCRIPTIVES EXTREME
/CINTERVAL 95
/MISSING PAIRWISE
/NOTOTAL.
```

1.4.1 **Output Files**

C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\Adjusted 26-10-2017

- Both Schools Test Descriptive (All)

1.5 **Merging School 1 and School 2 Results**

To further improve the normality of the distribution, the results from both schools are merged. The decision was based on the protocol confirmations from both schools that reflected that the study was carried out in the same manner and based on an independent sample T-Test for 3 critical variables between the two schools.

Note: Below are old versions, but new versions are similar.

```
GET
  FILE='E:\OneDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School 1\Both Schools Test (No Outlier).sav'.
DATASET NAME DataSet1 WINDOW=FRONT.
T-TEST GROUPS=School('School1' 'School2')
  /MISSING=ANALYSIS
  /VARIABLES=PreTest
  /CRITERIA=CI(.95).
```

T-Test

```
[DataSet1] E:\OneDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\School 1\Both Schools Test (No Outlier).sav
```

Group Statistics

	School	N	Mean	Std. Deviation	Std. Error Mean
PreTest	School1	26	4.65	2.208	.433
	School2	20	4.20	3.270	.731

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
PreTest	Equal variances assumed	3.421	.071	.561	44	.577	.454	.808	-1.175	2.083
	Equal variances not assumed			.534	31.699	.597	.454	.850	-1.278	2.186

```
T-TEST GROUPS=School('School1' 'School2')
  /MISSING=ANALYSIS
  /VARIABLES=PostTest
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	School	N	Mean	Std. Deviation	Std. Error Mean
PostTest	School1	26	10.38	3.645	.715
	School2	20	10.55	3.734	.835

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
PostTest	Equal variances assumed	.001	.971	-.151	44	.881	-.165	1.096	-2.374	2.043
	Equal variances not assumed			-.150	40.516	.881	-.165	1.099	-2.386	2.055

```
T-TEST GROUPS=School('School1' 'School2')
  /MISSING=ANALYSIS
  /VARIABLES=PCTChange
  /CRITERIA=CI(.95).
```

T-Test

Group Statistics

	School	N	Mean	Std. Deviation	Std. Error Mean
%Change	School1	26	18.4858	12.85665	2.52140
	School2	20	20.4845	11.38143	2.54496

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
%Change	Equal variances assumed	.000	.987	-.549	44	.586	-1.99873	3.64091	-9.33651	5.33904
	Equal variances not assumed			-.558	43.069	.580	-1.99873	3.58250	-9.22319	5.22573

When the P-value is less than the conventional .05, the null hypothesis is rejected and the conclusion is that the two means do indeed differ significantly. Since the p-values for all three variables are above .05 it means we cannot reject the null hypothesis (i.e. they are not statistically different).

This does not actively prove they are samples drawn from the same population. Two one-sided t-test (TOST) can potentially be used as a stronger equivalence test.

Output file: T-Test Comparison School1 and School2

1.5.1 **Output Files**

C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\Adjusted 26-10-2017

- Independent Sample T-Test (Both)

1.6 **Normality Test**

N=48, which is above the recommended lower threshold for normality in samples (n > 30).

Normal distribution was inspected visually using histograms and Normal Q-Q Plot, generated previously in descriptive statistics output files.

Normal Distribution was further verified by the Kolmogorov – Smirnov test.

If the test is non-significant (p >.05) it tells us that the distribution of the sample is **not** significantly different from a normal distribution.

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Level1Time	.147	46	.014	.887	46	.000
Level2Time	.112	46	.192	.922	46	.005
Level3Time	.188	46	.000	.802	46	.000
Level4Time	.164	46	.003	.923	46	.005
PreTest	.111	46	.200*	.962	46	.138
PostTest	.155	46	.007	.959	46	.101
%Pre-Test	.111	46	.200*	.962	46	.137
%Post-Test	.155	46	.007	.959	46	.101
%Change	.124	46	.075	.982	46	.690

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Normality of the Time variables is not considered a concern in this research. They are not primary variables for statistical analysis.

The Normal Q-Q Plot visually reflects a reasonably normal distribution for PostTest (and therefore the %Post-Test) results; however, the Kolmogorov – Smirnov indicates that PostTest results do not follow a Normal distribution.

Since Kolmogorov – Smirnov tests can be sensitive and T-tests are quite robust to issues with normality, T-Tests will be used with PostTest results but will also be supported by appropriate non-parametric test - i.e. a Wilcoxon Signed Ranks Test between pre and post-test results.

Since this is a repeated measure design homogeneity of variance is not a concern and therefore the Levene test is not required.

1.7 **Planned Statistical Analysis**

The following statistical analysis is planned:

1.7.1 **%Pre-Test**

1. Paired Sample T-test between %PreTest and %PostTest. (specify significance and confidence interval)
2. Correlation and Linear Regression between Gender and %PreTest (Considered, but ultimately rejected due to small number of female participants).

3. Correlation and Linear Regression between KS4Prediction and %PreTest.

1.7.2 %Post-Test

1. Paired Sample T-test between %PreTest and %PostTest. (specify significance and confidence interval)
2. One Sample T-Test between %PostTest and population mean (i.e. Target of grade boundary for C grade (i.e. 37))
3. Correlation and Linear Regression between Gender and %PostTest (Considered, but ultimately rejected due small number of female participants)
4. Correlation and Linear Regression between KS4Prediction and %PostTest
5. Correlation and Linear Regression between TotalTime and %PostTest
6. Correlation and Linear Regression between (Level3Time + Level4Time) and %PostTest
7. Correlation and Linear regression VARK dominant modality and %PostTest
8. Correlation and Linear regression IMMS-OVERALL and %PostTest
9. Correlation and Linear regression IMMS-Attention and %PostTest
10. Correlation and Linear regression IMMS-Relevance and %PostTest
11. Correlation and Linear regression IMMS-Confidence and %PostTest
12. Correlation and Linear regression IMMS-Satisfaction and %PostTest

1.7.2.1 *Survey Instrument Correlation*

4 A) All things considered, the E-Learning software is easy to use.

4 F) Sometimes I felt that I didn't quite understand what the E-Learning software was doing.

4 J) The E-Learning software is reliable (i.e. does not contain bugs or errors).

6 A) The learning content in the E-Learning software was represented in a clear and understandable way.

6 B) The learning content in the E-Learning software prepared me for the quiz questions (assessment activities).

6 C) The use of different methods to represent the same learning content helped my understanding.

6 L) I supplemented, or needed to supplement, the learning material in the E-Learning software with further textbook reading.

6 M) I asked, or wanted to ask, my teacher for support in understanding the learning material in the E-Learning software.

6 N) After completing the 4 levels of the E-Learning software, I was confident that I would be able to pass a test on it.

8 A) Overall, at what difficulty level do you believe the learning material represented in the E-Learning software was at?

8 B) Overall, at what difficulty level do you believe the practice activities (problem solving) were at?

8 C) Overall, at what difficulty level do you believe the quiz questions (assessment activities) were at?

10 B) I could use the E-Learning software for independent study to learn Computing.

10 C) The E-Learning software has increased my overall enthusiasm and interest in Computing.

12 B) The use of different methods to represent the same learning content made me feel overloaded.

12 C) After completing the 4 levels of the E-Learning software, my understanding of the subject matter had not improved.

1.7.3 %Change

1. Correlation and Linear Regression between Gender and %Change
2. Correlation and Linear Regression between KS4Prediction and %Change
3. Correlation and Linear Regression between TotalTime and %Change
4. Correlation and Linear Regression between (Level3Time + Level4Time) and %Change
5. Correlation and Linear regression VARK dominant modality and %Change
6. Correlation and Linear regression IMMS-OVERALL and %Change
7. Correlation and Linear regression IMMS-Attention and %Change
8. Correlation and Linear regression IMMS-Relevance and %Change
9. Correlation and Linear regression IMMS-Confidence and %Change
10. Correlation and Linear regression IMMS-Satisfaction and %Change

1.7.3.1 *Survey Instrument Correlation*

4 A) All things considered, the E-Learning software is easy to use.

4 F) Sometimes I felt that I didn't quite understand what the E-Learning software was doing.

4 J) The E-Learning software is reliable (i.e. does not contain bugs or errors).

6 A) The learning content in the E-Learning software was represented in a clear and understandable way.

6 B) The learning content in the E-Learning software prepared me for the quiz questions (assessment activities).

6 C) The use of different methods to represent the same learning content helped my understanding.

6 L) I supplemented, or needed to supplement, the learning material in the E-Learning software with further textbook reading.

6 M) I asked, or wanted to ask, my teacher for support in understanding the learning material in the E-Learning software.

6 N) After completing the 4 levels of the E-Learning software, I was confident that I would be able to pass a test on it.

8 A) Overall, at what difficulty level do you believe the learning material represented in the E-Learning software was at?

8 B) Overall, at what difficulty level do you believe the practice activities (problem solving) were at?

8 C) Overall, at what difficulty level do you believe the quiz questions (assessment activities) were at?

10 B) I could use the E-Learning software for independent study to learn Computing.

10 C) The E-Learning software has increased my overall enthusiasm and interest in Computing.

12 B) The use of different methods to represent the same learning content made me feel overloaded.

12 C) After completing the 4 levels of the E-Learning software, my understanding of the subject matter had not improved.

1.7.4 Correlation Analysis

Depending on how well the below assumptions are met the following parametric and non-parametric correlation tests will be used:

- Pearson's *r*, Pearson product-moment correlation coefficient (PPMCC)
- Spearman's correlation coefficient

Assumptions for Pearson's r, were not met due to distribution and outliers. Hence, Spearman's Rho with outliers is used.

1.7.4.1 *Assumptions to be checked prior to correlation analysis.*

1. Normality – checked via Kolmogorov-Smirnov test, Q-Plots and histograms.
2. Check linear relationship via scatterplots (Note: Pearson r will seriously underestimate the strength of a relationship if the variables are related in a non-linear fashion)
3. Use scatterplot and boxplots to check for outliers.
4. Related pairs a score on both variable x and variable y from same subject.
5. Independence of observation - Observations that make up your data must be independent of one another. The variables should not be dependent on each other and no confounding variables.
6. Missing data – check whether N is correct there are issues with small samples to show statistical significance. Report even when p>0.5.
7. Strength of Effect:
    - small r=.10 to .29
    - medium r= .30 to .49
    - large r = .50 to 1.0

1.7.4.2 *Preparatory steps and fitting model*

1. Generate Descriptive statistics, histograms, boxplots and tests for normality.
2. Generate Scatterplots
3. If assumptions are met then use Pearson's *r.* If they are not met then:
    - Use bootstrapping.
    - Also use and report non-parametric tests:
    - Use Spearman's correlation coefficient if assumptions are not met.
4. Test for correlation with and without outliers.
5. Report correlations even if statistical significance is not met. Give greater focus to Bootstrap confidence intervals.

1.7.4.3 *Linear Regression*

Where Pearson's *r* shows a correlation then a Linear regression will be carried out.

1.7.4.4 *Output files*

C:\Users\pyiatrou\SkyDrive\phd\PhD\Phase 3\4 Study\Pre-Test Post-Test\Adjusted 26-10-2017

- Both Schools Test Descriptive (All).sav
- Wilcoxon Signed Ranks Test (Both)
- Paired Sample T-Test (Both)
- Both Schools Test (All - Correlation)
- Both Schools Test (All - IMMS)
- Both Schools Test (All - Survey)
- Both Schools Test (All - VARK)
- Both One Sample T-Test

2 SURVEY INSTRUMENT ANALYSIS

2.1 Data Preparation Instructions

1. The Following columns and questions were removed when transcribing the SurveyMonkey Phase 3 survey results extract to intermediate excels:

Excel Column	Variable Name (SurveyMonkey)	Action	Comment
A	RespondentID	Delete column	Study StudentID (pseudonym) is instead used as identifier.
B	CollectorID	Delete column	No analysis required
C	StartDate	Delete column	No analysis required
D	EndDate	Delete column	No analysis required
E	IP Address	Delete column	No analysis required
F	Email Address	Clear email portion to retain StudentID (pseudonym)	Unique identifier for student participant used within the study.
H	First Name	Delete column	No data collected, no analysis required.
H	LastName	Delete column	No data collected, no analysis required.
I	Custom Data	Delete column	No data collected, no analysis required.
J	Which browser and browser version did you use to access the E-learning software?	Delete column	No analysis required
L	Q3. If you answered yes above, please explain your answer.	Delete column	Open answer on what other learning material student reviewed before taking post-test. No statistical analysis, will be analysed thematically.
X	Q5. Please describe any significant usability issues that need attention.	Delete column	Open answer, no statistical analysis. Will be analysed thematically.
DA	Q14. Please explain your above answer (The frequency I use the Internet and the Web to support my learning of the Computing subject is:)	Delete column	Open answer, no statistical analysis. Will be analysed thematically.
DC	Q16. Please explain your above answer (I would prefer using the Internet and the Web to support my learning of the computing subject, rather than this E-Learning software.)	Delete column	Open answer, no statistical analysis. Will be analysed thematically.
DE	Q18. Please explain your above answer (The frequency I use other E-Learning software to support my learning of the Computing subject is:)	Delete column	Open answer, no statistical analysis. Will be analysed thematically.

Excel Column	Variable Name (SurveyMonkey)	Action	Comment
DF	Q19. Describe briefly in your own words what you like and dislike about this E-Learning software.	Delete column	Open answer, no statistical analysis. Will be analysed thematically.

2. Resize column width and set wrap text property on row 1 to ensure visibility of column title / question text.
3. Rename worksheet to Survey (raw)
4. Set conditional formatting on blank cells to mark them in red fill for easy visibility.
5. Move Q11 Engagement and Motivation (IMMS) to a separate worksheet (IMMS (RAW)).
    a. Set conditional formatting on blank cells to mark them in red fill for easy visibility.
    b. Colour code columns according to their ARCS classification (Attention, Relevance, Confidence, Satisfaction).
    c. Set text colour to red for columns / questions which have results that must be reversed.
6. Copy IMMS (RAW) to a new worksheet IMMS (Reverse).
    a. To the right of each student participant specify average for Attention, Relevance, Confidence, Satisfaction.
    b. Create Overall average based on all values.
    c. Visually inspect formula cell references are correct for each formula.
    d. For each question that is reversed create duplicate column of original values.
    e. Manually reverse values (1=5, 2=4, 3=3, 4=2, 5=1).
    f. Visually inspect reverses values against original values to avoid transcription issues.
    g. Hide original values column.

2.2 Data Preparation and Transcription Verification actions

1. The Phase 3 survey results (Numeric coding) for each school were exported from survey monkey to the following location:
   E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results**School1**\Response Data\Excel\Sheet_1

   E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results**School2**\Response Data\Excel\Sheet_1
2. Created intermediate excels based on Data Cleaning Instructions 1-6 from previous section:

   E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results**School1 Survey Data v0.1**

E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results\School2**School2 Survey Data v0.1**

E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results**Both Schools Survey Data v0.1**

3. For the ranking questions a new worksheet (Ranking (RAW)) was created in Both Schools Survey Data v0.1, this worksheet included only questions 7 and 9.
4. The worksheet Ranking (RAW) was then copied to Ranking (cleaned). In this worksheet any participant who had 2 or more blank responses for question 7 or 9 were removed. This is to avoid skewing of the ranking based on non-response.
    a. The data cleaning exercise resulted in:
        - 30 complete responses for question 7
        - 33 complete responses for question 9

Student Participant	Non-Response Summary	Action Taken
P3Student6	3 non-responses in question 7.	All question 7 responses removed. Question 9 included as normal.
P3Student16	One missing response in Question 7 Multiple missing responses from question 9,	Question 7 - Animation is manually adjusted to be ranked as 9th. All question 9 responses removed.
P3Student17	Question 7 and 9 - no responses given	No action necessary.
P3Student23	4 non-responses in question 7.	All question 7 responses removed. Question 9 included as normal.
P3Student18	6 non-responses in question 7. 6 non-responses in question 9.	All question 7 responses removed. All question 9 responses removed.
P3Student22	5 non-responses in question 7.	All question 7 responses removed. Question 9 included as normal.
P3Student28	5 non-responses in question 7. 9 non-responses in question 9.	All question 7 responses removed. All question 9 responses removed.
P3Student13	4 non-responses in question 7.	All question 7 responses removed. Question 9 included as normal.
P3Student39	5 non-responses in question 7. 5 non-responses in question 9.	All question 7 responses removed. All question 9 responses removed.

Student Participant	Non-Response Summary	Action Taken
P3Student48	1 non-response in question 7.	Question 7 - Games is manually adjusted to be ranked as 1st.
P3Student44	5 non-responses in question 7. 4 non-responses in question 9.	All question 7 responses removed. All question 9 responses removed.
P3Student42	2 non-responses in question 7. 1 non-responses in question 9.	All question 7 responses removed. Question 9 - Games is manually adjusted to be ranked as 1st.
P3Student47	4 non-responses in question 7.	All question 7 responses removed. Question 9 included as normal.
P3Student51	3 non-responses in question 7. No responses for question 9.	All question 7 responses removed.
P3Student43	4 non-responses in question 7. No responses for question 9.	All question 7 responses removed.
P3Student36	4 non-responses in question 7. 4 non-responses in question 9.	All question 7 responses removed. All question 9 responses removed.
P3Student46	6 non-responses in question 7. No responses for question 9.	All question 7 responses removed.
P3Student37	1 non-responses in question 7. 5 non-responses in question 9.	Question 7 – Audio manually adjusted to be ranked as 7th. All question 9 responses removed.

5. Overall rankings based on Learning Benefit and engagement where then summed.

2.3 Treatment of Outliers

The response to the survey instrument contained a significant number of outliers. To a lesser extent the responses on the IMMS also contained several outliers. In this case Outliers are identified as 1.5×IQR (Interquartile range). Please refer to summary able below:

1. The outliers were verified as not being a transcription error.
2. Then they were investigated against:
    1. Check their exam results.
    2. Check their open questions
    3. Check their experience with e-learning and their use of internet.
    4. Check their KS 4 predictions

SPSS Ref	Num Outlier Responses	Student ID	Comment
11	9	P3Student1	
19	7	P3Student18	
18	2	P3Student23	
25	18	P3Student22	
1	6	P3Student12	
24	2	P3Student15	
47	1	P3Student37	
14	1	P3Student34	
26	6	P3Student28	
6	4	P3Student10	
21	2	P3Student31	
35	1	P3Student63	
15	1	P3Student16	
40	1	P3Student49	
12	1	P3Student19	
27	1	P3Student13	

3. The initial strategy was to remove all respondents who habitually offered outlier responses. A cut off of > 3 outlier responses.
4. This led to the removal of 6 students as highlighted in RED. This led to the average increase of mean of 0.15 and change of Median in 3 questions.
    - Both Schools Survey Descriptive (No Outlier - ALL)
5. Since the underlying reason for these outliers could not be identified and because removal arguably makes the sample less representative, this approach was rejected

For both the survey instrument and IMMS responses the approach is to:

1. Represent descriptive statistics with outliers, and
2. Represent descriptive statistics without outliers
3. This was used by running the same descriptive tests with filter (removing outliers) and without filter. Output file documents in title which outliers were removed by filter.

2.4 Coding Responses in SPSS

Variable	SPSS Variable	Coding Instructions	Comments
First Name	StudentID	None	Student Identifier of the form “P3Student1” Phase 3 - Student 1.
Other Learning	Q2OtherLearning	1 = No 2 = Yes.	Q2. No = No other learning material was reviewed between pre-test and post-test. Yes = Yes other learning material was reviewed

Variable	SPSS Variable	Coding Instructions	Comments
			between pre-test and post-test. Students who responded with Yes were removed from pre-test post-test analysis
4 A) All things considered, the E-Learning software is easy to use.	Q4AEasyToUse	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
4 B) The graphical parts (symbols, logos, diagrams, pictures and illustrations etc.) and design of the E-Learning software is appealing.	Q4BGraphicsAppealing	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 C) The graphical parts (symbols, logos, diagrams, pictures and illustrations etc.) of the E-Learning software are meaningful.	Q4CGraphicsMeaningful	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 D) The navigation and program controls of the E-Learning software are logically arranged and consistent.	Q4DNavConsistent	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 E) It is easy to use the navigation and program controls of the E-Learning software.	Q4DNavEasy	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 F) Sometimes I felt that I didn't quite understand what the E-Learning software was doing.	Q4FNotUnderstandSoftware	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
4 G) I found errors (bugs) in the E-Learning	Q4GNonRecoverBugs	1 Strongly disagree 2 Disagree	

Variable	SPSS Variable	Coding Instructions	Comments
software that were difficult to recover from.		3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 H) The E-Learning software felt speedy and responsive to my interactions.	Q4HSoftwareSpeedy	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 I) The E-Learning software gave accurate feedback in response to my interactions.	Q4IAccurateFeedback	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
4 J) The E-Learning software is reliable (i.e. does not contain bugs or errors).	Q4JSoftwareReliable	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
4 K) The various instructions and prompt messages are understandable.	Q4KInstructUnderstandable	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 A) The learning content in the E-Learning software was represented in a clear and understandable way.	Q6AContentClearUnder	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
6 B) The learning content in the E-Learning software prepared me for the quiz questions (assessment activities).	Q6BPreparedforQuiz	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
6 C) The use of different methods to represent the same learning content helped my understanding.	Q6CMultiModalUnderst	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
6 D) The practice activities	Q6DPracticeActivitiesUnderst	1 Strongly disagree 2 Disagree	

Variable	SPSS Variable	Coding Instructions	Comments
(problem solving) in the E-Learning software helped me understand the subject matter.		3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 E) The quiz questions (assessment activities) in the E-Learning software helped me understand the subject matter.	Q6EQuizUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 F) The visual material in the E-Learning software helped me understand the subject matter.	Q6FVisualUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 G) The audio material in the E-Learning software helped me understand the subject matter.	Q6GAudioUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 H) The text material in the E-Learning software helped me understand the subject matter.	Q6HTextUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 I) The collaborative activities (forum discussions, group or pair work) helped me understand the subject matter.	Q6ICollabUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 J) The “extend your knowledge” learning material in the E-Learning software helped me understand the subject matter.	Q6JExtendUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
6 K) The videos in the E-Learning software helped me understand	Q6KVideoUnderstanding	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree	

Variable	SPSS Variable	Coding Instructions	Comments
the subject matter.		5 Strongly Agree	
6 L) I supplemented, or needed to supplement, the learning material in the E-Learning software with further textbook reading.	Q6LSupplementTheSW	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
6 M) I asked, or wanted to ask, my teacher for support in understanding the learning material in the E-Learning software.	Q6MAskForHelp	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
6 N) After completing the 4 levels of the E-Learning software, I was confident that I would be able to pass a test on it.	Q6NTestConfidence	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
7) Please rank the following educational components with regards to their benefit to your learning. (1 is the most beneficial and 10 is least beneficial)	Q7TextRank Q7AudioRank Q7VideoRank Q7ExtendedKnowledgeRank Q7QuizzesRank Q7GamesRank Q7PicturesPhotosDiagRank Q7AnimatSimulRank Q7CollaborativeLearningRank Q7PracticeActivitiesRank	Each variable to have numeric 1 to 10. No duplicates between variables	
8 A) Overall, at what difficulty level do you believe the learning material represented in the E-Learning software was at?	Q8ALearningDifficulty	1 Too Easy 2. A Little Easy 3. At the right level 4. A little difficult 5. Too difficult	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
8 B) Overall, at what difficulty level do you believe the practice activities (problem solving) were at?	Q8BPracticeActivityDifficulty	1 Too Easy 2. A Little Easy 3. At the right level 4. A little difficult 5. Too difficult	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
8 C) Overall, at what difficulty level do you	Q8CQuizDifficulty	1 Too Easy 2. A Little Easy 3. At the right level	Variable will also be merged into Both Schools Test (No

Variable	SPSS Variable	Coding Instructions	Comments
believe the quiz questions (assessment activities) were at?		4. A little difficult 5. Too difficult	Outlier).sav for analysis against %PostTest and %Change.
9) Please rank the following educational components on whether they positively influenced your enthusiasm and interest in Computing (1 has the most positive influence and 10 has the least positive influence)	Q9TextRank Q9AudioRank Q9VideoRank Q9ExtendedKnowledgeRank Q9QuizzesRank Q9GamesRank Q9PicturesPhotosDiagRank Q9AnimatSimulRank Q9CollaborativeLearningRank Q9PracticeActivitiesRank	Each variable to have numeric 1 to 10. No duplicates between variables	
10 A) It is more interesting to use the E-Learning software to learn Computing than the textbooks.	Q10AInterestingTextBook	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
10 B) I could use the E-Learning software for independent study to learn Computing.	Q10BIndependentStudy	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
10 C) The E-Learning software has increased my overall enthusiasm and interest in Computing.	Q10COverallEnthusiasm	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
11) Engagement and Motivation (IMMS)	NA	NA	Will be coded separately refer to section X.
12 A) Overall, the E-Learning software was difficult to use.	Q12AOverallDifficulty	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
12 B) The use of different methods to represent the same learning content made	Q12BMultiModalOverload	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	

Variable	SPSS Variable	Coding Instructions	Comments
me feel overloaded.			
12 C) After completing the 4 levels of the E-Learning software, my understanding of the subject matter had not improved.	Q12CImprovedUnderstand	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
13) The frequency I use the Internet and the Web to support my learning of the Computing subject is:	Q13FreqInternet	1 Never 2 Less than once a Month 3 Monthly 4 Weekly 5 Daily 6 Several times per day	
15) I would prefer using the Internet and the Web to support my learning of the computing subject, rather than this E-Learning software.	Q15PreferInternet	1 Strongly disagree 2 Disagree 3 Neither Agree nor Disagree 4 Agree 5 Strongly Agree	
17) The frequency I use other E-Learning software to support my learning of the Computing subject is:	Q17FreqELearning	1 Never 2 Less than once a Month 3 Monthly 4 Weekly 5 Daily 6 Several times per day	

2.4.1 SPSS Data File

- BothSchoolsSurvey.sav

2.5 Engagement and Motivation (IMMS)

2.5.1 Coding Responses in SPSS

Variable	SPSS Variable	Coding Instructions	Comments
First Name	StudentID	None	Student Identifier of the form “P3Student1” Phase 3 - Student 1.
11 A) When I first looked at this lesson, I had the impression that it would be easy for me.	Q1C1	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).

Variable	SPSS Variable	Coding Instructions	Comments
11 B) There was something interesting at the beginning of this lesson that got my attention.	Q2A1	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 C) This material was more difficult to understand than I would like for it to be.	Q3C2R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 D) After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	Q4C3	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 E) Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.	Q5S1	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 F) It is clear to me how the content of this material is related to things I already know.	Q6R1	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 G) Many of the screens had so much information that it was hard to pick out and remember the important points.	Q7C4R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 H) These materials are eye-catching.	Q8A2	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 I) There were stories, pictures, or examples that showed me how this material could be important to some people.	Q9R2	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 J) Completing this lesson successfully was important to me.	Q10R3	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).

Variable	SPSS Variable	Coding Instructions	Comments
		5 Very True	
11 K) The quality of the writing helped to hold my attention.	Q11A3	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 L) This lesson is so abstract that it was hard to keep my attention on it.	Q12A4R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 M) As I worked on this lesson, I was confident that I could learn the content.	Q13C5	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 N) I enjoyed this lesson so much that I would like to know more about this topic.	Q14S2	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 O) The screens of this lesson look dry and unappealing.	Q15A5R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 P) The content of this material is relevant to my interests.	Q16R4	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 Q) The way the information is arranged on the screens helped keep my attention.	Q17A6	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 R) There are explanations or examples of how people use the knowledge in this lesson.	Q18R5	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 S) The exercises in this lesson were too difficult.	Q19C6R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 T) This lesson has things that stimulated my curiosity	Q20A7	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 U) I really enjoyed studying this lesson.	Q21S3	1 Not True 2 Slightly True 3 Moderately True	Grouped according to ARCS and used for

Variable	SPSS Variable	Coding Instructions	Comments
		4 Mostly True 5 Very True	internal validity test (Cronbach's alpha).
11 V) The amount of repetition in this lesson caused me to get bored sometimes.	Q22A8R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 W) The content and style of writing in this lesson convey the impression that its content is worth knowing.	Q23R6	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 X) I learned some things that were surprising or unexpected.	Q24A9	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 Y) After working on this lesson for a while, I was confident that I would be able to pass a test on it.	Q25C7	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 Z) This lesson was not relevant to my needs because I already knew most of it.	Q26R7R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 A.1) The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	Q27S4	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 B.1) The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.	Q28A10	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 C.1) The style of writing is boring.	Q29A11R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 D.1) I could relate the content	Q30R8	1 Not True 2 Slightly True	Grouped according to ARCS and used for

Variable	SPSS Variable	Coding Instructions	Comments
of this lesson to things I have seen, done, or thought about in my own life.		3 Moderately True 4 Mostly True 5 Very True	internal validity test (Cronbach's alpha).
11 E.1) There are so many words on each screen that it is irritating.	Q31A12R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 F.1) It felt good to successfully complete this lesson.	Q32S5	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 G.1) The content of this lesson will be useful to me.	Q33R9	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 H.1) I could not really understand quite a bit of the material in this lesson.	Q34C8R	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 I.1) The good organization of the content helped me be confident that I would learn this material.	Q35C9	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
11 J.1) It was a pleasure to work on such a well-designed lesson.	Q36S6	1 Not True 2 Slightly True 3 Moderately True 4 Mostly True 5 Very True	Grouped according to ARCS and used for internal validity test (Cronbach's alpha).
Attention	StudentAttention	Numeric value between 1-5 calculated on average of all attention questions.	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
Relevance	StudentRelevance	Numeric value between 1-5 calculated on average of all attention questions.	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
Confidence	StudentConfidence	Numeric value between 1-5 calculated on average of all attention questions.	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.

Variable	SPSS Variable	Coding Instructions	Comments
Satisfaction	StudentSatisfaction	Numeric value between 1-5 calculated on average of all attention questions.	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.
Overall	StudentIMMSOverall	Numeric value between 1-5 calculated on average of previous 4 variables.	Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.

2.5.2 SPSS Data File

- BothSchoolsIMMS.sav

2.6 Descriptive Statistics

2.6.1 Survey Instrument

For the following variables, descriptive statistics will be produced

Q4AEasyToUse	Q7TextRank	Q10AInterestingTextBook
Q4BGraphicsAppealing	Q7AudioRank	Q10BIndependentStudy
Q4CGraphicsMeaningful	Q7VideoRank	Q10COverallEnthusiasm
Q4DNavConsistent	Q7ExtendedKnowledgeRank	Q12AOverallDifficulty
Q4ENavEasy	Q7QuizzesRank	Q12BMultiModalOverload
Q4FNotUnderstandSoftware	Q7GamesRank	Q12CImprovedUnderstand
Q4GNonRecoverBugs	Q7PicturesPhotosDiagRank	Q13FreqInternet
Q4HSoftwareSpeedy	Q7AnimatSimulRank	Q15PreferInternet
Q4IAccurateFeedback	Q7CollaborativeLearningRank	Q17FreqELearning
Q4JSoftwareReliable	Q7PracticeActivitiesRank	
Q4KInstructUnderstandable		
Q6AContentClearUnder	Q8ALearningDifficulty	
Q6BPreparedforQuiz	Q8BPracticeActivityDifficulty	
Q6CMultiModalUnderst	Q8CQuizDifficulty	
Q6DPracticeActivitiesUnderst		
Q6EQuizUnderstanding	Q9TextRank	
Q6FVisualUnderstanding	Q9AudioRank	
Q6GAudioUnderstanding	Q9VideoRank	
Q6HTextUnderstanding	Q9ExtendedKnowledgeRank	
Q6ICollabUnderstanding	Q9QuizzesRank	
Q6JExtendUnderstanding	Q9GamesRank	
Q6KVideoUnderstanding	Q9PicturesPhotosDiagRank	
Q6LSupplementTheSW	Q9AnimatSimulRank	
Q6MAskForHelp	Q9CollaborativeLearningRank	
Q6NTestConfidence	Q9PracticeActivitiesRank	

2.6.1.1 *Output File*

- Both Schools Survey Descriptive.spv

2.6.1.2 *IMMS Outlier Analysis*

Outliers are identified as 1.5×IQR (Interquartile range).

38	1	1	P3Student36
1	13	13	P3Student12
26	15	15	P3Student28
25	10	11	P3Student22
11	2	2	P3Student1
21	1	1	P3Student31
19	2	2	P3Student18
6	1	1	P3Student10
18	2	2	P3Student23
42	1	1	P3Student37
39	3	3	P3Student46

2.6.2 **IMMS**

For the following variables, descriptive statistics will be produced:

- StudentAttention
- StudentRelevance
- StudentConfidence
- StudentSatisfaction
- StudentIMMSOverall

2.6.2.1 *Output file*

BothSchools IMMS Descriptive (Summary)

2.7 **Planned Statistical Analysis**

The survey instrument will be reported using Descriptive Statistics. There is no expectation of normality and no attempt to generalise to the wider GSCE population.

However, as documented in section 1.7.4, several variables from the survey instrument, including the IMMS response will be used in correlation and linear regression analysis against pre-test, post-test and %Change variables.

Parametric or non-parametric tests are used on the motivational sub-categories to assess on whether the inter-group results have a statistically significant:

- Kolmogorov-Smirnov - to test for normality
- Paired Sample T-Test (Parametric)
- Related-Samples Wilcoxon Signed Rank Test (Non-Parametric)

2.7.1 Survey Instrument Reliability

2.7.1.1 *SPSS Data File*

- FILE='E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results\BothSchoolsSurvey.sav'.

Alternate-Form and Internal Consistency reliability are verified in Phase 3 survey instrument:

- Alternate-Form: Depending on whether assumptions are met, either a parametric, or a non-parametric correlation analysis will be undertaken on the following question pair: 4 A) and 12 A).
- Internal Consistency: Cronbach's alpha will be assessed for the following two groups of questions:
    - Usability: 4A), 4C), 4D), 4E), 4H), 4I), 4J) and 4K)
    - Difficulty: 8A), 8B) and 8C

2.7.1.2 *Qualitative Triangulation*

Refer to folder: E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument

Excel file: "Survey Instrument Phase analysis V0.5" column "I" gives analysis of questions that can be triangulated together but due to response scales cannot have a statistical correlation analysis.

2.7.1.3 *Output File*

- BothSchools Survey internal validty (FINAL)

2.7.2 IMMS Internal Validity

2.7.2.1 *SPSS Data File*

- FILE='E:\OneDrive\phd\PhD\Phase 3\4 Study\Survey Instrument\Phase 3 Survey Results\BothSchoolsIMMS.sav'.

Cronbach Alpha will be calculated for all IMMS questions and for questions grouped under Attention, Relevance, Confidence, Satisfaction. This is in accordance with Keller's IMMS scoring guide.

Attention	Relevance	Confidence	Satisfaction
2	6	1	5
8	9	3 (reverse)	14
11	10	4	21
12 (reverse)	16	7 (reverse)	27
15 (reverse)	18	13	32
17	23	19 (reverse)	36
20	26 (reverse)	25	
22 (reverse)	30	34 (reverse)	
24	33	35	
28			
29 (reverse)			
31 (reverse)			

2.7.2.2 ***Output File***

- BothSchools IMMS internal validty (FINAL)

3 VARK ANALYSIS

3.1 Data Preparation and Transposition Verification actions

1. The full Phase 3 VARK results (Numeric coding) from both schools were exported from survey monkey to the following location:
   - E:\OneDrive\phd\PhD\Phase 3\4 Study\VARK\Phase 3\Phase_3_VARK_All_Numeric_coding_170206\Excel\ Sheet 1
2. An intermediate excel was transposed with preliminary Analysis and created:
   - E:\OneDrive\phd\PhD\Phase 3\4 Study\VARK
   - Both Schools VARK Analysis
3. The answers to each question are colour coded according to which modality they represent. The guideline to this document "VARK Questionnaire Answers" from:
   - E:\OneDrive\phd\PhD\Phase 3\4 Study\VARK
4. Verified grouping and colour coding twice
5. Verified colour coding via count of each group,
6. Verified formulas
7. For Each student a numeric V.A.R.K profile is created and the dominant modality or modalities is identified.
8. Summation for each V.A.R.K modality is created and turned into a percentage value for each.
9. Preliminary analysis against phase 1 and phase 2-cycle 1.

3.2 Coding Responses in SPSS

Variable	SPSS Variable	Coding Instructions	Comments
First Name	StudentID	None	Student Identifier of the form "P3Student1" Phase 3 - Student 1.
Visual	Visual	Count of participant responses in Visual modality	VARK Question Groupings defined in document VARK Questionnaire Answers.
Aural	Aural	Count of participant responses in Aural modality	VARK Question Groupings defined in document VARK Questionnaire Answers.
ReadWrite	ReadWrite	Count of participant responses in Read/Write modality	VARK Question Groupings defined in document VARK Questionnaire Answers.
Kinaesthetic	Kinaesthetic	Count of participant responses in Kinaesthetic modality	VARK Question Groupings defined in document VARK Questionnaire Answers.

Variable	SPSS Variable	Coding Instructions	Comments
Dominant	DModality	Visual = V Aural = A Read/Write = R Kinaesthetic = K Multiple Dominant Modalities = M	Dominant Modality. Variable will also be merged into Both Schools Test (No Outlier).sav for analysis against %PostTest and %Change.

3.2.1 SPSS Data File

E:\OneDrive\phd\PhD\Phase 3\4 Study\VARK\Phase 3

- BothSchoolsSummaryVARK v0.1

3.2.2 SPSS Output

E:\OneDrive\phd\PhD\Phase 3\4 Study\VARK\Phase 3

- Both Schools VARK Descriptive

3.3 Planned Statistical Analysis

Parametric or non-parametric tests to assess whether VARK sub-categories have a statistical difference:

- Kolmogorov-Smirnov - to test for normality
- Paired Sample T-Test (Parametric)
- Related-Samples Wilcoxon Signed Rank Test (Non-Parametric)

N E-LEARNING SOFTWARE EVALUATION PROTOCOL (FINAL)

As discussed in section 5.2 of the thesis, the e-learning evaluation protocol was iteratively developed and refined through the three phases of this research study, and four versions of the e-learning evaluation protocol were developed and released. This appendix includes the fourth and final version of the e-learning evaluation protocol.

Protocol and feedback template for heuristics evaluation of high-school e-learning software

by

Peter Yiatrou

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1 DOCUMENT DETAILS

1.1 Document Version

Version	Date	Changes
0.1	11/08/2016	**Phase 2-Cycle 2** The first stable version of the heuristic evaluation protocol and feedback template; drafted in accordance with the following documents: • GCSE Computer Science E-Learning Pedagogy v1.5, • Draft Evaluation page and • Pilot Calculation
0.2	25/06/2017	Updates based on version 0.1 in consideration of: • GCSE Computer Science E-Learning Pedagogy v1.7b(CLEAR).docx • Phase 2 – Cycle 2 pilot evaluation findings • Phase 3 Evaluation protocol literature review • Feedback from education experts on version 0.1 • Pilot Calculation v0.1
0.3	02/07/2017	**Phase 3** Updates based on version 0.2 in consideration of: • Removal of Learning Objectives from Level 4 Blue • Updates to calculation excel to remove the learning objectives of Level-4 Blue. • Update to response scale of Importance questions to have a label for each option.
0.4	09/10/2018	**Final** Updates based on version 0.3 in consideration of: • GCSE Computer Science E-Learning Pedagogy v1.8.docx • Phase 3 Teacher Workshop. • Feedback from education experts on version 0.3 • Final literature review and thesis updates. • Grammar and proofreading.

1.2 Document Distribution

Name	Role	Institution	Date

1.3 Copyright and Disclaimer

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1 INTRODUCTION

1.1 Research Context

Recently, a number of developed countries[1] have shown an increased focus towards high-school computer science. In parallel, there is an increasing integration of technology-enhanced learning in education.

One area of technology-enhanced learning is the use of e-learning software within high-schools. Although e-learning software has the potential to offer substantial learning benefits; there remains a concern that there is inconsistency in the quality of existing software, which often falls short, in particular in educational value.

In order to support the increased use of e-learning software and simultaneously safeguard the educational benefits to students, a comprehensive set of pedagogical heuristics have been developed. The heuristics and their supporting criteria are dual-purpose:

1. To guide the pedagogical design of e-learning software, and
2. To serve as the basis of a protocol to guide the evaluation of such e-learning software.

1.2 Supporting Documents

This document outlines both the evaluation protocol to carry out an e-learning evaluation and the feedback template used to document the evaluation results. It is supported by the following documents:

- GCSE Computer Science E-Learning Pedagogy v1.8
- Computer Science E-Learning Pedagogy Appendices v0.5
- Summary Feedback Template v0.1.

The evaluation protocol does not replace the aforementioned documents; however, in order to comprehensively support the evaluators' understanding of each heuristic, this document also includes the heuristic ID, title, description and condensed evaluation criteria.

[1] These countries include, but are not limited to: Australia, Belgium, France, India, Israel, Italy, New Zealand, Sweden, South Africa, Russia, the United Kingdom, and the United States.

2 UNDERLYING PRINCIPLES FOR E-LEARNING EVALUATION

2.1 Going Beyond Usability

The pedagogical heuristics evaluation protocol, from this point, simply referred to as the evaluation protocol, builds upon existing usability inspection methods for interactive software. Usability inspections are typically known as heuristics evaluations; expert evaluators examine the user interface design and judge its compliance with recognized usability principles (the *"heuristics"*) with the aim of identifying as many usability problems as possible. In contrast, this evaluation protocol does not focus on usability, but on the educational value of the e-learning software. Educational experts (teachers and/or instructional designers) will examine the e-learning software and judge its support for the pedagogical heuristics.

These heuristics supplement existing literature on instructional design and extend existing e-learning heuristics since they focus more tightly and in-depth on pedagogy rather than usability. Usability is critical to e-learning software and is a mandatory prerequisite; however, the heuristics and evaluation protocol do not give guidance on Graphical User Interface (GUI) design and general usability. This is a separate subject area that must be considered. There are a number of available heuristics in interface design and usability; one set of general usability heuristics that is well established is outlined by Jacob Nielsen, this is included in the pedagogy appendices document in Appendix D.

2.2 The Composition of Educational Value

This evaluation protocol assesses the pedagogical quality of e-learning software. However, it is important to note that even if a specific e-learning implementation is pedagogically excellent, it still may not lead to the desired learning objectives if the educational content is not appropriate. Therefore, this protocol additionally assesses educational content and the e-learning software's support for the intended learning objectives. This evaluation protocol, therefore, focuses on educational value, which is the combination of content quality and pedagogical quality.

- **Content Quality** - The level of support the e-learning software gives to the learning objectives specified in the chosen curriculum.
- **Pedagogical Quality** - The level of support the e-learning software gives to the pedagogical heuristics judged to be relevant to the given educational setting.

Please refer to Figure 1 for a visual representation of the underlying composition of educational value.

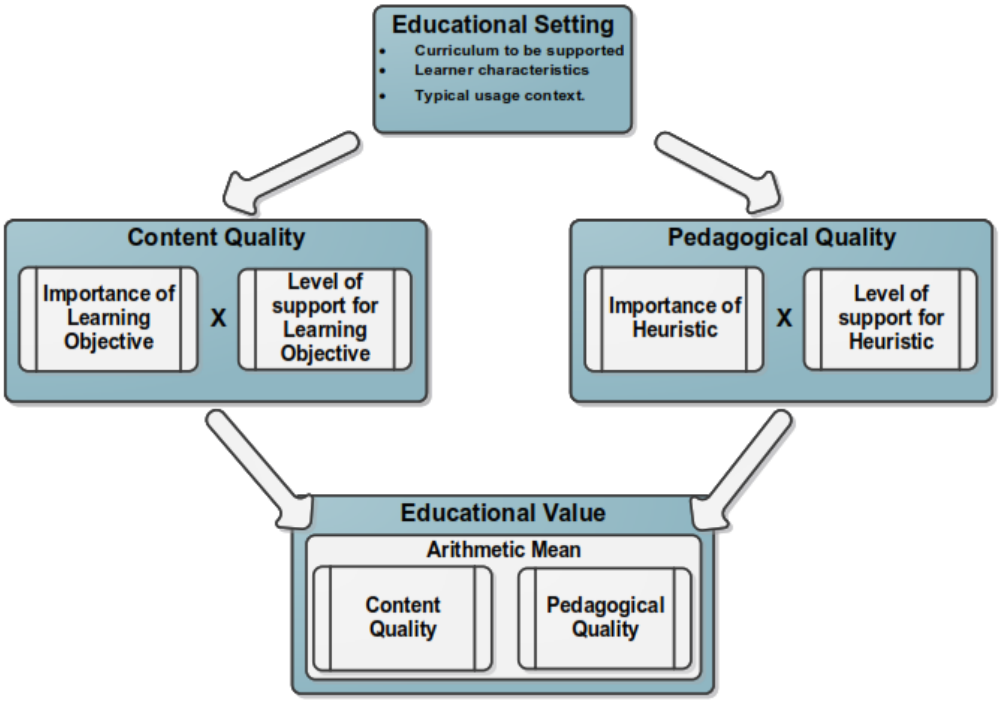

Figure 1: The composition of educational value

It is important to note that **not** all heuristics or learning objectives are applicable or are of similar importance. The evaluation of any e-learning software cannot be held in isolation; it must first consider the educational setting (learning context) in which the software will be used. This will help the evaluators to understand the relative applicability and importance of specific heuristics and learning objectives.

The evaluators must have a firm understanding of the: curriculum and specific learning objectives the software must support; the characteristics of the learners who will use the software; and what is the typical usage context the software will be used in.

If teachers are undertaking evaluations for themselves, they will typically already know this information. If the evaluation is requested by an educational institution, then they may give this information to the evaluation group, or potentially there may be some interchange between those who have requested the evaluation and the evaluation group in order to finalise the educational setting.

Each evaluator uses their own experience, in conjunction with their knowledge of the educational setting and their understanding of the pedagogical heuristics to judge:

1. Whether each heuristic and learning objective is applicable to the particular educational setting,

2. If judged to be applicable then the evaluator judges the **importance** of each heuristic and learning objective, and
3. Finally, the evaluator judges the **level of support** the e-learning software gives to the applicable heuristics and learning objectives.

The importance and the level of support are then multiplied to give the e-learning software's weighted support for each heuristic and each learning objective. The individual weighted support values are summed to create Content Quality and Pedagogical Quality values. These are in turn compared against the theoretical maximum levels to create the %Content Quality and %Pedagogical Quality. Finally, these are averaged to generate %Educational Value. The calculation process is not a critical step for the evaluators since the embedded excel object in Section 8 does this after it is filled with the evaluation results.

2.3 Intended Usage

It should be noted that the proposed heuristics that underlie this evaluation protocol are not directly intended to instruct pedagogy to teachers. However, many of the heuristics and approaches outlined in the pedagogy can be used by experienced teachers to further inform their teaching practice. The pedagogical heuristics are intended for use in the following scenarios:

1. They provide reference heuristics to guide teachers and instructional designers in the pedagogical design of new e-learning software, and
2. In the context of this document, they are used as evaluation heuristics for the review and selection of e-learning software appropriate for high-school computer science education.

When used for evaluation purposes, the pedagogical heuristics and evaluation protocol can be used for three main purposes (formative evaluation, summative evaluation, and comparative evaluation):

1. The formative evaluation of e-learning software during the design and development stages to improve the educational value of the software before it is released.
2. The evaluation of e-learning software prior to its use, so that teachers can make the right software selection decision and plan their lessons in alignment with the pedagogical qualities of the software.
3. The systematic comparative evaluation of an e-learning software with one or more different implementations of equivalent software.

Refer to Figure 2 for a visual representation of intended usage of the pedagogical heuristics and the evaluation protocol.

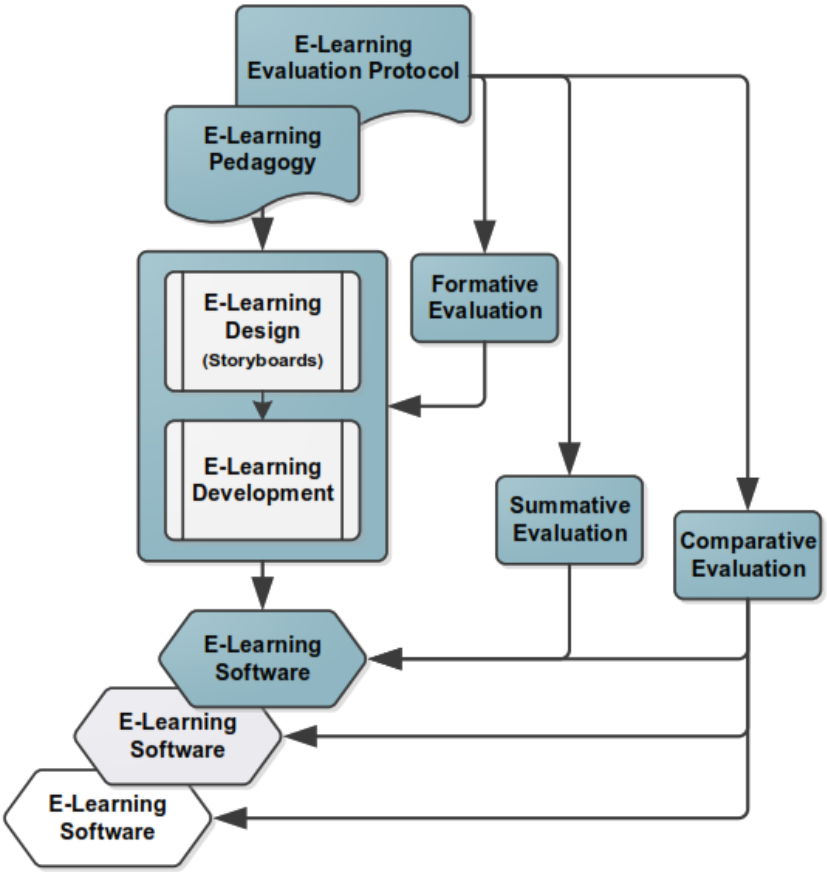

Figure 2: Intended usage of pedagogical heuristics and evaluation protocol

2.3.1 Formative Evaluation

The e-learning pedagogy can be used by a teacher or instructional designer as reference heuristics for the pedagogically informed design of e-learning software. During the design and development process, after the storyboard design is stable, a different set of (impartial) teachers or instructional designers can use the evaluation protocol to give a formative evaluation. The formative evaluation can focus either on a detailed storyboard design or a pre-release version of the software. In this manner, the evaluation group can iteratively feed into the design and development process to improve the educational value of the software.

2.3.2 Summative and Comparative Evaluation

Considering the context of high-school computing, a teacher who intends to enrich their teaching with digital resources, may use the evaluation protocol to decide which e-learning software best fits with the pedagogical strategies planned for their classroom.

For schools or other educational institutions planning to invest in e-learning software to support a computing curriculum, a more rigorous evaluation process can be carried out. The educational organisation can organise a group of teachers, instructional designers or other education experts who can use the evaluation protocol to quantitatively measure the content quality, the

pedagogical quality and the overall educational value of the e-learning software. Ultimately, the evaluation protocol can be used to advise the purchasing decisions for e-learning software; it does this by supporting the comparative evaluation of different e-learning implementations that focus on the same learning outcomes.

2.4 Intended Audience

As previously mentioned, the proposed heuristics and evaluation protocol are intended for use by teachers and / or instructional designers engaged in the design of new e-learning software or in the "**expert**" evaluation of existing e-learning software.

The term expert does not necessarily mean an expert in the evaluation process; instead, the focus is on the level and area of expertise of the evaluator. Evaluators can conceptually be grouped into novices, experienced and experts. In the context of this evaluation protocol:

1. a **novice** has general knowledge and expertise in using computers,
2. an **experienced evaluator** has the experience of a novice, and knowledge and expertise in teaching and pedagogy, and
3. an **expert evaluator** additionally has knowledge and expertise in the domain of computer science.

The evaluation protocol is prescribed to the level of detail that a novice could undertake an e-learning evaluation. However, it is anticipated that experienced and expert evaluators will produce progressively better evaluation performance. It should also be noted that in order to do a full e-learning evaluation of educational value (content quality and pedagogical quality) the evaluator must be classified as an expert since only someone with computer science expertise could evaluate content quality.

What exactly constitutes knowledge and expertise in a given area is difficult to define, but it is proposed to be relevant educational qualifications (i.e. a subject qualification and a teaching qualification) and a minimum of one, or preferably two years of experience. If the evaluator does not have relevant qualifications, then their experience should be significantly longer.

One shortcoming of heuristic evaluations is the potential for subjectivity since the evaluation (although guided) is ultimately based on the evaluator's judgement, experience and disposition at the time of the evaluation. In addition, there is the potential for incomplete evaluation coverage, in which an evaluator overlooks content and pedagogical quality feedback. It is therefore highly recommended that e-learning evaluations are carried out by multiple evaluators. The *"collected wisdom"* of several evaluators is not just equal to that of the best evaluator in the group. The overall accuracy and results of an evaluation are dramatically

improved by combining the results from multiple evaluators. The number of evaluators in an evaluation will likely be governed by the circumstances of the evaluation, but the aim is to involve three to five evaluators.

3 HIGH-LEVEL FLOW OF E-LEARNING EVALUATION

To ensure consistent evaluation results which are both reliable and valid, the e-learning evaluation protocol follows a predefined process which is broken into three broad stages: Preparation, Individual Evaluations and Consensus. Please refer to Figure 3 for a visual representation of the evaluation process.

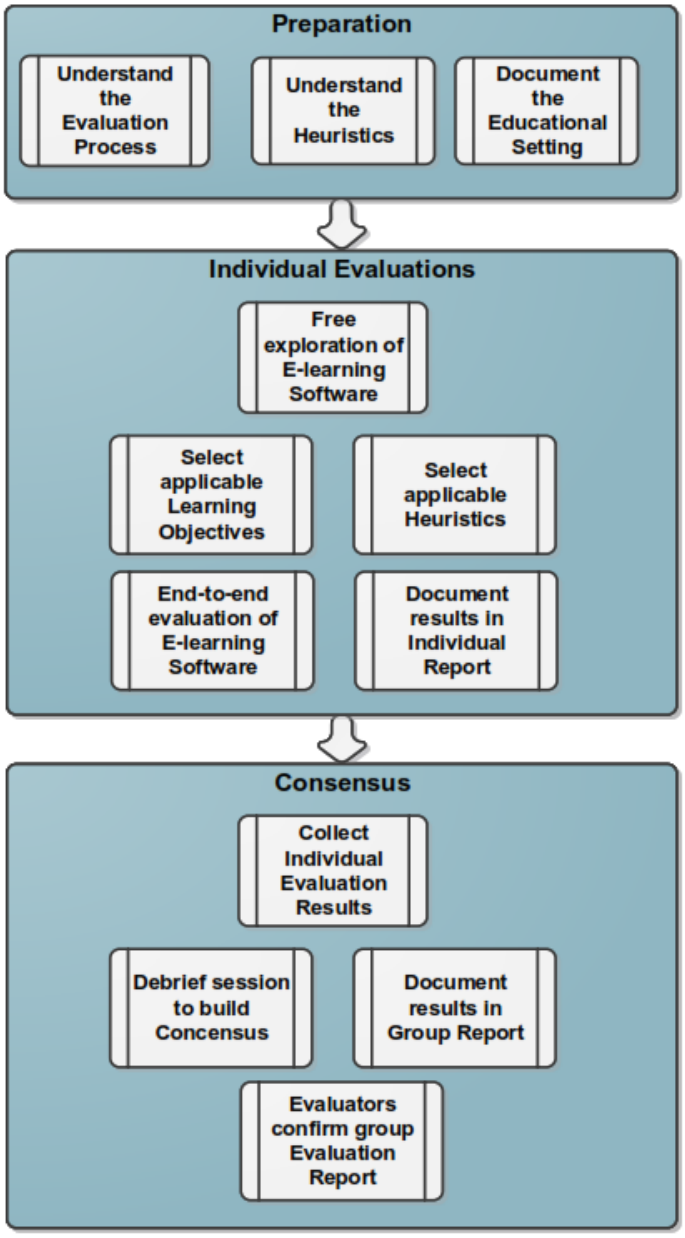

Figure 3: High-level flow of e-learning evaluation

3.1 Preparation

The exact form and level of attention given to the preparatory stage is highly dependent on whether:

1. The evaluators are novices, experienced, or experts (refer to section 2.4);
2. Whether the evaluators have previous knowledge of the heuristics;
3. Whether the evaluators have previously undertaken a similar evaluation, and therefore have knowledge of the evaluation protocol; and
4. Whether the evaluators are documenting the educational setting or are being given the educational setting by the evaluation requestor.

The preparatory phase is used to provide the evaluators with the structure and guidance needed to undertake a reliable and valid evaluation. It is informed by points one to four above, and information (pre-reading) and/or training is provided on the: the evaluation process; the evaluation heuristics; domain-specific content and curriculum; and, potentially, the educational setting in which the e-learning software will be used.

3.2 Individual Evaluations

Each evaluator conducts his or her evaluation individually and independently to form an unbiased opinion. Typically, evaluators use a minimum of two iterations through the e-learning software; a free exploration is used to get familiar with the flow of the software and its basic functions thus forming a general view of the software's design ethos.

Subsequent iterations are used to identify findings in relation to content and pedagogical quality. The proposed heuristics are not intended to be implemented as a mandatory checklist, but as a toolset in which the correct tools (heuristics) are selected by a teacher or instructional designer based on the educational setting. It is therefore critical that the evaluators consider the educational setting in which the software will be used when deciding whether specific heuristics and learning objectives are applicable, and if applicable, their importance and level of support within the software.

Each evaluator documents their findings in parallel in their personal evaluation report (this document), this should include descriptive text feedback and numeric evaluation metrics for importance and level of support.

3.3 Consensus

The final objective of the evaluation process is a single evaluation report that fairly represents the combined findings of the evaluation group. To support this objective, a debrief session is run by an unbiased facilitator whose role is to encourage effective discussion, align the individual

evaluation findings, and aggregate them into a consolidated response, which should be representative of the group. For more information on the role of the facilitator, please refer to Appendix A of this document.

After the consolidated group report is finalised it is then shared with the evaluators either for their feedback or their confirmation that it is accurate.

3.3.1 In Case Consensus Cannot be Built

As discussed previously, part of the facilitator's responsibilities is to support the evaluation group in building consensus. However, in the unlikely scenario that during the debrief session consensus cannot be reached; the facilitator has two main options: if the root of ongoing disagreement is one (or two) evaluator(s) then they may be tactfully requested to leave the evaluation group; if the group is judged to be dysfunctional overall, then the evaluation may be stopped and rescheduled later with different evaluators.

4 GUIDANCE STEPS FOR E-LEARNING EVALUATION

As discussed, this protocol is intended for use by teachers and instructional designers engaged in heuristic evaluations of e-learning software. The protocol is based on 21 pedagogical heuristics that can be used to measure the educational value of an e-learning software implementation. The below procedure offers guiding steps on how the evaluation should be carried out:

1. The evaluators should review the pedagogical heuristics to make sure they understand the heuristics and the criteria by which to judge support.
    - Alternate Option: A short training on the heuristics can be delivered in step 2.
2. The evaluation facilitator should give an introductory briefing, answer any questions the evaluators have about the heuristics and provide a short demo (high-level training) on the navigation and functional characteristics of the e-learning software.
3. Before beginning the evaluation, the evaluators should document their understanding of the educational setting the e-learning software will be used in. Such as:
    a) Target audience and learner characteristics: A thorough description of the intended audience and their learner characteristics.
    b) Instructional goals and objectives: The evaluators should know as much as possible about the needs that the e-learning software is intended to address.
    c) The typical context for using the software: realistic scenarios for when, where, and how the e-learning software will be used should be known.
    - Alternate Option: If the evaluation has been requested by an educational institution then they will provide the educational setting.
4. The evaluators should expend time exploring the e-learning software before beginning the actual heuristic evaluation.
5. Based on their knowledge of the educational setting, the evaluator should provisionally update their feedback template to remove from consideration learning objectives and heuristics that are not relevant to the particular educational setting.
6. The evaluator will assume the role of a typical learner and should go through the software from beginning to end to conduct their individual heuristic evaluation.
7. The evaluator should document the following items in their feedback template:
    a. The importance of each learning objective within the educational setting (refer to Figure 4);

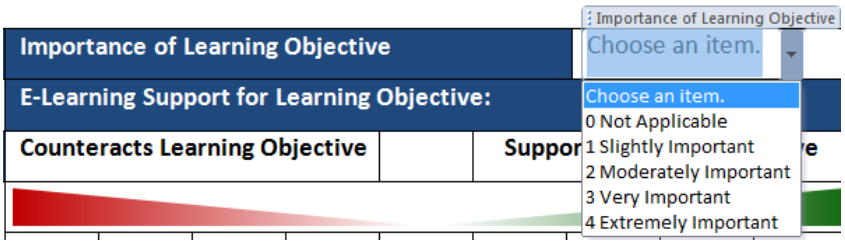

Figure 4: The response scale for the importance of a learning objective.

b. For learning objectives that are judged to be applicable; the level of support the e-learning software provides to it (refer to Figure 5);

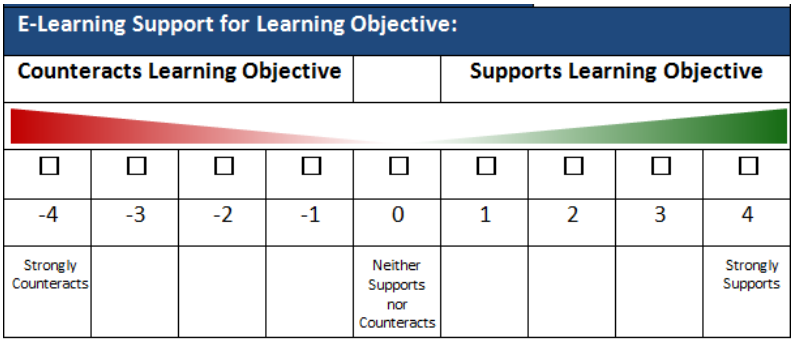

Figure 5: The response scale for the level of support the e-learning software provides to a learning objective.

c. Supporting comments for the evaluator's judgement of the importance of a learning objective and the level of support the e-learning software provides for a learning objective;

d. The importance of each heuristic within the educational setting (refer to Figure 6);

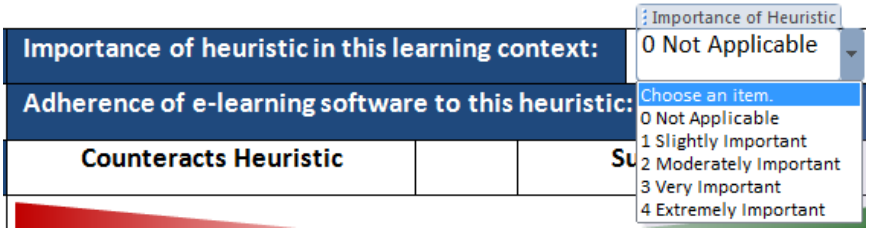

Figure 6: The response scale for the importance of the heuristic in this educational setting.

e. For heuristics that are judged to be applicable; the level of adherence the e-learning software provides to it (refer to Figure 7); and

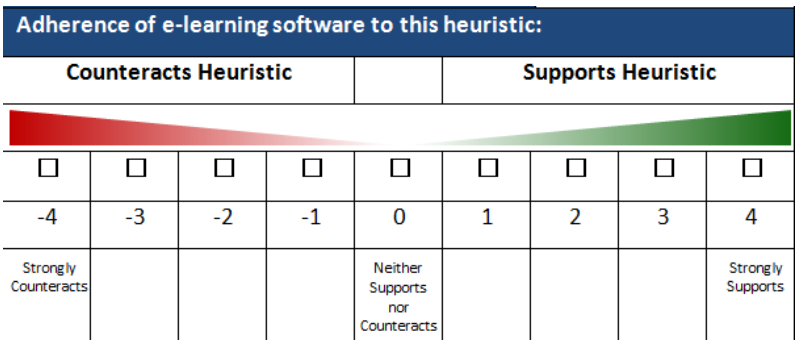

Figure 7: The response scale for the level of adherence the e-learning software has towards the heuristic.

f. Supporting comments for the evaluator's judgement of the importance of a heuristic and the level of adherence the e-learning software provides to a heuristic.

8. Either the evaluators or the evaluation facilitator will transfer the quantitative findings into the summary results excel embedded in each feedback template.
9. Most heuristic evaluations involve three to five evaluators. Once all evaluators have completed their evaluations, they should be brought together for a debriefing session led by the facilitator. The debriefing should build consensus between evaluators on:
    a. the relative importance of the learning objectives and the heuristics to a particular educational setting,
    b. the level of support the e-learning software provides to the learning objectives and heuristics, and
    c. weak areas and recommendations for how to improve support for specific learning objectives or heuristics.
    - Important: In order to support common understanding within the group: the facilitator should briefly present (again) the educational setting at the start of the debrief meeting; and when discussing each learning objective and heuristic, have them available for review and clarification.
10. The evaluation facilitator should document the consolidated findings from the debrief session into a single evaluation feedback report.
11. The evaluators should confirm the report is a fair representation of their consolidated findings.

5 EVALUATION FEEDBACK TEMPLATE

5.1 Educational Setting

Target Audience and Learner Characteristics: (Consider age, education level, motivation, incentive, computer experience and any other characteristics you consider relevant)	**Example:** • GCSE Students – 15/16 year olds • Both genders • Some interest in computer science but varying levels of motivation • Varying levels of ability • Comfortable with using computers • A reasonable level of English language skills, but may not be 1st language
Typical Context for using the E-learning Software: (Consider typical learning or teaching contexts e. g. asynchronous learning, in class synchronous instruction, in-class asynchronous learning, blended learning, flipped teaching, homework, revision)	**Example:** • Teaching GCSE Computer Science, potentially any of the following exam boards OCR, AQA, EDEXCEL. • The software will typically be used by students individually (with some collaborative work) under a scheme of work directed by a teacher. The students would be assigned to complete work in class (in class asynchronous) or for homework. • As part of their lesson plan, the teacher may also use the software for blended learning, flipped teaching, homework or revision.

	• The software can also be used for individual independent learning but is unlikely to be used as the only educational resource for a student to sit the GCSE Computer Science exam.

5.2 Learning Objectives Evaluation

ID	Learning Objective:	Importance of Learning Objective								Choose an item.
1	Example: Understand the concepts of variables and constants	E-Learning Support for Learning Objective:								
Supporting Comments:		Counteracts Learning Objective					Supports Learning Objective			
		☐	☐	☐	☐	☐	☐	☐	☐	☐
		-4	-3	-2	-1	0	1	2	3	4
		Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
2	Example: Understand the concept of data types	E-Learning Support for Learning Objective:	

Supporting Comments:	Counteracts Learning Objective					Supports Learning Objective			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
3	Example: Be able to use arithmetic calculations in your algorithms	E-Learning Support for Learning Objective:	

Supporting Comments:	Counteracts Learning Objective					Supports Learning Objective			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
4	Example: Be able to use Boolean expressions in your algorithms	E-Learning Support for Learning Objective:	

Supporting Comments:	Counteracts Learning Objective					Supports Learning Objective			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
5	Example: Using flowcharts determine the purpose of simple algorithms and explain how they work	E-Learning Support for Learning Objective:	

Supporting Comments:	Counteracts Learning Objective					Supports Learning Objective			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective								Choose an item.
6	Example: Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.	E-Learning Support for Learning Objective:								
Supporting Comments:		Counteracts Learning Objective					Supports Learning Objective			
		☐	☐	☐	☐	☐	☐	☐	☐	☐
		-4	-3	-2	-1	0	1	2	3	4
		Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

5.3 Pedagogical Heuristics Evaluation

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
1	**Use authentic educational material, examples and activities.**	**Adherence of e-learning software to this heuristic:**	

Description:	Counteracts Heuristic					Supports Heuristic			
Authentic learning represents learning material in a manner that focuses on the context of when the knowledge and skills will be used. It allows the learner a closer tie to reality and a better understanding of the relevancy of the material and its true value. This, in turn, leads learners to take greater ownership of their learning, a deeper understanding and increased knowledge transfer to the real-world.	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. **Provide contextual authenticity (explore real-world dimensions, offer realistic background, simulate real-life complexities, use practices and tools used by practitioners in the field)** 2. **Provide cognitive authenticity by engaging the learner in activities which present the same type of intellectual challenges as those in the real world.** 3. **Provide activities that are intrinsically motivating that learners are encouraged to solve.** 4. **Provide learning and activities that are personally relevant or interesting to the learner.**	

5. Provide learning and activities that are not artificially constrained. **6. Provide the technical affordance for teachers and instructional designers to easily change text and visual learning material to be more authentic and personalised to their students.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
1.1	**Ensure the currency of learning material.**	**Adherence of e-learning software to this heuristic:**	

Description:

The nature of information is that it is continually changing; meaning its accuracy and validity must be re-evaluated, which in turn leads to a re-evaluation of existing knowledge and the possibility to learn more. Learning material in the e-learning software and the Collaborative Learning Environment (CLE) must be kept up-to-date; also, students should be given access to a learning network of other current learning resources and the skills to evaluate the validity of those learning resources.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Learning material and activities are up-to-date and easily editable so they can be kept current.**
2. **The e-learning software acts as a focal point that recommends other learning resources (nodes on the learning network) that are current.**
3. **Push and pull technology is used to keep learning material up-to-date.**
4. **Interactions with other people are supported, so they can provide up-to-date information**.

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
2	**Prompt reflective practice to support learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

Reflective practice is the careful contemplation of one's own thinking processes, actions and beliefs that in turn support further learning; it is an integral part of the constructivist knowledge building process. Learners typically do not reflect on their learning unless guided to do so, therefore, the e-learning software and CLE should provide reflective prompts and associated activities. These typically take the form of questions or discussions that stimulate the imagination, theory creation, further thinking, further questions or meta-cognitive thinking.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. Provide reflective prompts within the learning material **2. Include reflective practice at key points when students are challenged in accommodating new learning.** **3. Reflective activities should lead to further iterations of activity, feedback and observation based on the reflection.** **4. Provide to learners' collaborative reflection activities such as collaborative journals focused on recent learning events.** **5. Ask the learners to provide peer feedback or assessment.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
3	**Make expert and learner thinking processes explicit.**	**Adherence of e-learning software to this heuristic:**	

Description:

Students often learn something; but, may not be clear on the rationale behind it, when to do it, how to gauge progress or whether the approach is working. The e-learning software and teachers (via the CLE) should make invisible mental processes explicit for the learner to understand and thereby implement. Likewise, learners must undertake activities to clarify and reflect on their underlying thinking and the rationale for their actions in resolving a problem.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. Make solution steps and underlying thinking explicit during problem-solving. **2. Focus attention on expert behaviour.** **3. Promote learner reflection on their own thinking processes.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
4	**Use problem-based learning (PBL) to facilitate learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

Problem-based learning, in contrast to part-task instruction, focuses on the bigger picture and begins with an authentic problem or work assignment which drives the learning process in trying to solve the problem. Working on the problem takes the form of a guided discovery that integrates into the process the necessary knowledge and skills to solve the problem and arguably results in a richer more challenging learning experience.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Provide an increased focus on whole-task and guided discovery learning strategies.**
2. **Use appropriately complex and ill-structured problems.**
3. **Provide suitably rich problem representations (context).**
4. **Include multiple problems / case studies to initiate the learning process and give an authentic context.**
5. **Use a problem-based learning flow to guide the students in the approach to tackle the problem.**
6. **The problem-based learning flow can be used in iterative cycles.**

Supporting Comments:

7. Support and educate students on the metacognitive processes needed in problem-based learning. **8. Provide a collaborative environment to support the social-interactivity inherent in problem-solving.** **9. Provide a Problem Manipulation Environment.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
4.1	Use worked examples to support problem-based learning.	Adherence of e-learning software to this heuristic:	

Description:

A worked example is a step-by-step demonstration of how to perform a task or solve a problem and is one of the most effective methods to support learning; in particular, the far transfer of learning and building new cognitive skills. In this context, the examples are non-trivial and involve higher order thinking to solve problems where there are potentially multiple appropriate solutions.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Gradually transition from worked examples to problems.**
2. **Promote student explanation of worked examples.**
3. **Selectively include instructional explanation of worked examples where appropriate.**
4. **Support far-transfer by using examples that provide the same underlying principles in different contexts.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
5	**Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.**	**Adherence of e-learning software to this heuristic:**	

Description:

To facilitate deep learning, students must integrate new learning material into existing schemas in their long-term memory. This allows learning to move beyond memorization and fact recall and enables the more flexible application of knowledge and skills to scenarios not explicitly covered in the learning material.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (Multiple heuristics from the below are supported):

- **1: Use authentic educational material, examples and activities.**
- **2: Prompt reflective practice to support learning.**
- **3: Make expert and learner thinking processes explicit.**
- **4: Use problem-based learning (PBL) to facilitate learning.**
- **4.1: Use worked examples to support problem-based learning.**
- **6.2: Exemplify computational thinking in problem-solving activities.**
- **9: Use social-interaction to increase learning and promote higher-order thinking.**
- **16.1: Support visual modal preference. Guideline 10, support for visualization.**

Supporting Comments:

Note: The evaluation result for this heuristic is based on the level of support for the sub-heuristics listed above.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6	**Support problem-solving through computational thinking.**	**Adherence of e-learning software to this heuristic:**	

Description:

Computational thinking is a way of thinking based on computer science concepts in order to reformulate and solve problems. There currently is no authoritative definition of what these computer science thought processes are, but one stable definition involves six concepts: a thought process, abstraction, decomposition, algorithmic design, evaluation, and generalisation. Computational thinking is both an important computer science topic that arguably deserves its own pedagogical heuristics, but also a way of thinking that influences the heuristics for problem-solving.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (Both of the below heuristics are supported):	Supporting Comments:
1. **6.1: Build a foundation for computational thinking.** 2. **6.2: Exemplify computational thinking in problem-solving activities.** **Note:** The evaluation result for this heuristic is based on the level of support for the sub-heuristics above.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6.1	**Build a foundation for computational thinking.**	**Adherence of e-learning software to this heuristic:**	

Description:

Before students can employ computational thinking, they must first have a clear foundation on what are the elements of computational thinking, be presented with real-world examples to broaden their knowledge base, and become comfortable with the use of computational vocabulary to describe problems and solutions.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Emphasise to students that the focus is not on creating tangible artefacts but about fostering specific thought processes.**
2. **Provide students a clear definition of the following computational thinking concepts: abstraction, decomposition, algorithmic design, evaluation, and generalisation.**
3. **Make use of computational vocabulary to describe problems and solutions to increase the students' comfort with concepts and terminology.**
4. **Bring computational thinking concepts to life with the use of real-world examples.**
5. **Make computational thinking more tangible to students by exemplifying it using algorithms (either as flowcharts or pseudocode).**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6.2	**Exemplify computational thinking in problem-solving activities.**	**Adherence of e-learning software to this heuristic:**	

Description:

Once a stable foundation of computational thinking concepts and terminology is established, we must exemplify the ethos, approaches and concepts used in computational thinking through worked examples and problem-solving activities that learners can actively engage in.

Counteracts Heuristic								Supports Heuristic
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Use problem-solving activities and worked examples as a vehicle to use and exemplify computational thinking.** (Heuristics 4, 4.1)
2. **Make computational thinking processes explicit to learners whilst walking through worked examples and problem-solving activities.** (Heuristic 3)
3. **Use a three-stage progression model: Use-Modify-Create.**
4. **Use a Problem Manipulation Environment for students to engage in computational thinking.**
5. **Instil in learners the ethos behind computational thinking** (refer to pedagogy Appendix B.4).

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
7	**Distribute well-designed practice activities across the lesson to support learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

Practice activities should be distributed throughout the e-learning software to support and solidify learning, rather than as an assessment of learning. The design of these activities should be for the student to apply their learning and promote further thinking, instead of shallow activities such as recognising or reiterating facts.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Practice activities should be integrated into the learning experience to support and solidify learning, instead of focusing them as an assessment.**
2. **The number and distribution of practice activities should be carefully considered in relation to intended learning outcomes.**
3. **Practice activities should be designed for the student to apply their learning and promote further thinking** (minimising shallow memory-based activities)**.**
4. **Practice activities should provide variety and intrinsic motivation.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
7.1	**Provide explanatory feedback to practice activities to promote learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

Explanatory feedback on practice activities is a further opportunity to promote learning, instead of focusing solely on assessment. In comparison to other factors influencing learning, integrating explanatory feedback into the learning process is one of the most effective.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Provide feedback that tells the learner whether the answer is correct or incorrect accompanied by a succinct explanation.**
2. **The explanation should provide cues, reinforcement or information on how to successfully complete a task or achieve learning goals.**
3. **Feedback should be provided at, or just above, the level where the student is learning.**
4. **Position the feedback in close proximity to both the question and answer, so the learner can see all together.**
5. **Feedback should focus on the task or task process and not on the learner.**
6. **Emphasise progressive feedback that shows improvement over time.**

Supporting Comments:

7. Feedback should be used to complete the feedback loop - Give students the opportunity to produce improved work based on the feedback. **8. In more complex problem-solving activities, that include multiple steps, it is important to provide step-wise feedback.**	

ID	**Heuristic Title:**	**Importance of heuristic in this learning context:**	Choose an item.
8	**Provide scaffolding to advance learning progress.**	**Adherence of e-learning software to this heuristic:**	

Description:

Scaffolding is the process by which a teacher or other guiding figure (including the e-learning software and more knowledgeable students) provide additional instructional assistance, guidance, or prompting that supports a student's learning process so they can accomplish an activity that is usually out of their reach.

Counteracts Heuristic					**Supports Heuristic**			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	**Supporting Comments:**
1. Choose appropriate scaffolding or combination of scaffolding approaches for the situation (Macro, Micro, Automated or Social). **2. Choose a variety of scaffolding techniques.** **3. Gradually remove scaffolding support as learners advance and develop their own learning strategies.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
9	**Use social-interaction to increase learning and promote higher-order thinking.**	**Adherence of e-learning software to this heuristic:**	

Description:

Social Constructivism builds upon cooperative and collaborative learning, and reflective learning practices to emphasise the importance of social interactions in shaping the learner's knowledge construction. It supports learners in reaching a higher level of learning than what can be achieved individually. In addition, the social interaction of individuals can often lead to learning that is greater than the sum of the individuals, and can ultimately result in a shared understanding inherently derived from the learning community.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. **Use social-interaction to foster the learner's ability to develop and evaluate their opinion in relation to other people's opinions.** 2. **Provide a suitable learning environment and context for social-interaction.** 3. **Provide dialogue with knowledgeable others so learners can experience expert knowledge, behaviour and guidance.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
10	**Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).**	**Adherence of e-learning software to this heuristic:**	

Description:

The Zone of Proximal Development (ZPD) is a theoretical space of understanding which is just above the level of understanding of a given individual and which can only be reached with support. It is the necessity of this support by others that explains the importance of social interaction for learning development. It should be noted that the role of the more knowledgeable other is not a role reserved only for the teacher; it is often taken by a more capable peer.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Educational material should progressively increase in challenge and maintain the learner at the upper limits of their current learning capacity.**
2. **Teachers should be able to easily update text and visual learning material to be more challenging.**
3. **Learners should be supported with scaffolding and access to more knowledgeable others.**
4. **Learners should have access to a learning community.**
5. **Provide learning content and activities that adapt to the learner's current abilities and progress.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
11	**Use collaborative learning activities.**	**Adherence of e-learning software to this heuristic:**	

Description:

The integration and construction of knowledge in schemas (in long-term memory) happen on an individual level; however, it is evident that other people affect the learning process and that arguably learning most naturally occurs, not in isolation, but when students work together. Collaborative learning capitalizes on other people's knowledge, skills and resources; allowing learners to monitor one another's work, share information, summarise points, verify and test their knowledge, and debate their opinions.

Counteracts Heuristic — **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Ensure social interdependence of the group.**
2. **Design the collaborative activity based on intended learning outcomes.**
3. **Design the collaborative activity to ensure the quality of the collaborative dialogue.**
4. **Provide structure and support for collaborative activities**
5. **Consider team size and composition.**
6. **Pre-train and prepare students for collaborative activities.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
11.1	**Support collaborative and situated learning via mobile devices.**	**Adherence of e-learning software to this heuristic:**	

Description:

Arguably, we are currently living through a paradigm shift from education in formal settings, towards education that extends beyond the classroom to become more situated, personal, collaborative and informal. This paradigm shift is supported by the explosion of mobile devices, their significantly enhanced capabilities, and pervasive wireless networks and cloud computing that enable communication, collaboration and sharing of information resources almost anywhere.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **The instructional design of the e-learning software and collaborative learning activities should support self-directed learning.**
2. **The implementation of the e-learning software should be developed considering technologies that are commonly accessible on mobile devices** (e.g. Web browsers and HTML5, etc.)**.**
3. **The instructional design and implementation of the e-learning software should intrinsically support the form factor and characteristics of mobile devices (responsive design).**
4. **The instructional design and implementation of the e-learning software should be enhanced to take advantage of learning opportunities only available on mobile devices**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
12	**Develop and nurture networks to support learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

Connectivism proposes that knowledge lies in a diversity of opinions and that this knowledge resides in a network of interconnected entities called nodes. These nodes can be almost anything with learning value such as individuals, groups, systems, fields, ideas, or communities; but for the most part, the focus lies on humans and digital resources. In its most powerful form, the connectivist network can be developed into a learning community that clusters together similar areas of interest and facilitates the sharing of knowledge, dialogue and other interactions that support learning.

Counteracts Heuristic — **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **The e-learning software should act as a focal point that recommends other learning resources (nodes on the network) through web links.**
2. **The e-learning software should promote collaborative learning interactions with other students and/or teachers.**
3. **The learning process should be cyclical in nature. The learner joins the network to gather information, updates their understanding and later reconnects to the network to share their new knowledge.**
4. **The e-learning software and its constituent learning objects should act as nodes on the network.**

Supporting Comments:

5. The e-learning software can make use of information and other learning resources found on the network. **6. The learning network should be developed into a learning community.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
13	**Use constructivist approaches to increase intrinsic motivation in the learner.**	**Adherence of e-learning software to this heuristic:**	

Description:

Intrinsic motivation stems from interest or enjoyment in the learning or the activity itself, and originates within the individual rather than relying on external incentives. Motivation is essential in giving the learner the incentive to devote the mental energy to learn. Several constructivist principles such as whole-task and problem-based learning, authentic learning, active learning, mindful activity, etc. are shown to be intrinsically motivational and therefore supportive of the learning process.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Focus on whole-task (holistic) learning and on problem-based learning.**
2. **Focus on authentic educational material, examples and activities.**
3. **Focus on social and collaborative learning to improve student engagement.**
4. **Enable learners to manage and take responsibility for their own learning.**
5. **Convey the importance of the learning activity to the Learner.**
6. **Focus on active learning that encourages the student to actively engage their mental processes.**

Supporting Comments:

7. Provide a problem manipulation environment that supports mindful activity.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14	**Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.**	**Adherence of e-learning software to this heuristic:**	

Description:

Irrespective of the effectiveness of the learning material, without motivation, students are hampered from learning, and whilst motivation cannot be directly controlled, it can be positively influenced. According to the ARCS model, in order to predictably improve motivation and performance, the instructional material and environment should capture the learner's attention, ensure relevance to the learner, build learner confidence and ensure learner satisfaction.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (Multiple heuristics from the below are supported):

1. **14.1: Use "Attention" grabbing strategies to increase learner motivation.**
2. **14.2: Explain the "Relevance" of the learning material to increase motivation.**
3. **14.3: Build "Confidence" to increase learner motivation.**
4. **14.4: Build "Satisfaction" to increase learner motivation.**

Note: The evaluation result for this heuristic is based on the level of support for the sub-heuristics listed above.

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.1	Use “Attention” grabbing strategies to increase learner motivation.	Adherence of e-learning software to this heuristic:	

Description:

The first step in increasing learner motivation is to capture their attention and then employ strategies to sustain their attention throughout the learning process. This involves initial inquiry arousal, stimulating a deeper level of curiosity and then sustaining attention via varied instructional techniques.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. **Capture student attention at the start of the learning process** via stimulating graphics, animations and/or instructional material that invoke a sense of wonderment, incongruity, conflict, or personal or emotional resonance with the students. 2. **Stimulate a deeper level of curiosity by fostering the learner’s inherent nature to explore, discover and understand.** 3. **Maintain attention via variable instructional design; avoid using the same instructional approaches repeatedly.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.2	**Explain the "Relevance" of the learning material to increase motivation.**	**Adherence of e-learning software to this heuristic:**	

Description:

To ensure that motivation is maintained the learner must perceive the learning material has a personal relevance to them; there must be a "*connection between the instructional environment, which includes content, teaching strategies, and social organization, and the learner's goals, learning styles, and past experiences*" (Keller 2008, p.177).

Counteracts Heuristic								Supports Heuristic
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (one or more supported):

1. **Aligning with learner goals -** Reflect an understanding of the learners' needs and demonstrate how the new knowledge or skills will support them in achieving their goals.
2. **Aligning with learning styles –** If criteria 1 cannot be satisfied then establish relevance related to how something is taught.
3. **Aligning with what is familiar –** Engage the students on a personal level and relate the learning material back to the learner's real life.

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.3	**Build "Confidence" to increase learner motivation.**	**Adherence of e-learning software to this heuristic:**	

Description:

Building learners' confidence in their ability to learn also increases their motivation to learn; any learned helplessness or fear of the topic, skill or environment that hinders learning should be addressed and replaced by an expectation of success. The positive expectancy for success should then be followed promptly by actual success that the learners can clearly attribute to their own abilities and efforts.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (one or more supported):

1. **Establish trust and positive expectations for learning success.**
2. **Provide opportunities for meaningful success.**
3. **Balance a stable e-learning environment with the learner's need to feel in control and responsible for their success.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.4	**Build "Satisfaction" to increase learner motivation.**	**Adherence of e-learning software to this heuristic:**	

Description:

Once motivation is inspired in the learner, it needs to be maintained by providing the learner with a sense of satisfaction with the process and/or results of the learning experience. This is achieved by a combination of intrinsic methods, extrinsic reinforcement and a sense of fairness in the learning results.

Counteracts Heuristic — **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (one or more supported):

1. **Use intrinsically motivational learning experiences** (i.e. meaningful and authentic practice activities, opportunities for coordination/collaboration, opportunities for learner control, providing a holistic view).
2. **Provide positive extrinsic reinforcement to learners' successes** (to supplement not replace intrinsic motivation).
3. **Ensure learners perceive the learning process, assessment and rewards as being fair.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15	**Use gamification to increase motivation and learning performance.**	**Adherence of e-learning software to this heuristic:**	

Description:

In the context of e-learning, gamification is the use of game design elements within e-learning software to increase the pleasure, fun, and motivation in the learning process and to encourage positive learning behaviour. Game design elements must be tightly integrated with existing intrinsically motivational aspects of the software. Suggested game design elements include: points, leaderboards, achievements/badges, levels, rewards, progression, challenge, storytelling, clear goals, rapid feedback, explanatory feedback, freedom to fail, etc.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (Multiple heuristics from the below are supported):

1. **Integrate gamification elements tightly with existing learning processes.**
2. **Build extrinsic gamification elements on top of existing learning processes.**

Note: The evaluation result for this heuristic is based on the level of support for the sub-heuristics listed above.

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15.1	**Integrate gamification elements tightly within existing learning processes.**	**Adherence of e-learning software to this heuristic:**	

Description:

Many aspects of good game design correlate with existing pedagogical practices; therefore, they should already exist within the instructional design of the e-learning software. These should not be reinvented for gamification purposes; instead, gamification elements should simply integrate with the existing pedagogical elements. These pedagogical elements include: storytelling, progressive challenge, intrinsically motivational activities, rapid explanatory feedback, tutorials on how to use (play), and social interaction.

Counteracts Heuristic						Supports Heuristic		
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (one or more supported):

1. **Gamified learning should offer progression and progressive challenge.**
2. **Gamified learning should offer an engaging story.**
3. **Gamified learning should allow learners the freedom to fail and provide rapid feedback to support learning.**
4. **Gamified learning should provide activities for learners to engage in.**
5. **Game rules and tutorials need to be explained to players.**
6. **Gamified learning is a social activity.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15.2	**Build extrinsic gamification elements on top of existing learning processes.**	**Adherence of e-learning software to this heuristic:**	

Description:

Certain gamification elements are not part of established pedagogical approaches; they attempt to leverage people's love of competition and reward to encourage desired learning behaviour. They reflect learner progress and attempt to motivate desired learning behaviour through extrinsic rewards such as points, leaderboards, achievements/badges and levels. Since these gaming elements are not inherently part of existing pedagogical practices, they need to be built on top; however, they should only be used if there is an existing foundation in heuristic 15.1.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Encourage desired learning behaviour with instant reward. This is achieved by the following mechanisms:**
    a. Points are a quantifiable metric that track and define progress; typical examples include experience, skill, social, and redeemable points.
    b. Badges are usually awarded for actions a player has just completed and offer a visual display of achievement.
2. **Communicate progress to the learner via points, badges, a progress bar and levels.**

Supporting Comments:

3. Provide Social Recognition for desired learning behaviour.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16	**Use multi-modal learning approaches.**	**Adherence of e-learning software to this heuristic:**	

Description:

Students are not restricted to only one of the modal preferences (visual, aural, read-write, or kinaesthetic). It is typical for students to exhibit a preference for one particular mode and relative weakness or strength in other modes. However, even the relatively weaker modes should not be ignored; students should still be exposed to diverse learning experiences and encouraged to develop into more versatile learners. The e-learning software should accommodate the four modalities by providing a variety of different learning options that consider the different learning styles.

Counteracts Heuristic						Supports Heuristic		
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (a significant subset of the following are supported):

1. **The e-learning software and associated CLE activities incorporate learning material that supports the four VARK modal preferences.**
   - 16.1: Support visual modal preference.
   - 16.2: Support aural modal preference.
   - 16.3: Support read-write modal preference.
   - 16.4: Support kinaesthetic modal preference.

Supporting Comments:

2. The e-learning software and associated CLE activities should provide an approximate balance between the four modal preferences. **3. The choice and balance of modal channels must carefully consider and align with the learning context and content.** **4. The e-learning software and associated CLE activities should support the four modal preferences without causing cognitive overload.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.1	**Support visual modal preference.**	**Adherence of e-learning software to this heuristic:**	

Description:

Visual learners prefer graphical and symbolic ways of representing information. They have good visual recall and prefer information to be presented visually, in the form of diagrams, graphs, maps, posters, displays, etc. In addition, where learning material is complex, includes invisible or difficult to see phenomena, or has difficult concepts or process steps, then special attention must be given to visualization tools that help learners to construct appropriate mental images and visualize activities.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (a subset of the following are supported):

1. **Learning material that is rich in visual depictions such as:**

a) Diagrams	b) Maps	c) Mind-maps
d) Posters	e) Graphs	f) Displays
g) Flowcharts	h) Multimedia	i) Symbolic representations
j) Graphical organisers	k) Visual demonstrations	l) Visual modelling

2. **Represent thought processes as visual representations.**
3. **Focus on the big picture with holistic instead of reductionist approaches.**
4. **Use underlining, highlighters and different colours.**

Supporting Comments:

5. Link text with associated diagrams and pictures. **6. Use non-visual learning that is appealing to visual learners:** a. Provide past examples of finished products. b. Activities that allow freedom and emphasise creativity. c. Group learning. d. Role-playing. **7. Avoid over-focus on word usage, syntax and grammar.** **8. Promote activities to convert notes into one-page pictures and vice versa.** **9. Provide the opportunity for students to use diagrams and visual elements in answering questions and in assignments.** **10. Support visualization by including visual representations of learning material that is very complex, includes invisible or difficult to see phenomena, or has difficult concepts or process steps.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.2	Support aural modal preference.	Adherence of e-learning software to this heuristic:	

Description:

Auditory learners prefer to learn from listening. They have good auditory memory and benefit from lectures, tutorials, discussions with other students and faculty, interviewing, hearing stories, audio tapes, etc.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (a subset of the following are supported):

1. **Give additional focus to auditory learning material.**
2. **Promote lectures and tutorials that are primarily focused around hearing the teacher talk.**
3. **Emphasise oral presentation, instructions, questioning, answers and reward.**
4. **Promote discussion activities with other students and/or teacher.**
5. **Promote activities to orally describe overheads, pictures and other visuals to somebody else.**
6. **Promote activities to record interesting examples, stories and jokes as memory aids.**
7. **Promote activities to create audio versions of instructional texts and learner notes.**
8. **Promote activities to interview experts.**

Supporting Comments:

9. **Promote activities to read written notes aloud.** 10. **Promote activities to supplement existing written notes by talking with others and collecting notes from the textbook or other learning resources.** 11. **Promote activities to orally report your understanding of a topic or explain your notes to another aural person.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.3	**Support read-write modal preference.**	**Adherence of e-learning software to this heuristic:**	

Description:

Read-write learners prefer to learn through information represented as words, they benefit from lecture notes, note taking, journals, lists, definitions, textbooks, etc.

Counteracts Heuristic						Supports Heuristic		
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (a subset of the following are supported):

1. **Give increased focus on individual learning.**
2. **Avoid vague, non-specific activities in favour of giving more concrete direction on expectations and deliverables.**
3. **Provide written learning material (lecture notes, handouts and references to textbook and manuals)**
4. **Use lists, headings, glossaries and definitions.**
5. **Promote the use of:**
    a. Written directions.
    b. Written questions.
    c. Well-structured open-ended questions with a text response.
    d. Essay writing activities.
    e. Journaling activities
    f. Word walls activities (wordle).

Supporting Comments:

6. **Allocate reading time.** 7. **Promote activities to write notes, then rewrite and reread repeatedly as a revision tactic.** 8. **Promote activities to rewrite subject ideas and principles into different words.** 9. **Promote activities to reconstruct any visual elements such as diagrams, graphs, charts etc. into textual statements.** 10. **Promote activities to reconstruct actions, events or behaviours into textual statements.** 11. **Promote activities to arrange learning material and notes into titles, hierarchies and points.** 12. **Promote activities to represent list-based learning material into multiple-choice questions.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.4	**Support kinaesthetic modal preference.**	**Adherence of e-learning software to this heuristic:**	

Description:

Kinaesthetic learners prefer learning that connects to their experience and reality. They are more adept at recalling events and associated feelings or physical experiences from memory. This experience can be derived through physical activity such as field trips, manipulating objects and other practical first-hand experience. However, it can also be derived through simulation and the presentation of information strongly tied to experience and reality. Hence, Kinaesthetic learning can be multi-modal since the information describing experience and reality can be presented in a visual, aural or read-write form.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (a subset of the following are supported):

1. **Promote practical activities (experiments) either real or simulated that engage understanding by doing.**
2. **Promote learning material directly connected to experience and reality.**
3. **Promote learning based on real-life examples.**
4. **Provide case studies and real-life applications to help with the understanding of principles and abstract concepts.**
5. **Provide questions based on practical activities.**
6. **Provide learning based on live demonstrations.**

Supporting Comments:

7. **Promote activities focused on finding solutions to real life problems.** 8. **Promote activities that incorporate an element of trial and error.** 9. **Provide learning material that uses exhibits, samples, pictures and photographs that illustrate an idea and tie back to real life.** 10. **Promote activities to recall experiments and physical experiences from memory.** 11. **Promote learning that uses multiple senses, such as sight and hearing or tries to evoke the senses of touch, taste and smell.** 12. **Promote activities that use previous exam papers and conditions.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17	**Integrate words and graphics together, instead of words alone.**	**Adherence of e-learning software to this heuristic:**	

Description:

An important part of active processing is to construct visual and text representations of learning material and to connect them mentally. The e-learning software should, therefore, include both words (audio or screen text) and graphics (static illustrations, animations or videos etc.) to support learners in developing their mental models. The visual elements should not be treated as an afterthought after the text has been written; instead, multimedia lessons should contain words and corresponding visuals that work together to explain the learning material.

Adherence of e-learning software to this heuristic:

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):	Supporting Comments:
1. **Visual elements should be integrated with accompanying aural or printed text.** 2. **A variety of graphical types can be used in accordance with the intended learning outcomes.** For a brief description of these graphical types, please refer to the pedagogy appendices, Appendix B.7. 3. **Graphical elements should be used to provide navigational support and signposts for learning.** This is discussed in depth in heuristic 21.1	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	**Adherence of e-learning software to this heuristic:**	

Description:

It is important to avoid learning material that requires learners to split their attention between, and mentally integrate, multiple sources of information. The process of integrating distinct sources of information creates an unnecessary cognitive load that can be avoided by aligning and integrating words (audio or screen text) in close proximity (i.e. contiguous) to corresponding graphics.

Counteracts Heuristic						Supports Heuristic		
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **For contiguity to apply, the multiple sources of information are essential for understanding, and difficult to understand in isolation.**
2. **Place printed words near corresponding graphics.** Please refer to pedagogy appendix B.8 for a brief outline of common mistakes in this area.
3. **Avoid the overuse of text.** Please refer to pedagogy appendix B.9 for some tips on how to reduce unnecessary text.
4. **Synchronise spoken words with corresponding graphics.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17.2	Representing words as audio, on-screen text or both	Adherence of e-learning software to this heuristic:	

Description:

When words are accompanying visual elements, and both require the learner's simultaneous attention, it is typically better to present the words as audio instead of on-screen text. This avoids cognitive overload by balancing the learning material across two separate cognitive channels - words in the auditory channel and graphics in the visual channel. Furthermore, it is typically recommended to not duplicate words via audio and screen text. This avoids situations where the learner focuses too much on screen text to the detriment of the graphics or potentially focusing on the screen text and narration and comparing whether they are equivalent. However, exceptions to these guidelines do apply.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Words communicated in audio form should be preferred over on-screen text if the text needs to be synchronised with more dynamic visual elements such as animations, videos, or series of static frames.**
2. **When explaining graphical elements, it is better to avoid duplicating words in both audio and screen text.**
3. **The audio material must be clear and concise and synchronised with the visual learning material.**

Supporting Comments:

4. **When you do not have a simultaneous graphical presentation then modality does not apply, and screen text alone can be presented.** **Exception Scenarios** 5. **In some scenarios, keywords should still be highlighted on screen with visual elements to act as a graphical organiser and to direct the learner's attention.** 6. **With specific learning contexts and learning material, screen text should be preferred even if there is a simultaneous graphical presentation.** For instance: a. when words should remain available to the learner over time, b. when the words are technical, unfamiliar or formulae, c. when the words are not in the learner's native language, d. when lengthy text is being presented or is necessary for future reference, or e. when the text lists keys steps in a procedure or gives directions in a practice exercise. 7. **There remain some conditions when the use of redundant on-screen text in conjunction with audio narration can give learning benefits**: a. When there is no graphical element, you may decide to have narration and some text, therefore using dual channels and not overloading either. b. The scenarios listed in point 6.	

c. When there is ample time to process the visual elements; for instance, when text and graphics are presented sequentially or when the pace of the presentation is sufficiently slow.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
18	**Avoid adding learning content that does not directly support your instructional goal.**	**Adherence of e-learning software to this heuristic:**	

Description:

Learning content should directly support the instructional goal. There is a strong temptation to add extra material in e-learning that will grab the attention of students and keep them interested and engaged. This can lead to interesting but unnecessary learning material, the use of overly dramatic stories and examples, and gratuitous use of text, audio, visual and multimedia elements, which in turn can actually harm the learning process. It is important to note this is one of the most commonly violated principles but is relatively easy to implement and can give a significant learning improvement.

Counteracts Heuristic — **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **The learning material should not be embellished with unnecessary detail or material that focuses only on creating interest.**
2. **The interest and engagement should come from the core learning content and instructional design.**
3. **Avoid the addition of environment sounds and / or background music.**
4. **Avoid pictures and graphics that are purely decorative.**

Supporting Comments:

5. **Avoid visual elements that are somewhat (indirectly or tentatively) related to learning objectives since they disrupt the learning process.** 6. **Use simpler visuals.** 7. **Avoid adding extraneous text with embellished textual or narrative descriptions, in preference for concise focused text or narrative.** 8. **Avoid lengthy audio or video segments which can cause learner frustration from having to progress through the entire segment to extract the relevant learning.**	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
19	**Optimise essential processing by segmenting learning material and providing pre-training.**	**Adherence of e-learning software to this heuristic:**	

Description:

In the cognitive learning theory, essential processing reflects the learning processes used by the student to understand the core learning material. It is fundamental to the learning process, but is significantly impacted by the inherent complexity of the material. Therefore, to get better learning results, it is vital that the complexity of the learning material is effectively managed. Two approaches are suggested to manage this complexity: segmenting breaks a lesson into manageable segments that do not overload the student's cognitive processes, and pre-training provides foundation information that gives names and characteristics of key concepts that can be built upon and used in the main learning segments.

Counteracts Heuristic								Supports Heuristic
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Break learning material into smaller segments and present them sequentially.**
2. **Organise segments into metaphorical chapters.**
3. **Provide a stable foundation for learning by giving a pre-training which orients the learner and explains terminology and pre-requisite concepts.**

Supporting Comments:

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
20	**Use a conversational style in screen text and audio narration.**	**Adherence of e-learning software to this heuristic:**	

Description:

It is recommended that the e-learning software should use a conversational style (using first- and second-person and active language) in both screen text and audio narration and should avoid the use of formal and passive voice. This helps the learner engage with the e-learning software in a manner closer to a social conversational partner.

Counteracts Heuristic | **Supports Heuristic**

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Use a more informal conversational style in narration and screen text to give learners a sense that they are in a conversation with a partner; this motivates learners to work harder to understand the material.**
2. **The conversational tone and style mean using words like "I", "we" and "you".**
3. **Words and phrasing should be less formal but without reducing the importance of the learning material.**
4. **Do not overuse the conversational style to the point it becomes a distraction to learning; it should remain polite, friendly and respectful whilst not degenerating into slang and /or colloquialisms.**

Supporting Comments:

5. In an audio narration, make sure the voice of the narration is human with a standard accent instead of a computer-generated voice.	

ID	**Heuristic Title:**	**Importance of heuristic in this learning context:**	Choose an item.
21	**Provide restricted navigational control in the e-learning software.**	**Adherence of e-learning software to this heuristic:**	

Description:

Learner control is implemented by navigational features that allow the learner to choose the path they take through the e-learning software, by selecting the topics and instructional elements they prefer, and the pace at which they undertake learning. This pedagogy recommends a restricted level of navigational control and focuses more towards program control. However, the learner must be given freedom in a number of key areas; these are the pace of learning, the ability to revisit content that has already been covered and to allow learners as much personal control (as possible) over their actual learning experience.

Counteracts Heuristic					**Supports Heuristic**			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

Supporting Comments:

1. **Restrict learners' ability to control the order of lessons, topics and screens within the e-learning software, but allow the previously covered material to be revisited.** 2. **Display all important educational material as default in order to avoid it being skipped by the learner.** 3. **Allow the learners' the flexibility to learn at their own pace.** 4. **Balance a stable e-learning environment with learners need to feel in control and responsible for their success.** For details, refer to heuristic 14.3 guideline-3.	

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
21.1	**Provide consistent navigational elements and signposts for learning.**	**Adherence of e-learning software to this heuristic:**	

Description:

The e-learning software should provide a clear and consistent Graphical User Interface (GUI) that places a minimal cognitive demand on the learner and intuitively supports learning. One important part of this is to provide clear navigational elements and visual cues (signposts) of the learning material that emphasises recognition rather than recall.

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

Evaluation Criteria (One or more supported):

1. **Provide a clear and consistent navigational interface that allows the learner to intuitively progress through the e-learning software and control the educational material.**
2. **Provide clear and consistent signposts for learning, such as a course map, screen titles, embedded topic headers, labels, summaries, links, etc.**
3. **Ensure pre-training and/or a guide is provided to learners that explains the navigational interface and learning signposts.**

Supporting Comments:

6 EVALUATION RESULTS

Please double click on the embedded excel object and update the values in the yellow cells in order to calculate the pedagogical support of the e-learning software for the defined learning objectives.

Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Understand the concepts of variables and constants	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
2	Understand the concept of data types	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
3	Be able to use arithmetic calculations in your algorithms	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4	Be able to use Boolean expressions in your algorithms	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
5	Using flowcharts determine the purpose of simple algorithms and explain how they work	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6	Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
			Content Quality:	0	0	0%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
1.1	Ensure the currency of learning material.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
2	Prompt reflective practice to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
3	Make expert and learner thinking processes explicit.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4	Use problem based learning (PBL) to facilitate learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4.1	Use worked examples to support problem based learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6	Support problem solving through Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.1	Build a foundation for Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.2	Exemplify Computational Thinking in problem solving activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
7	Distribute well-designed practice activities across the lesson to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
7.1	Provide explanatory feedback to practice activities to promote learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
8	Provide scaffolding to advance learning progress.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
9	Use social-interaction to increase learning and promote higher-order thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
11	Use collaborative learning activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.1	Use "Attention" grabbing strategies to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.2	Explain the "Relevance" of the learning material to increase motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.3	Build "Confidence" to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.4	Build "Satisfaction" to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15	Use gamification to increase motivation and learning performance.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15.1	Integrate gamification elements tightly within existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15.2	Build extrinsic gamification elements on top of existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16	Use multi-modal learning approaches.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.1	Support visual modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.2	Support aural modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.3	Support read-write modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.4	Support kinaesthetic modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17	Integrate words and graphics together, instead of words alone.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17.2	Representing words as audio, on-screen text or both	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
18	Avoid adding learning content that does not directly support your instructional goal.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
19	Optimise essential processing by segmenting learning material and providing pre-training.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
20	Use a conversational style in screen text and audio narration.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
21	Provide restricted navigational control in the E-Learning software.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
21.1	Provide consistent navigational elements and signposts for learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
			Pedagogical Quality:	0	0	0%
			Educational Value:			0%

7 GLOSSARY

Glossary Term	Description
Accommodation	In relation to constructivist principles, accommodation is the process by which existing schemas have to be altered to cope with new experiences that contradict the existing mental model.
Active processing	According to Cognitive Load Theory, human learning occurs when the appropriate cognitive processes are engaged to mentally organise incoming auditory and visual sensory information and integrate it with existing knowledge so that it can be stored in and recalled from long-term memory.
Assimilation	In relation to constructivist principles, assimilation is the process by which new information reinforces an existing schema and the schema is augmented with new information
Collaboration	Collaboration involves a joint group endeavour to solve the problem; all group members contributing to the same task.
Collaborative Learning Environment (CLE)	A collaborative learning environment is a software system that offers various tools and services that support learners in working and learning together.
Cognitive Load Theory (CLT)	CLT explains how incoming information from eyes and ears is transformed into knowledge and skills in human memory. It proposes that learners do not passively receive incoming information, but instead undertake active cognitive processes that organise the incoming information into logical structures and integrate it with existing knowledge for long-term recall.
Constructivism	Constructivist approaches recognise a real world that sets limits on our experiences, but proposes that there is no uniformly perceived single reality; in fact, each person's perception of reality is a mental construct founded on their interpretation of their interactions with the world. An individual's reality is therefore based on their existing experience and understanding, which is in turn used to make sense of their current perception of events.

Cooperation	Cooperation involves the division and assignment of tasks within the group to solve the problem.
Deep Learning	As opposed to surface learning, in which learning material is passively memorised with a primary aim of passing assessments; deep Learning is learning where there is a vigorous interaction with the learning material to truly understand it and integrate it with previous experience and knowledge. Meaning it is integrated into existing mental schemas in the learner's long-term memory.
Dual Channels	Humans have separate channels for processing visual and auditory material.
Equilibrium	In relation to constructivist principles, equilibrium is the process of arriving at a stable state where there is no longer conflict between new knowledge and existing mental schemas.
Extrinsic	Not forming part of or belonging to a thing, or originating from the outside. Typically, something originating outside of a thing and acting upon that thing.
Far Transfer	Far Transfer is the application of skills and knowledge learned in one situation to a different situation. It builds upon deep learning and requires learners to adjust the underlying principles they have learnt, for use in a new scenario or new problem.
Gamification	Gamification is the use of game design elements in non-game contexts. It does not focus on creating fully fledged games, but instead uses game dynamics, mechanics, and frameworks to increase pleasure, fun, motivation and influence behaviour.
Heuristic	A heuristic is a specific rule-of-thumb or argument derived from experience
Higher Order Thinking	Higher Order Thinking theorises that some types of learning are more valuable, but require more cognitive processing and are more difficult to teach and learn. According to Bloom's taxonomy analysis, evaluation and synthesis are thought to be of a higher order as compared to remembering, understanding and applying facts and concepts.

Intrinsic	Belonging to the essential nature or constitution of a thing or originating and included wholly within an organ or part.
Mental Model	Mental models are our internal symbolic representation of external reality. They explain our thought process about how something works in the real world and shape our behaviour and approaches to solving problems.
Metacognition	Metacognition is "cognition about cognition"; in this context, it relates to thinking about one's own thinking process such as study skills, memory capabilities, and the ability to monitor learning. It is a self-awareness of our own cognitive processes and the understanding of how to regulate those processes to maximize learning.
Mindful Activity	Mindful Activity is an activity in which the learner is in direct contact with real or virtual objects and is encouraged to manipulate them in order to think, hypothesise and test their hypothesis.
Multi-Modal	Multi-modal approaches combine a mixture of approaches and teaching methods to offer balanced modal coverage.
Learning Theory	Learning theories are conceptual frameworks that describe how humans acquire new, or modify or reinforce existing knowledge, behaviour, skills, values, or preferences.
Limited Mental Capacity	At any given time, humans can actively process only limited information in each channel; material that exceeds this threshold may enter working memory but will not be processed and encoded into long-term memory.
Part-task Instruction	Traditional teaching methods take a part-task approach which breaks the syllabus down into small parts that teach topics and sub-topics; these are in turn followed by frequent (relatively small) practice activities. This approach gradually builds knowledge and skills in the learner.
Pedagogy	Pedagogy focuses on the theory and practice of education, more specifically the study and practice of how best to teach.
Problem Manipulation Environment	As part of active learning, students are encouraged to engage in mindful activity in which they manipulate real or virtual objects to support their thinking and reflective processes, and

	to test their hypothesis. This environment should have a low floor in terms of ease of entry and a high ceiling in terms features and functionality that learners can eventually master. In a computing context, such an environment should allow students to model and run simulations, look-under-the-hood on existing solutions, employ trial and error, implement designs, and test and debug solutions.
Progressive Disclosure	Progressive Disclosure is an instructional technique used to reduce cognitive load by disclosing the minimal learning material required and releasing more information progressively thereby avoiding learners being overwhelmed. This technique can also be used to create curiosity and maintain suspense by not providing all necessary material in one go.
Reflective Practice	Reflective practice is the capacity to reflect (think deeply or carefully) on our actions or thought processes in order to develop insight that in turn enables improvement. It is argued that experience alone does not necessarily lead to learning; deliberate reflection on experience is essential.
Schema	Schemas are the mental constructs that organise and categorise our skills, and knowledge and understanding of the world.

APPENDIX A – THE ROLE OF THE EVALUATION FACILITATOR

The facilitator acts as a guiding figure throughout the entire evaluation process. However, it is unrealistic to expect that each evaluation will have a professional or highly experienced facilitator engaged; nevertheless, it is important that this role is actively assigned to an evaluator: with some leadership and facilitator skills; who is categorised as an expert evaluator (refer to section 2.4) with comprehensive knowledge of the education setting; and additional experience of both the heuristics and preferably the e-learning software.

The facilitator role is crucial during the debrief meeting in building consensus since the final deliverable of the evaluation process is a single evaluation report. To this end, it is essential that the debrief session is run by an impartial facilitator who cultivates productive group discussion and accurately documents the group's consensus in the final report. Specifically, the aim is to reach a consensus in the areas of:

1. Numerical evaluation of the importance of the applicable heuristics and learning objectives,
2. Numerical evaluation of the level of support the software provides to the applicable heuristics and learning objectives, and
3. Descriptive comments on pedagogical issues and improvement recommendations.

Evaluation debrief sessions, and in particular, the role of the facilitator, share much in common with focus groups; but with some notable differences. In a focus group the facilitator typically contributes structure and process to the groups' interactions, so they are able to work effectively; the facilitator is a helper and enabler whose goal is to support the group. However, a debrief session, and the role of the facilitator in it, include the focus group characteristics and go further. A debrief facilitator should remain neutral and fair; however, considering whether the evaluation is formative or summative, they may wish to give some additional emphasis on either the qualitative (descriptive) or quantitative (numerical and measurable) nature of the debrief session.

1. Giving a slight qualitative emphasis in formative assessments is useful since it motivates richer feedback on weak areas and recommendations on how to improve e-learning software, these can then be fed back into the design and development process.
2. A slight quantitative emphasis in a summative or comparative assessment gives better alignment on the numeric measures of importance and level of support. The final quantitative measures of content quality, pedagogical quality and educational value can

then be used to impartially evaluate multiple e-learning implementations and select accordingly.

Likewise, in a debrief session the facilitator goes beyond being an enabler and the gatekeeper of group-process; they must also be a content expert (knowledgeable of the syllabus, the heuristics, and to some extent the e-learning software) and therefore able and active in correcting misconceptions before they influence the final group response. With evaluators who are inexperienced with the heuristics and/or the evaluation process it is typical that they may:

1. misunderstand the educational setting and therefore evaluate unduly harshly or leniently,
2. misunderstand a heuristic or its criteria, and therefore evaluate unduly harshly or leniently,
3. overlook particular functionality in the e-learning software and therefore respond that particular heuristics are weakly or not supported, or
4. overlook particular content in the e-learning software and therefore respond that particular learning objectives are weakly or not supported.

Such misconceptions are often self-correcting since they are corrected in discussion within the group, but if not, then they must be corrected by the facilitator to avoid corrupting the group result. The facilitator must be able to explain and clarify the: educational setting; heuristics and their criteria; and the learning objectives. In addition, the above scenarios are particularly damaging when there are dominant evaluators within the group. It is already a part of the facilitator's role to balance such dominant figures, but it becomes critical if a dominant evaluator is working under a misconception and driving the group in the wrong direction.

O PHASE 3 EDUCATIONAL SETTING FOR EVALUATION OF LEVEL 3 ORANGE

As discussed in section 5.4.4 of the thesis, the evaluation of any e-learning software cannot be held in isolation; there must first be consideration of the educational setting (learning context) in which the software will be used. An important characteristic of this evaluation protocol is that it explicitly considers the intended learning context, such as the target audience and their characteristics, and the typical context for using the e-learning software. The educational setting is particularly important since it guides evaluators in defining whether specific learning outcomes and heuristics are applicable within the given learning context. For reference, this appendix contains the educational setting for Level-3 Orange which was used in the Phase 3 workshop.

The software has the following Learning Objectives.

1. Understand the concepts of variables and constants
2. Understand the concept of data types
3. Be able to use arithmetic calculations in your algorithms
4. Be able to use Boolean expressions in your algorithms
5. Using flowcharts determine the purpose of simple algorithms and explain how they work
6. Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.

You evaluate how important each Learning Objective is in the educational setting and how well the software supports it.

Target Audience and Learner Characteristics: (Consider age, education level, motivation, incentive, computer experience and any other characteristics you consider relevant)	GCSE Students – 15/16-year olds Both genders Some interest in Computer Science but varying levels of motivation Varying levels of ability Comfortable with using computers Reasonable level of English language skills, but may not be their 1st language
Typical Context for using the E-Learning software: (Consider typical learning or teaching contexts e. g. asynchronous learning, in class synchronous instruction, in class asynchronous learning, blended learning, flipped teaching, homework, revision)	Teaching GCSE Computer Science, potentially any of the following exam boards OCR, AQA, EDEXCEL. The software will typically be used by students individually (with some collaborative work) under a scheme of work directed by a teacher. The students would be assigned to complete work in class (in class asynchronous) or for homework. As part of their lesson plan, the teacher may also use the software for blended learning, flipped teaching, homework or revision. The software can also be used for individual independent learning, but is unlikely to be used as the only educational resource for a student to sit the GCSE Computer Science exam.

P PHASE 3 E-LEARNING EVALUATION RESPONSE COLLECTION INSTRUMENT

As discussed in section 3.7.3.3.5, in normal circumstances, the e-learning evaluation protocol document is also a feedback template that allows evaluators to record their evaluation results in a structured and consistent manner. However, due to the time constraints imposed by the workshop, a mechanism was necessary to consolidate the evaluation results from all group members within a 15-minute window, before the group debrief sessions. In response to this constraint, an online survey instrument was developed and used to collect the respondents' quantitative feedback on the level of importance of each heuristic and learning objective, and the level of support the software gave to each heuristic and learning objective. For reference, the alternate survey instrument is contained in this appendix.

E-Learning Evaluation Protocol - Individual Results Collection v0.3

1. **Welcome to the E-Learning Evaluation of Level 3: Orange - Algorithms and Flowcharts**

Thank you for evaluating the e-learning software "Level 3: Orange - Algorithms and Flowcharts."

Before starting the evaluation activity, please make sure you have a good understanding of:

1. **The educational setting (learning context)**
2. **The underlying pedagogical heuristics, and**
3. **The evaluation procedure**

The above points are described in the document "E-Learning Software Evaluation Protocol (P3) v0.2."

It is strongly recommended that you have a copy of the document open for your reference whilst you carry out your individual evaluation.

IMPORTANT: Questions are grouped in pairs. If you mark a Learning Objective or a Heuristic as "Non Applicable", then do not answer the 2nd question related to that Learning Objective or Heuristic.

* Please confirm which evaluation group you are a member of?

E-Learning Evaluation Protocol - Individual Results Collection v0.3

2. **Learning Objectives (LO) Evaluation**

* LO1: Understand the concepts of variables and constants
Please specify the importance of this Learning Objective in the given Educational Setting.

LO1: Understand the concepts of variables and constants.
Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* LO2: Understand the concept of data types
Please specify the importance of this Learning Objective in the given Educational Setting.

LO2: Understand the concept of data types

Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* LO3: Be able to use arithmetic calculations in your algorithms

Please specify the importance of this Learning Objective in the given Educational Setting.

LO3: Be able to use arithmetic calculations in your algorithms.

Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* LO4: Be able to use Boolean expressions in your algorithms.

Please specify the importance of this Learning Objective in the given Educational Setting.

LO4: Be able to use Boolean expressions in your algorithms.

Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* LO5: Using flowcharts determine the purpose of simple algorithms and explain how they works.

Please specify the importance of this Learning Objective in the given Educational Setting.

LO5: Using flowcharts determine the purpose of simple algorithms and explain how they works.

Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* LO6: Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.

Please specify the importance of this Learning Objective in the given Educational Setting.

LO6: Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.
Please specify the level of support the e-learning software provides to this Learning Objective.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

E-Learning Evaluation Protocol - Individual Results Collection v0.3

3. **Heuristics Evaluation (H) (1/4)**

* H1: Use authentic educational material, examples and activities.
Please specify the importance of this Heuristic in the given Educational Setting.

H1: Use authentic educational material, examples and activities.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H1.1: Ensure the currency of learning material.
Please specify the importance of this Heuristic in the given Educational Setting.

H1.1: Ensure the currency of learning material.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H2: Prompt reflective practice to support learning.
Please specify the importance of this Heuristic in the given Educational Setting.

H2: Prompt reflective practice to support learning.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H3: Make expert and learner thinking processes explicit.

Please specify the importance of this Heuristic in the given Educational Setting.

H3: Make expert and learner thinking processes explicit.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H4: Use problem based learning (PBL) to facilitate learning.

Please specify the importance of this Heuristic in the given Educational Setting.

H4: Use problem based learning (PBL) to facilitate learning.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H4.1: Use worked examples to support problem based learning.

Please specify the importance of this Heuristic in the given Educational Setting.

H4.1: Use worked examples to support problem based learning.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H5: Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.
Please specify the importance of this Heuristic in the given Educational Setting.

H5: Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H6: Support problem solving through computational thinking.
Please specify the importance of this Heuristic in the given Educational Setting.

H6: Support problem solving through computational thinking.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H6.1: Build a foundation for computational thinking.
Please specify the importance of this Heuristic in the given Educational Setting.

H6.1: Build a foundation for computational thinking.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H6.2: Exemplify computational thinking in problem solving activities.
Please specify the importance of this Heuristic in the given Educational Setting.

H6.2: Exemplify computational thinking in problem solving activities.
Please specify the level of support the e-learning software provides to this Heuristic

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

E-Learning Evaluation Protocol - Individual Results Collection v0.3

4. **Heuristics Evaluation(H) (2/4)**

* H7: Distribute well-designed practice activities across the lesson to support learning.
Please specify the importance of this Heuristic in the given Educational Setting.

H7: Distribute well-designed practice activities across the lesson to support learning.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H7.1: Provide explanatory feedback to practice activities to promote learning.
Please specify the importance of this Heuristic in the given Educational Setting.

H7.1: Provide explanatory feedback to practice activities to promote learning.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H8: Provide scaffolding to advance learning progress.
Please specify the importance of this Heuristic in the given Educational Setting.

H8: Provide scaffolding to advance learning progress.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H9: Use social-interaction to increase learning and promote higher-order thinking.
Please specify the importance of this Heuristic in the given Educational Setting.

H9: Use social-interaction to increase learning and promote higher-order thinking.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H10: Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).
Please specify the importance of this Heuristic in the given Educational Setting.

H10: Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H11: Use collaborative learning activities.
Please specify the importance of this Heuristic in the given Educational Setting

H11: Use collaborative learning activities.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H11.1: Support collaborative and situated learning via mobile devices.
Please specify the importance of this Heuristic in the given Educational Setting.

H11.1: Support collaborative and situated learning via mobile devices.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H12: Develop and nurture networks to support learning.
Please specify the importance of this Heuristic in the given Educational Setting.

H12: Develop and nurture networks to support learning.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H13: Use constructivist approaches to increase intrinsic motivation in the learner.
Please specify the importance of this Heuristic in the given Educational Setting.

H13: Use constructivist approaches to increase intrinsic motivation in the learner.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H14: Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.
Please specify the importance of this Heuristic in the given Educational Setting.

H14: Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H14.1: Use “Attention” grabbing strategies to increase learner motivation.
Please specify the importance of this Heuristic in the given Educational Setting.

H14.1: Use “Attention” grabbing strategies to increase learner motivation.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

E-Learning Evaluation Protocol - Individual Results Collection v0.3

5. **Heuristics Evaluation (3/4)**

* H14.2: Explain the “Relevance” of the learning material to increase motivation.
Please specify the importance of this Heuristic in the given Educational Setting.

H14.2: Explain the “Relevance” of the learning material to increase motivation.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H14.3: Importance of Learning Objective

H14.3: Level of support the e-learning software provides to this heuristic:

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H14.4: Build “Satisfaction” to increase learner motivation.
Please specify the importance of this Heuristic in the given Educational Setting.

H14.4: Build “Satisfaction” to increase learner motivation.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H15: Use gamification to increase motivation and learning performance.
Please specify the importance of this Heuristic in the given Educational Setting.

H15: Use gamification to increase motivation and learning performance.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H15.1: Integrate gamification elements tightly within existing learning processes.
Please specify the importance of this Heuristic in the given Educational Setting.

H15.1: Integrate gamification elements tightly within existing learning processes.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H15.2: Build extrinsic gamification elements on top of existing learning processes.
Please specify the importance of this Heuristic in the given Educational Setting.

H15.2: Build extrinsic gamification elements on top of existing learning processes.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H16: Use multi-modal learning approaches.
Please specify the importance of this Heuristic in the given Educational Setting.

H16: Use multi-modal learning approaches.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H16.1: Support visual modal preference.

Please specify the importance of this Heuristic in the given Educational Setting.

H16.1: Support visual modal preference.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H16.2: Support aural modal preference.

Please specify the importance of this Heuristic in the given Educational Setting.

H16.2: Support aural modal preference.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H16.3: Support read-write modal preference.

Please specify the importance of this Heuristic in the given Educational Setting.

H16.3: Support read-write modal preference.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H16.4: Support kinaesthetic modal preference.

Please specify the importance of this Heuristic in the given Educational Setting.

H16.4: Support kinaesthetic modal preference.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

E-Learning Evaluation Protocol - Individual Results Collection v0.3

6. **Heuristics Evaluation(H) (4/4)**

* H17: Integrate words and graphics together, instead of words alone.
Please specify the importance of this Heuristic in the given Educational Setting.

H17: Integrate words and graphics together, instead of words alone.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H17.1: Apply contiguity by aligning words (audio or screen text) with corresponding graphics.
Please specify the importance of this Heuristic in the given Educational Setting.

H17.1: Apply contiguity by aligning words (audio or screen text) with corresponding graphics.
Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H17.2: Representing words as audio, on-screen text or both
Please specify the importance of this Heuristic in the given Educational Setting.

H17.2: Representing words as audio, on-screen text or both

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H18: Avoid adding learning content that does not directly support your instructional goal.

Please specify the importance of this Heuristic in the given Educational Setting.

H18: Avoid adding learning content that does not directly support your instructional goal.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H19: Optimise essential processing by segmenting learning material and providing pre-training.

Please specify the importance of this Heuristic in the given Educational Setting.

H19: Optimise essential processing by segmenting learning material and providing pre-training.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H20: Use a conversational style in screen text and audio narration.

Please specify the importance of this Heuristic in the given Educational Setting.

H20: Use a conversational style in screen text and audio narration.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

* H21: Provide restricted navigational control in the e-learning software.

Please specify the importance of this Heuristic in the given Educational Setting.

H21: Provide restricted navigational control in the e-learning software.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

H21.1: Provide consistent navigational elements and signposts for learning.

Please specify the importance of this Heuristic in the given Educational Setting.

H21.1: Provide consistent navigational elements and signposts for learning.

Please specify the level of support the e-learning software provides to this Heuristic.

-4 Strongly Counteracts	-3	-2	-1	0 Neither Supports nor Counteracts	1	2	3	4 Strongly Supports
○	○	○	○	○	○	○	○	○

Q PHASE 1 E-LEARNING EVALUATION CALCULATION

As discussed in section 6.7.1 of the thesis, during the Phase 1 e-learning design activity (storyboard creation), an initial e-learning evaluation rubric was constructed. This was used to evaluate the e-learning software prototype Algorithms V04a; the detailed evaluation breakdown is included for reference in this appendix.

		Heuristic Average	Screen 1	Screen 2	Screen 3	Screen 4	Screen 5	Screen 6	Screen 7	Screen 8	Screen 9	Screen 10	Screen 11	Screen 12	Screen 13	Screen 14	Screen 15	Screen 16	Screen 17	Screen 18	Screen 19	Screen 20	Screen 21	Screen 22	Screen 23	Screen 24	Screen 25	Screen 26	Screen 27	Sc
0	Learning Objective Coverage	75.71%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	Use authentic educational material, examples and activities.	46.15%	0	0	1	1	1	1	1	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	0	0
2	Use constructivist approaches to increase intrinsic motivation in the learner.	57.69%	0	0	1	1	1	1	1	1	0	0	1	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	0
3	Provoke reflective practice to support learning.	7.69%	0	0	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	Utilise worked examples to support learning.	19.23%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	1	0	1	0	1	0	
5	Use Problem Based Learning (PBL) approaches to facilitate learning and develop thinking skills.	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	Prepare the foundation for Problem Based Learning (PBL).	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	Make expert and learner thinking processes explicit.	3.85%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	Well-designed practice activities should be distributed across the lesson to support learning.	46.15%	0	0	1	1	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	1	1	1	0	0	0
9	Practice activities should have explanatory feedback to promote learning.	38.46%	0	0	1	1	1	1	1	0	0	0	1	0	1	1	0	1	0	0	0	0	0	0	0	1	0	0	0	0
10	Use social interaction as a basis for learning.	7.69%	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	Target learning towards the learner's Zone of Proximal Development (ZPD).	30.77%	0	0	0	1	0	0	1	0	0	0	1	0	0	1	0	1	0	0	0	0	0	0	1	1	1	0	0	0
12	Provide scaffolding to advance learning progress.	42.31%	0	1	0	0	0	1	0	0	1	0	1	1	1	0	0	1	1	0	0	0	0	0	1	0	1	0	1	0
13	Use collaborative activities to support learning.	7.69%	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	Provide structure and meaningful guidance in collaborative activities	3.85%	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	Support collaboration through mobile devices.	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	Develop and nurture networks to support learning.	15.38%	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
17	Cultivate the network into a community.	7.69%	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	Information is constantly changing therefore its accuracy and validity may change over time.	7.69%	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	
19	Learning Styles used to promote self-reflection and active management of learning.	0.00%	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	VARK modal preferences are to be implemented using a Multi-Modal strategy.	61.54%	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	1	0	0	0	0	0	0	1	1	1	1	1	0
21	Support Visual Modal Preference	57.69%	0	0	1	0	1	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0	0	0	1	1	1	1	1	0
22	Support Aural Modal Preference	50.00%	0	0	1	1	1	1	0	1	1	1	1	1	0	0	1	0	1	0	0	0	0	0	0	0	0	1	1	0
23	Support Read-Write Modal Preference	96.15%	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
24	Support Kineasthetic Modal Preference	46.15%	0	0	1	1	1	1	1	1	0	0	0	0	1	0	1	1	0	0	0	0	0	0	1	1	1	0	0	0
25	Use words and graphics together, instead of words alone.	30.77%	0	0	0	0	0	0	0	0	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	1	1	0
26	Static illustrations can be better than animations.	26.92%	0	0	0	0	0	0	0	0	1	1	1	1	0	1	1	0	0	0	0	0	0	0	0	0	0	0	1	0
27	Apply contiguity by aligning words with corresponding graphics.	19.23%	0	0	0	0	0	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
28	When presenting text and graphical learning material simultaneously, present words as audio narration rather than on-screen text.	-15.38%	0	0	0	0	0	0	0	0	-1	-1	-1	1	0	0	-1	-1	0	0	0	0	0	0	0	0	0	0	0	0
29	Avoid explaining visuals with words both in audio and screen text.	3.85%	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
30	Avoid adding learning content that does not directly support the instructional goal.	88.46%	0	1	1	1	1	1	1	0	1	1	1	1	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	0
31	Optimise essential processing by breaking a lesson into parts.	96.15%	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
32	Support germane cognitive processing by non-trivial practice and authentic examples and problems.	53.85%	0	0	1	1	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	0	0	1	1	1	0	1	0
33	Screen text and audio narration should use a conversational style.	76.92%	0	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	0	0	0	1	1	1	1	1	0
34	Provide limited learner control in navigating through the E-Learning software.	100.00%	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
35	Provide navigational support and signposts for learning.	100.00%	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0
36	Use multimedia to support visualization of learning material.	11.54%	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0
	Heuristic Average	35.60%																												
	Weighted Principle Average	26.96%																												

R PHASE 3 EVALUATION WORKSHOP FOCUS GROUP QUESTIONS

As discussed in section 3.7.3, although not part of the evaluation process, at the end of the Phase 3 workshop, two focus groups were planned in which the teacher participants had a facilitated discussion to give their feedback on the day. To ensure consistency between both focus groups, a set of guiding questions was developed and used. For reference, these questions are contained in this appendix.

R.1 E-Learning Evaluation Protocol

What experience does your school have of using e-learning software?

What personal experience do you have of using e-learning software to teach?

What experience do you have in selecting or evaluating e-learning software?

Is e-learning software evaluation something you would get involved in, if your school had a need?

If yes, please elaborate your thoughts on how you would proceed.

Please consider whether you could use the heuristics and the evaluation procedure described today to evaluate e-learning software?

What would you improve about the evaluation procedure described today?

Specifically:

1. Explanation of heuristics
2. Explanation of the evaluation procedure
3. The evaluation activity
4. The recording of individual evaluation results
5. The group debrief session
6. The time allocated to the specific activities

R.2 Pedagogical Heuristics

Please comment on the appropriateness of the heuristics for 15 to 18 years olds (Key Stages 4 & 5)?

Please comment on the appropriateness of the heuristics for Computer Science education?

Please comment on the feasibility of the heuristics to be implemented in a High School environment?

Considering this morning's discussion of the e-learning heuristics, what are your thoughts on whether there is balanced pedagogical coverage?

(Are there any gaps, weak areas or areas with too much focus?)

Please elaborate on what new heuristics or pedagogical areas are not considered in the pedagogy?

R.3 Background Information use of E-Learning software

How often do you already use the Internet and the Web to support / supplement your teaching?

- Typically integrating smaller digital resources into teaching.

Please elaborate on what e-learning software you currently use to support the teaching of Computer Science?

How often do you use this e-learning software?

- *Differentiate between a digital resource found on the web and more comprehensive e-learning software which covers a significant portion of sylubus.
- (examples OCR Moodle, BBC Bytesize, Khan Academy, UDemy)

What are your thoughts on whether e-learning software could have any impact on student motivation towards the computing subject?

What are your thoughts on whether e-learning software could have a *positive educational impact?*

What do you think are the benefits of incorporating E-Learning software into your teaching?

What do you think are the barriers that would prevent or discourage you from using E-Learning software in your teaching?

In what scenario or for what purpose would you recommend to students the use of the E-Learning software for independent study?

S EVALUATION RESULTS: LEVEL 1 WHITE ALGORITHMS AND COMPUTATIONAL THINKING V0.5

As discussed in section 6.2.2.4 of the thesis, below is the quantitative evaluation of Content Quality, Pedagogical Quality and overall Educational Value for the e-learning software: Level 1 White - Algorithms and Computational Thinking V0.5. **NOTE:** This evaluation was carried out by the researcher as part of Phase 3.

Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Understand and explain the term algorithm	4 Extremely Important	4 Strongly Supports	4	4	
2	Understand that the same problem can be solved by more than one algorithm.	3 Very Important	2	1.5	3	
3	Understand the factors that can be used to evaluate the efficiency of an algorithm.	3 Very Important	3	2.25	3	
4	Understand and explain the term Computational Thinking	3 Very Important	4 Strongly Supports	3	3	
5	Understand and explain the underlying elements of Computational Thinking	4 Extremely Important	4 Strongly Supports	4	4	
6	Be able to recognise elements of Computational Thinking in a problem solving process.	4 Extremely Important	3	3	4	
			Content Quality:	17.75	21	85%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	3 Very Important	4 Strongly Supports	3	3	
1.1	Ensure the currency of learning material.	1 Slightly Important	3	0.75	1	
2	Prompt reflective practice to support learning.	1 Slightly Important	2	0.5	1	
3	Make expert and learner thinking processes explicit.	1 Slightly Important	0 Neither Supports NOR Counteracts	0	1	
4	Use problem based learning (PBL) to facilitate learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4.1	Use worked examples to support problem based learning.	1 Slightly Important	1	0.25	1	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	4 Extremely Important	4 Strongly Supports	4	4	
6	Support problem solving through Computational Thinking.	4 Extremely Important	3	3	4	
6.1	Build a foundation for Computational Thinking.	4 Extremely Important	4 Strongly Supports	4	4	
6.2	Exemplify Computational Thinking in problem solving activities.	3 Very Important	3	2.25	3	
7	Distribute well-designed practice activities across the lesson to support learning.	4 Extremely Important	4 Strongly Supports	4	4	
7.1	Provide explanatory feedback to practice activities to promote learning.	3 Very Important	2	1.5	3	
8	Provide scaffolding to advance learning progress.	3 Very Important	2	1.5	3	
9	Use social-interaction to increase learning and promote higher-order thinking.	1 Slightly Important	1	0.25	1	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	2 Moderately Important	3	1.5	2	
11	Use collaborative learning activities.	1 Slightly Important	1	0.25	1	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	2 Moderately Important	3	1.5	2	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	4 Extremely Important	3	3	4	
14.1	Use "Attention" grabbing strategies to increase learner motivation.	4 Extremely Important	2	2	4	
14.2	Explain the "Relevance" of the learning material to increase motivation.	4 Extremely Important	3	3	4	
14.3	Build "Confidence" to increase learner motivation.	4 Extremely Important	4 Strongly Supports	4	4	
14.4	Build "Satisfaction" to increase learner motivation.	4 Extremely Important	3	3	4	
15	Use gamification to increase motivation and learning performance.	1 Slightly Important	2	0.5	1	
15.1	Integrate gamification elements tightly within existing learning processes.	2 Moderately Important	2	1	2	
15.2	Build extrinsic gamification elements on top of existing learning processes.	1 Slightly Important	0 Neither Supports NOR Counteracts	0	1	
16	Use multi-modal learning approaches.	3 Very Important	3	2.25	3	
16.1	Support visual modal preference.	4 Extremely Important	4 Strongly Supports	4	4	
16.2	Support aural modal preference.	2 Moderately Important	2	1	2	
16.3	Support read-write modal preference.	4 Extremely Important	4 Strongly Supports	4	4	
16.4	Support kinaesthetic modal preference.	2 Moderately Important	2	1	2	
17	Integrate words and graphics together, instead of words alone.	3 Very Important	3	2.25	3	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	2 Moderately Important	3	1.5	2	
17.2	Representing words as audio, on-screen text or both	2 Moderately Important	2	1	2	
18	Avoid adding learning content that does not directly support your instructional goal.	3 Very Important	3	2.25	3	
19	Optimise essential processing by segmenting learning material and providing pre-training.	3 Very Important	3	2.25	3	
20	Use a conversational style in screen text and audio narration.	3 Very Important	2	1.5	3	
21	Provide restricted navigational control in the E-Learning software.	3 Very Important	4 Strongly Supports	3	3	
21.1	Provide consistent navigational elements and signposts for learning.	3 Very Important	4 Strongly Supports	3	3	
			Pedagogical Quality:	73.75	99	74%
			Educational Value:			80%

T EVALUATION RESULTS: LEVEL 2 YELLOW BELT ALGORITHMS AND COMPUTATIONAL THINKING V0.5

As discussed in section 6.2.2.4 of the thesis, below is the quantitative evaluation of Content Quality, Pedagogical Quality and overall Educational Value for the e-learning software: Level 2 Yellow - Algorithms and Computational Thinking V0.5. **NOTE:** This evaluation was carried out by the researcher as part of Phase 3.

Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Use a systematic approach to problem solving	4 Extremely Important	4 Strongly Supports	4	4	
2	Determine the purpose of simple algorithms and explain how they work	4 Extremely Important	4 Strongly Supports	4	4	
3	Explain simple algorithms in terms of their inputs, processing and outputs.	4 Extremely Important	4 Strongly Supports	4	4	
4	Understand and explain the underlying elements of Computational Thinking	1 Slightly Important	0 Neither Supports NOR Counteracts	0	1	
5	Using flowcharts determine the purpose of simple algorithms and explain how they work	2 Moderately Important	1	0.5	2	
6	Be able to recognise elements of Computational Thinking in a problem solving process	3 Very Important	2	1.5	3	
			Content Quality:	14	18	78%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	3 Very Important	3	2.25	3	
1.1	Ensure the currency of learning material.	1 Slightly Important	3	0.75	1	
2	Prompt reflective practice to support learning.	1 Slightly Important	1	0.25	1	
3	Make expert and learner thinking processes explicit.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4	Use problem based learning (PBL) to facilitate learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4.1	Use worked examples to support problem based learning.	3 Very Important	0 Neither Supports NOR Counteracts	0	3	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	3 Very Important	3	2.25	3	
6	Support problem solving through Computational Thinking.	2 Moderately Important	2	1	2	
6.1	Build a foundation for Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.2	Exemplify Computational Thinking in problem solving activities.	2 Moderately Important	2	1	2	
7	Distribute well-designed practice activities across the lesson to support learning.	4 Extremely Important	4 Strongly Supports	4	4	
7.1	Provide explanatory feedback to practice activities to promote learning.	3 Very Important	2	1.5	3	
8	Provide scaffolding to advance learning progress.	3 Very Important	1	0.75	3	
9	Use social-interaction to increase learning and promote higher-order thinking.	1 Slightly Important	1	0.25	1	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	3 Very Important	3	2.25	3	
11	Use collaborative learning activities.	1 Slightly Important	1	0.25	1	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	3 Very Important	2	1.5	3	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	3 Very Important	3	2.25	3	
14.1	Use “Attention” grabbing strategies to increase learner motivation.	2 Moderately Important	2	1	2	
14.2	Explain the “Relevance” of the learning material to increase motivation.	3 Very Important	3	2.25	3	
14.3	Build “Confidence” to increase learner motivation.	3 Very Important	3	2.25	3	
14.4	Build “Satisfaction” to increase learner motivation.	3 Very Important	3	2.25	3	
15	Use gamification to increase motivation and learning performance.	1 Slightly Important	2	0.5	1	
15.1	Integrate gamification elements tightly within existing learning processes.	2 Moderately Important	2	1	2	
15.2	Build extrinsic gamification elements on top of existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16	Use multi-modal learning approaches.	3 Very Important	3	2.25	3	
16.1	Support visual modal preference.	3 Very Important	3	2.25	3	
16.2	Support aural modal preference.	3 Very Important	2	1.5	3	
16.3	Support read-write modal preference.	3 Very Important	3	2.25	3	
16.4	Support kinaesthetic modal preference.	2 Moderately Important	1	0.5	2	
17	Integrate words and graphics together, instead of words alone.	3 Very Important	3	2.25	3	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	2 Moderately Important	3	1.5	2	
17.2	Representing words as audio, on-screen text or both	2 Moderately Important	2	1	2	
18	Avoid adding learning content that does not directly support your instructional goal.	3 Very Important	3	2.25	3	
19	Optimise essential processing by segmenting learning material and providing pre-training.	3 Very Important	3	2.25	3	
20	Use a conversational style in screen text and audio narration.	3 Very Important	3	2.25	3	
21	Provide restricted navigational control in the E-Learning software.	3 Very Important	4 Strongly Supports	3	3	
21.1	Provide consistent navigational elements and signposts for learning.	3 Very Important	4 Strongly Supports	3	3	
			Pedagogical Quality:	55.75	86	65%
			Educational Value:			71%

U EVALUATION RESULTS: LEVEL 3 ORANGE FLOWCHARTS V0.3

As discussed in section 6.2.2.4 of the thesis, below is the quantitative evaluation of Content Quality, Pedagogical Quality and overall Educational Value for the e-learning software: Level 3 Orange - Flowcharts V0.3. **NOTE:** This evaluation was carried out by workshop group 1 as part of Phase 3.

Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Understand the concepts of variables and constants	4 Extremely Important	4 Strongly Supports	4	4	
2	Understand the concept of data types	3 Very Important	3	2.25	3	
3	Be able to use arithmetic calculations in your algorithms	4 Extremely Important	3	3	4	
4	Be able to use Boolean expressions in your algorithms	4 Extremely Important	3	3	4	
5	Using flowcharts determine the purpose of simple algorithms and explain how they work	4 Extremely Important	4 Strongly Supports	4	4	
6	Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.	4 Extremely Important	4 Strongly Supports	4	4	
			Content Quality:	20.25	23	88%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	4 Extremely Important	3	3	4	
1.1	Ensure the currency of learning material.	3 Very Important	3	2.25	3	
2	Prompt reflective practice to support learning.	3 Very Important	2	1.5	3	
3	Make expert and learner thinking processes explicit.	3 Very Important	2	1.5	3	
4	Use problem based learning (PBL) to facilitate learning.	4 Extremely Important	4 Strongly Supports	4	4	
4.1	Use worked examples to support problem based learning.	4 Extremely Important	4 Strongly Supports	4	4	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	4 Extremely Important	3	3	4	
6	Support problem solving through Computational Thinking.	4 Extremely Important	3	3	4	
6.1	Build a foundation for Computational Thinking.	4 Extremely Important	3	3	4	
6.2	Exemplify Computational Thinking in problem solving activities.	4 Extremely Important	2	2	4	
7	Distribute well-designed practice activities across the lesson to support learning.	4 Extremely Important	2	2	4	
7.1	Provide explanatory feedback to practice activities to promote learning.	4 Extremely Important	1 Slightly Supports	1	4	
8	Provide scaffolding to advance learning progress.	3 Very Important	3	2.25	3	
9	Use social-interaction to increase learning and promote higher-order thinking.	3 Very Important	0 Neither Supports NOR Counteracts	0	3	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	4 Extremely Important	2	2	4	
11	Use collaborative learning activities.	3 Very Important	0 Neither Supports NOR Counteracts	0	3	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	3 Very Important	0 Neither Supports NOR Counteracts	0	3	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	4 Extremely Important	1 Slightly Supports	1	4	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	4 Extremely Important	3	3	4	
14.1	Use "Attention" grabbing strategies to increase learner motivation.	4 Extremely Important	2	2	4	
14.2	Explain the "Relevance" of the learning material to increase motivation.	3 Very Important	3	2.25	3	
14.3	Build "Confidence" to increase learner motivation.	4 Extremely Important	3	3	4	
14.4	Build "Satisfaction" to increase learner motivation.	3 Very Important	3	2.25	3	
15	Use gamification to increase motivation and learning performance.	4 Extremely Important	3	3	4	
15.1	Integrate gamification elements tightly within existing learning processes.	4 Extremely Important	3	3	4	
15.2	Build extrinsic gamification elements on top of existing learning processes.	1 Slightly Important	3	0.75	1	
16	Use multi-modal learning approaches.	4 Extremely Important	4 Strongly Supports	4	4	
16.1	Support visual modal preference.	4 Extremely Important	4 Strongly Supports	4	4	
16.2	Support aural modal preference.	3 Very Important	4 Strongly Supports	3	3	
16.3	Support read-write modal preference.	4 Extremely Important	4 Strongly Supports	4	4	
16.4	Support kinaesthetic modal preference.	3 Very Important	2	1.5	3	
17	Integrate words and graphics together, instead of words alone.	4 Extremely Important	4 Strongly Supports	4	4	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	4 Extremely Important	4 Strongly Supports	4	4	
17.2	Representing words as audio, on-screen text or both	3 Very Important	4 Strongly Supports	3	3	
18	Avoid adding learning content that does not directly support your instructional goal.	3 Very Important	4 Strongly Supports	3	3	
19	Optimise essential processing by segmenting learning material and providing pre-training.	3 Very Important	3	2.25	3	
20	Use a conversational style in screen text and audio narration.	3 Very Important	3	2.25	3	
21	Provide restricted navigational control in the E-Learning software.	3 Very Important	4 Strongly Supports	3	3	
21.1	Provide consistent navigational elements and signposts for learning.	3 Very Important	4 Strongly Supports	3	3	
			Pedagogical Quality:	95.75	136	70%
			Educational Value:			79%

V EVALUATION RESULTS: LEVEL 4 BLUE PSEUDO-CODE V0.3

As discussed in section 6.2.2.4 of the thesis, below is the quantitative evaluation of Content Quality, Pedagogical Quality and overall Educational Value for the e-learning software: Level 4 Blue - Pseudo-Code V0.3. **NOTE:** This evaluation was carried out by the researcher as part of Phase 3.

Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Using pseudocode determine the purpose of simple algorithms and explain how they work.	4 Extremely Important	4 Strongly Supports	4	4	
2	Using pseudocode explain simple algorithms in terms of their inputs, processing and outputs	2 Moderately Important	2	1	2	
3	Using trace tables systematically step through an algorithm.	4 Extremely Important	3	3	4	
4	Be able to recognise elements of Computational Thinking in the problem solving process.	1 Slightly Important	1	0.25	1	
			Content Quality:	8.25	11	75%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	3 Very Important	3	2.25	3	
1.1	Ensure the currency of learning material.	1 Slightly Important	3	0.75	1	
2	Prompt reflective practice to support learning.	1 Slightly Important	0 Neither Supports NOR Counteracts	0	1	
3	Make expert and learner thinking processes explicit.	1 Slightly Important	1	0.25	1	
4	Use problem based learning (PBL) to facilitate learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4.1	Use worked examples to support problem based learning.	3 Very Important	3	2.25	3	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	3 Very Important	3	2.25	3	
6	Support problem solving through Computational Thinking.	2 Moderately Important	2	1	2	
6.1	Build a foundation for Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.2	Exemplify Computational Thinking in problem solving activities.	2 Moderately Important	2	1	2	
7	Distribute well-designed practice activities across the lesson to support learning.	4 Extremely Important	4 Strongly Supports	4	4	
7.1	Provide explanatory feedback to practice activities to promote learning.	3 Very Important	2	1.5	3	
8	Provide scaffolding to advance learning progress.	3 Very Important	4 Strongly Supports	3	3	
9	Use social-interaction to increase learning and promote higher-order thinking.	2 Moderately Important	3	1.5	2	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	3 Very Important	3	2.25	3	
11	Use collaborative learning activities.	2 Moderately Important	3	1.5	2	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	3 Very Important	2	1.5	3	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	3 Very Important	3	2.25	3	
14.1	Use “Attention” grabbing strategies to increase learner motivation.	1 Slightly Important	1	0.25	1	
14.2	Explain the “Relevance” of the learning material to increase motivation.	3 Very Important	3	2.25	3	
14.3	Build “Confidence” to increase learner motivation.	4 Extremely Important	4 Strongly Supports	4	4	
14.4	Build “Satisfaction” to increase learner motivation.	4 Extremely Important	4 Strongly Supports	4	4	
15	Use gamification to increase motivation and learning performance.	1 Slightly Important	2	0.5	1	
15.1	Integrate gamification elements tightly within existing learning processes.	2 Moderately Important	2	1	2	
15.2	Build extrinsic gamification elements on top of existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16	Use multi-modal learning approaches.	3 Very Important	3	2.25	3	
16.1	Support visual modal preference.	3 Very Important	3	2.25	3	
16.2	Support aural modal preference.	3 Very Important	2	1.5	3	
16.3	Support read-write modal preference.	3 Very Important	3	2.25	3	
16.4	Support kinaesthetic modal preference.	2 Moderately Important	1	0.5	2	
17	Integrate words and graphics together, instead of words alone.	3 Very Important	3	2.25	3	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	2 Moderately Important	3	1.5	2	
17.2	Representing words as audio, on-screen text or both	2 Moderately Important	2	1	2	
18	Avoid adding learning content that does not directly support your instructional goal.	3 Very Important	4 Strongly Supports	3	3	
19	Optimise essential processing by segmenting learning material and providing pre-training.	3 Very Important	3	2.25	3	
20	Use a conversational style in screen text and audio narration.	3 Very Important	3	2.25	3	
21	Provide restricted navigational control in the E-Learning software.	3 Very Important	4 Strongly Supports	3	3	
21.1	Provide consistent navigational elements and signposts for learning.	3 Very Important	4 Strongly Supports	3	3	
			Pedagogical Quality:	66.25	90	74%
			Educational Value:			74%

W E-LEARNING EVALUATION SUMMARY FEEDBACK TEMPLATE

As discussed in section 6.7.3.2 and 7.9 of the thesis, one of the findings in Phase 3 relating to the e-learning evaluation protocol, was that the evaluation feedback document (resulting from the debrief session) was too long. Hence, one recommendation was to shorten the document to a more manageable length. This appendix contains the first version of the e-learning evaluation summary feedback document.

Summary feedback template for heuristics evaluation of high-school e-learning software

by

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Facilitator Name:	
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Software title and version:	

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2 EXECUTIVE SUMMARY

The e-learning software <<e-learning software title and version>> was evaluated by <<evaluation group members>> on <evaluation date>> and was assessed to have Content Quality of <<x%>>, Pedagogical Quality of <<y%>> and overall Education Value of <<z%>>. The Educational Setting for the e-learning software is described in section 3.1. Specific comments for each learning objective are documented in section 0. Specific comments on each heuristic are documented in section 3.3. A breakdown of the quantifiable metrics of Content Quality, Pedagogical Quality and Educational Value are documented in section 4. Other points of note are <<….>>.

3 SUMMARY EVALUATION FEEDBACK TEMPLATE

3.1 Educational Setting

Target Audience and Learner Characteristics: (Consider age, education level, motivation, incentive, computer experience and any other characteristics you consider relevant)	**Example:** • GCSE Students – 15/16 year olds • Both genders • Some interest in computer science but varying levels of motivation • Varying levels of ability • Comfortable with using computers • A reasonable level of English language skills, but may not be 1st language
Typical Context for using the E-learning Software: (Consider typical learning or teaching contexts e. g. asynchronous learning, in class synchronous instruction, in-class asynchronous learning, blended learning, flipped teaching, homework, revision)	**Example:** • Teaching GCSE Computer Science, potentially any of the following exam boards OCR, AQA, EDEXCEL. • The software will typically be used by students individually (with some collaborative work) under a scheme of work directed by a teacher. The students would be assigned to complete work in class (in class asynchronous) or for homework. • As part of their lesson plan, the teacher may also use the software for blended learning, flipped teaching, homework or revision. • The software can also be used for individual independent learning but is unlikely to be used as the only educational resource for a student to sit the GCSE Computer Science exam.

3.2 Learning Objectives Evaluation

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
1	Example: Understand the concepts of variables and constants	E-Learning Support for Learning Objective:	
Supporting Comments:		Counteracts Learning Objective	Supports Learning Objective

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
2	Example: Understand the concept of data types	E-Learning Support for Learning Objective:	
Supporting Comments:		Counteracts Learning Objective	Supports Learning Objective

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
3	Example: Be able to use arithmetic calculations in your algorithms	E-Learning Support for Learning Objective:	
Supporting Comments:		Counteracts Learning Objective	Supports Learning Objective

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective	Choose an item.
4	Example: Be able to use Boolean expressions in your algorithms	E-Learning Support for Learning Objective:	
Supporting Comments:		Counteracts Learning Objective	Supports Learning Objective

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Learning Objective:	Importance of Learning Objective								Choose an item.
5	Example: Using flowcharts determine the purpose of simple algorithms and explain how they work	E-Learning Support for Learning Objective:								
Supporting Comments:		Counteracts Learning Objective					Supports Learning Objective			
		☐	☐	☐	☐	☐	☐	☐	☐	☐
		-4	-3	-2	-1	0	1	2	3	4
		Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

3.3 Pedagogical Heuristics Evaluation

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
1	Use authentic educational material, examples and activities.	Adherence of e-learning software to this heuristic:	
Supporting Comments:		Counteracts Heuristic	Supports Heuristic

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
1.1	Ensure the currency of learning material.	Adherence of e-learning software to this heuristic:	
Supporting Comments:		Counteracts Heuristic	Supports Heuristic

☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
2	**Prompt reflective practice to support learning.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
3	**Make expert and learner thinking processes explicit.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
4	**Use problem-based learning (PBL) to facilitate learning.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
4.1	Use worked examples to support problem-based learning.	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
5	**Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6	**Support problem-solving through computational thinking.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6.1	Build a foundation for computational thinking.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
6.2	Exemplify computational thinking in problem-solving activities.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
7	**Distribute well-designed practice activities across the lesson to support learning.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
7.1	**Provide explanatory feedback to practice activities to promote learning.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
8	**Provide scaffolding to advance learning progress.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
9	**Use social-interaction to increase learning and promote higher-order thinking.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
11	Use collaborative learning activities.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
11.1	Support collaborative and situated learning via mobile devices.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
12	Develop and nurture networks to support learning.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
13	Use constructivist approaches to increase intrinsic motivation in the learner.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.1	Use “Attention” grabbing strategies to increase learner motivation.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.2	Explain the “Relevance” of the learning material to increase motivation.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.3	Build “Confidence” to increase learner motivation.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
14.4	Build “Satisfaction” to increase learner motivation.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15	Use gamification to increase motivation and learning performance.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15.1	Integrate gamification elements tightly within existing learning processes.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
15.2	Build extrinsic gamification elements on top of existing learning processes.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16	Use multi-modal learning approaches.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.1	Support visual modal preference.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.2	Support aural modal preference.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.3	Support read-write modal preference.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
16.4	Support kinaesthetic modal preference.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17	**Integrate words and graphics together, instead of words alone.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:

Counteracts Heuristic					Supports Heuristic			
☐	☐	☐	☐	☐	☐	☐	☐	☐
-4	-3	-2	-1	0	1	2	3	4
Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
17.2	Representing words as audio, on-screen text or both	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
18	Avoid adding learning content that does not directly support your instructional goal.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
19	**Optimise essential processing by segmenting learning material and providing pre-training.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
20	**Use a conversational style in screen text and audio narration.**	**Adherence of e-learning software to this heuristic:**	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
21	Provide restricted navigational control in the e-learning software.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

ID	Heuristic Title:	Importance of heuristic in this learning context:	Choose an item.
21.1	Provide consistent navigational elements and signposts for learning.	Adherence of e-learning software to this heuristic:	

Supporting Comments:	Counteracts Heuristic					Supports Heuristic			
	☐	☐	☐	☐	☐	☐	☐	☐	☐
	-4	-3	-2	-1	0	1	2	3	4
	Strongly Counteracts				Neither Supports nor Counteracts				Strongly Supports

4 EVALUATION RESULTS

Please double click on the embedded excel object and update the values in the yellow cells in order to calculate the pedagogical support of the e-learning software for the defined learning objectives.

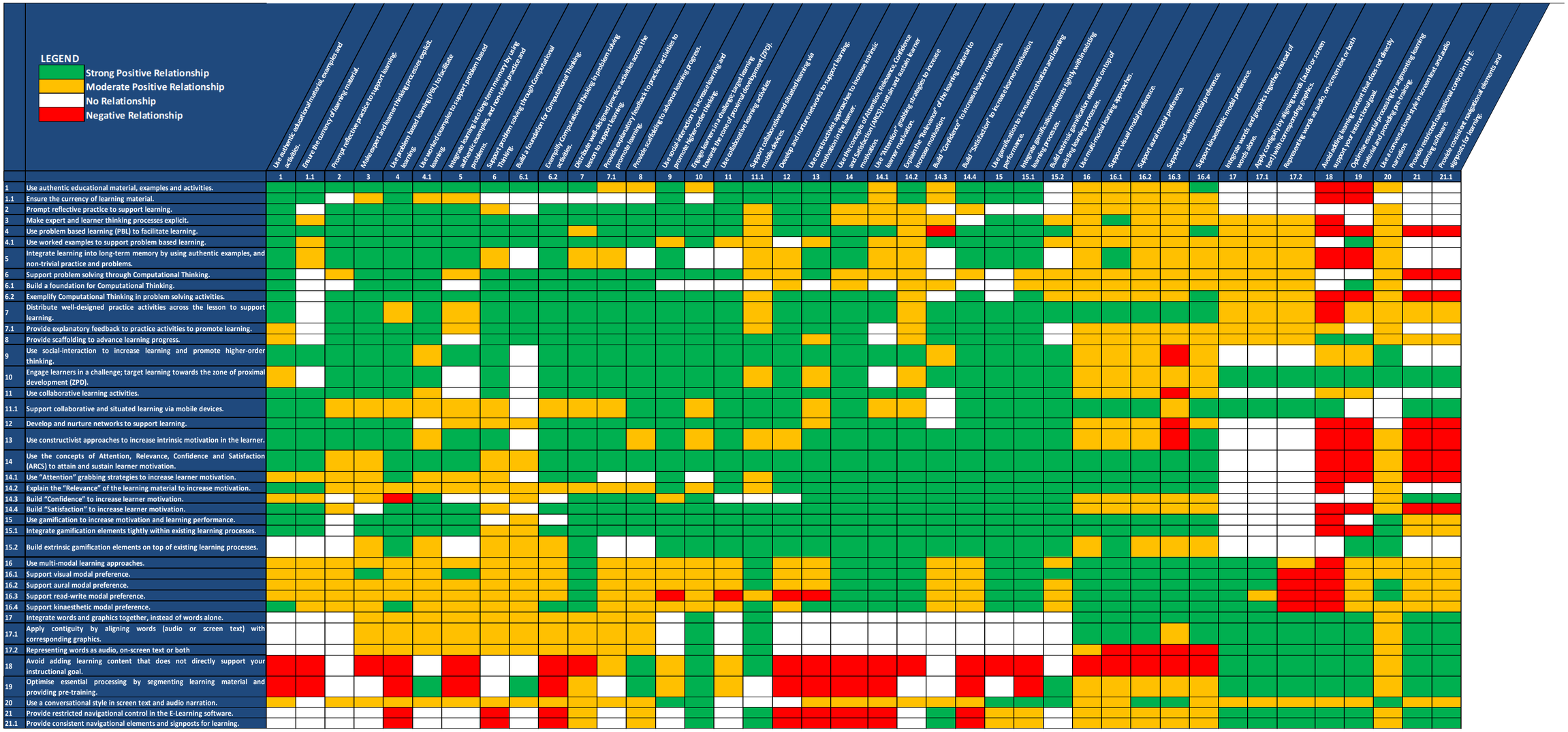
Learning Objectives

ID	Learning Objective	Importance of Learning Objective	Support for Learning Objective	Weighted Support for Learning Objective	Theoretical Maximum Support	
1	Understand the concepts of variables and constants	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
2	Understand the concept of data types	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
3	Be able to use arithmetic calculations in your algorithms	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4	Be able to use Boolean expressions in your algorithms	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
5	Using flowcharts determine the purpose of simple algorithms and explain how they work	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6	Using flowcharts explain simple algorithms in terms of their inputs, processing and outputs.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
			Content Quality:	0	0	0%

Heuristics

ID	Heuristic Title	Importance of Heuristic in Learning Context	Support for Heuristic	Weighted Support for Heuristic	Theoretical Maximum Support	
1	Use authentic educational material, examples and activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
1.1	Ensure the currency of learning material.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
2	Prompt reflective practice to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
3	Make expert and learner thinking processes explicit.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4	Use problem based learning (PBL) to facilitate learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
4.1	Use worked examples to support problem based learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
5	Integrate learning into long-term memory by using authentic examples, and non-trivial practice and problems.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6	Support problem solving through Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.1	Build a foundation for Computational Thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
6.2	Exemplify Computational Thinking in problem solving activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
7	Distribute well-designed practice activities across the lesson to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
7.1	Provide explanatory feedback to practice activities to promote learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
8	Provide scaffolding to advance learning progress.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
9	Use social-interaction to increase learning and promote higher-order thinking.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
10	Engage learners in a challenge; target learning towards the zone of proximal development (ZPD).	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
11	Use collaborative learning activities.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
11.1	Support collaborative and situated learning via mobile devices.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
12	Develop and nurture networks to support learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
13	Use constructivist approaches to increase intrinsic motivation in the learner.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14	Use the concepts of Attention, Relevance, Confidence and Satisfaction (ARCS) to attain and sustain learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.1	Use “Attention” grabbing strategies to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.2	Explain the “Relevance” of the learning material to increase motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.3	Build “Confidence” to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
14.4	Build “Satisfaction” to increase learner motivation.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15	Use gamification to increase motivation and learning performance.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15.1	Integrate gamification elements tightly within existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
15.2	Build extrinsic gamification elements on top of existing learning processes.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16	Use multi-modal learning approaches.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.1	Support visual modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.2	Support aural modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.3	Support read-write modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
16.4	Support kinaesthetic modal preference.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17	Integrate words and graphics together, instead of words alone.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17.1	Apply contiguity by aligning words (audio or screen text) with corresponding graphics.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
17.2	Representing words as audio, on-screen text or both	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
18	Avoid adding learning content that does not directly support your instructional goal.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
19	Optimise essential processing by segmenting learning material and providing pre-training.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
20	Use a conversational style in screen text and audio narration.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
21	Provide restricted navigational control in the E-Learning software.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
21.1	Provide consistent navigational elements and signposts for learning.	0 Not Applicable	0 Neither Supports NOR Counteracts	0	0	
			Pedagogical Quality:	0	0	0%
			Educational Value:			0%

X HEURISTICS INTERRELATIONSHIP MATRIX

As discussed in section 4.6.2 of the thesis, the heuristics interrelationship matrix represents the interrelationships between heuristics as documented in the Related Heuristics section of each heuristic. This matrix offers a high-level visual indicator to teachers and instructional designers on how the heuristics can positively support or potentially counteract each other. Its value is in stimulating reflection in teachers and instructional designers on how their choice of heuristics may affect other heuristics. However, ultimately, in any given e-learning implementation it cannot be guaranteed that these relationships will materialise or that other relationships will not emerge.

Note: The dimensions of the matrix mean that in an electronic copy of this document the matrix must be viewed on a large screen monitor and in a paper copy of the document the matrix should be printed on a 55cm x 40cm page.