Interview Questions (Adaptive Learning Expert)

Section 1 – Introduction

I am pleased to welcome **Dr Firstname Lastname**, Adaptive Learning Expert, to my interview today. I will be interviewing Firstname for approximately one hour as a key informant for my research study titled **'The Design, Development and Evaluation of a Domain Model for Post-Primary Mathematics'**.

Good afternoon, Firstname. Thank you very much for agreeing to meet me here today, the 10th April 2018, in the **Interview Venue**. You are already aware that I asked you to be a participant in my Research Study in an email on 6th March 2018. I attached an Information Sheet B, Consent Form and these Interview Questions to the most recent email that I sent you on 9th April 2018. I would like to emphasise once again that your participation is entirely voluntary. If you do wish to participate in my Research Study and proceed with this interview, I need to confirm the following:

1.1 Are you aware that the audio of the interview that has just begun is being recorded using an Olympus DS-30 Digital Voice Recorder and that this entire interview will be recorded?

1.2 Have you read Information Sheet B and the Consent Form?

1.3 Are you happy to sign the Consent Form and proceed with this interview?

Thank you for signing the Consent Form. The interview will last for approximately one hour. As you know, I emailed you the questions/themes that I am about to use in this interview. It will be based on the screencasts, domain model artefacts and Google Forms survey and the context will be the new Draft Specification for Junior Cycle Mathematics published in November 2017 and Adaptive Learning and Personalisation. You have been chosen as a Key Informant for this Research Study as a result of your vast experience working in the field of Adaptive Learning and Personalisation.

To begin, I would like to get some idea of your previous experiences as a student and lecturer in the area of Mathematics.

Section 2 – Experience of Maths

2.1 Did you **like Maths** in school and were you always good at Maths?

2.2 Would you say that Maths was your **favourite subject** in school and if not where did it rank?

2.3 Did you study Maths at university and if so was it your **favourite subject**?

2.4 How much of your undergraduate degree course was devoted to Maths and was Maths one of your **final year degree subjects**?

2.5 Did you ever work as a **Maths lecturer**, e.g. by teaching Maths as module on an undergraduate Computer Science course?

2.6 If so, **for how many years did you teach Maths** to undergraduate students?

2.7 (If you taught Maths), did you **enjoy teaching Maths** to undergraduate students and do you miss it?

During this interview, I would like to talk to you about a number of interrelated areas and concepts: adaptive learning, personalisation, expert-driven v data-driven paradigms, general adaptive learning architectures, specific domain model/user model/teaching model architecture, learning objects, learning management systems, authoring systems, research centres, special user groups and commercial development.

I would also like to present to you once more a number of domain model artefacts that I have created for part of the new Junior Cycle Mathematics syllabus that will be implemented in all post-primary schools in September 2018. As you know, I previously emailed you the links to the artefacts that I created using three separate applications: the **GAM Authoring Tool** (developed by the European GRAPPLE project that you were involved in), **Mindomo** (which is mind mapping software) and **Rhumbl** (developed by the MIT Mapping Lab).
First up: adaptive learning architecture and expert-driven versus data-driven systems.

Section 3 – Adaptive Learning 1 (Architecture, Expert-Driven v Data-Driven)

My understanding is that **Adaptive Educational Hypermedia Systems (AEHS)** were originally developed between 1990 and 1996 by either taking existing **Intelligent Tutor Systems (ITS)** and adding hypermedia components or by taking existing educational hypermedia and adding adaptive features.

Reference:

Brusilovsky, P. (2003). Developing Adaptive Educational Hypermedia Systems: From Design Models to Authoring Tools. In T. Murray, S. B. Blessing, & S. Ainsworth (Eds.), *Authoring Tools for Advanced Technology Learning Environments: Toward Cost-Effective Adaptive, Interactive and Intelligent Educational Software* (pp. 377-409). Dordrecht: Springer Netherlands. https://doi.org/10.1007/978-94-017-0819-7_13

It appears to me that much of the early pioneering work was carried out by **Professor Paul De Bra** in Technical University Eindhoven and **Professor Peter Brusilovsky** in University of Pittsburgh. De Bra actually claims in his October 017 valedictory lecture that the they became known as Peter and Paul, the two apostles! I am also aware that you worked on the European GRAPPLE project between 2007 and 2011 with De Bra and that you have co-authored papers with Brusilovsky, e.g. yourself, your TCD colleague Owen Conlan and Brusilovsky co-authored a paper in 2007 titled *From Learning Objects to Adaptive Content Services for E-Learning*.

Reference:

Brusilovsky, P., Wade, V., & Conlan, O. (2007). From learning objects to adaptive content services for e-learning. *Architecture solutions for e-learning systems*, 243-261. Retrieved from https://pdfs.semanticscholar.org/93de/21af50f6eb1bea89d16822669399bdd9bfe9.pdf

3.1 Could you tell me when and how you become interested in, and involved in, **adaptive learning**?

I have referred to the 2007 paper you co-authored with Brusilovsky and Conlan. I became aware of Brusilovsky's work almost one year ago. On 13th April 2017, I met Dr. Ioana Ghergulescu in her workplace (Adaptemy on Lower Mount Street, Dublin 2). You may be aware that Adaptemy, Dublin City University and National College of Ireland are the three Irish partners in the current Newton Project, which is funded by the European Union's Horizon 2020 Research and Innovation programme and whose remit is to develop, integrate and disseminate innovative technology enhanced learning (TEL) methods and tools. I explained to Dr. Ghergulescu that I was interested in developing part of an adaptive learning system for post-primary Mathematics during Year 2 of my MSc in Applied eLearning course in DIT. Dr. Ghergulescu referred me to the work of Peter Brusilovsky and specifically to Brusilovsky and Millan's classic 2007 paper titled *User Models for Adaptive Hypermedia and Adaptive Educational Systems*.

Reference

Brusilovsky, P., & Millán, E. (2007). User Models for Adaptive Hypermedia and Adaptive Educational Systems. In P. Brusilovsky, A. Kobsa, & W. Nejdl (Eds.), *The Adaptive Web* (pp. 3-53), Berlin Heidelberg: Springer-Verlag. Retrieved from https://pdfs.semanticscholar.org/55cfe/fc79fb172d179c186c117dd172dc171fb176c18786666.pdf

3.2 Was this an exciting time to be involved in **adaptive learning**?

It is just over 10 years since you wrote in the abstract of that 2007 paper you co-authored with Brusilovsky and Conlan "This paper argues that a new generation of powerful E-learning systems could start on the crossroads of two emerging fields: courseware re-use and adaptive educational systems. I would like to talk to you about the role of digital content including learning objects, Reusable Learning Resources (**RLRs**), Open Educational Resources (**OERs**), the failed National Digital Learning Repository (**NDLR**) and granulation later in this interview. However, my question for the moment is:

3.3 **Has the early promise**, expectation and hype surrounding adaptive learning / adaptive educational systems **been fulfilled**?

There are a number of popular architectures for Adaptive Hypermedia Systems (AHS). One of these architectures consists of a Domain Model/User Model/Application Model or in the case of Adaptive Educational Hypermedia Systems (AEHS), Domain Model/Learner Model/Teaching Model.

Reference

De Bra, P., Houben, G.-J., & Wu, H. (1999). *AHAM: a Dexter-based reference model for adaptive hypermedia*. Paper presented at the Proceedings of the tenth ACM Conference on Hypertext and hypermedia: returning to our diverse roots: returning to our diverse roots, Darmstadt, Germany. https://doi.org/10.1145/294469.294508

3.4 (a) In your opinion, is a **Domain Model/Learner Model/Teaching Model architecture** the best way to achieve an **effective adaptive learning system**?

(b) Is this architecture tied to **expert-driven** adaptive learning systems?

(c) What are the **principal adaptive learning architectures** worth considering in relation to creating expert-driven adaptive learning systems, e.g. your paper in 2007 (co-authored with Brusilovsky and Conlan referred to "a new service-based architecture for adaptive Elearning" and also referred to "the idea of adaptive reusable content services."

(d) Is there a completely different set of architectures that suit the **data-driven paradigm**?

My understanding is that, in general, adaptive systems are either **data-driven** or **expert-driven**. Almost all of the systems that I have read about are expert-driven. The data-driven paradigm appears to have had a lot of success in recent years in relation to machine learning, language translation, self-driving cars and other specific AI applications. I have read Brusilovsky's 2017 PowerPoint presentation (available on SlideShare) titled *From Expert-Driven to Data-Driven Adaptive Learning* and to De Bra's 2017 valedictory lecture simply called *It's personal*. In these 2017 presentations, Brusilovsky and De Bra appear to be engaging somewhat with the more recent data-driven paradigm.

Reference:

Brusilovsky, P. (2017, August). *From Expert-Driven to Data-Driven Adaptive Learning*. Keynote slides for the Workshop on Advancing Education with Data presented at the 23rd ACM SIGKDD International Conference on Knowledge Discovery and Data Mining. ACM, Halifax, Nova Scotia. Retrieved from https://www.slideshare.net/pbrusilovsky/from-expertdriven-to-datadriven-adaptive-learning.

De Bra, P. M. E. (2017). *It's personal*. Eindhoven: Technische Universiteit Eindhoven. Retrieved from https://pure.tue.nl/ws/files/78016653/Rede_De_Bra_LR_13_10_2017.pdf

3.4 (a) In your opinion, are the best adaptive learning systems **expert-driven** or **data-driven**?

(b) In your opinion, are the best adaptive learning systems for Mathematics **expert-driven** or **data-driven** or are all adaptive learning systems **domain agnostic**?

Section 4a – Adaptive Learning 2 (Domain Model in General)

As you know, a *Domain Model* is a semantic structure of concepts and the relationships between these concepts. One of the principal research objectives include for this research study was the development and evaluation of a Domain Model (DM) for Mathematics.

Reference:

Aroyo, L., De Bra, P., Houben, G.-J., & Vdovjak, R. (2004). Embedding information retrieval in adaptive hypermedia: IR meets AHA! *New Review of Hypermedia and Multimedia, 10*(1), 53-76. https://doi.org/10.1080/13614560410001728146

Vrablecova & Simko have stated in a 2016 research paper in *Ieee Transactions on Learning Technologies* that a domain model is an essential part of an Adaptive Educational Hypermedia System (AEHS).

4a.1 How important is a **domain model** as part of an adaptive learning system?

4a.2 In your opinion, is a **domain model** something that can only be created by a subject matter expert?

I am aware of research and development efforts to **create domain models automatically**. For example, in the same 2016 research paper titled *Supporting Semantic Annotation of Educational Content by Automatic Extraction of Hierarchical Domain Relationships* co-authored by Vrablecova & Simko and alluded to a few minutes ago, they state (and I quote):

> "We propose a method for automated domain acquisition coping with described specifics. In general, the method is based on statistical and linguistic processing of underlying resources created by teachers and eventually also by learners. The goal of the proposed method is automated acquisition of domain model, i.e., identification of relevant domain terms for underlying resources and creation of relationships between them."

4a.3 (a) Have you much knowledge of automatic extraction of hierarchical domain relationships?
(b) Do you think that for the domain post-primary Mathematics, it would be better that a subject matter expert(s) take a lot of time to create an excellent **domain model** once rather than trying to get a machine to build the domain model?

Reference:

Vrablecova, P., & Simko, M. (2016). Supporting Semantic Annotation of Educational Content by Automatic Extraction of Hierarchical Domain Relationships. *Ieee Transactions on Learning Technologies, 9*(3), 285-298.

In his valedictory lecture in October 2017 *It's Personal* published on 13th October 2017, Paul de Bra reflected how he started his professional career working with databases, took a conscious decision to move away from them with the emergence of hypertext and the web, and in recent years moved back to the databases required to store semantic data. In this published lecture, he stated and (I quote):

> "The research on adaptation I mentioned so far is purely expert-driven: an expert designs the adaptation rules. A first step away from this manual labor is the use of databases with semantic relations, and generating adaptation from the database by using template rules."

4.4 Is there a role for data-driven **domain models**? For example, perhaps a subject matter expert could build the original domain model (or models) and then, depending on data fed back from the user model (or learner model) , the best domain model could be chosen or the domain model could be subsequently adapted.

Section 4b – Adaptive Learning 3 (Domain Model for Mathematics)

I would now like to talk to you about moving towards a **domain model for Mathematics** and more specifically in relation to post-primary Mathematics. Once again, the importance of a domain model was underscored by Šimko in a 2012 paper titled *Automated Acquisition of Domain Model for Adaptive Collaborative Web-Based Learning*. He stated and I quote:

(The) "adaptation engine responsible for advanced functionality in the educational system relies on the domain model semantically describing subject domain."

Reference:

Šimko, M. (2012). Automated Acquisition of Domain Model for Adaptive Collaborative Web-Based Learning. *Information Sciences and Technologies Bulletin of the ACM Slovakia, 4*(2), 1-9. Retrieved from http://acmbulletin.fiit.stuba.sk/vol4num2/simko.pdf

The importance of connections a future domain model for post-primary Mathematics is highlighted by the following statement (and I quote) in the Draft Specification for the new Junior Cycle Mathematics course due to commence in September 2018:

> "Students should be able to make connections within strands and between strands, as well as connections between mathematics and the real world."

Reference:

NCCA. (2017). *Draft Specification for Junior Cycle Mathematics*. Retrieved from https://www.ncca.ie/media/3164/jcmathematics_draft_specification.pdf.

4b.1 Due to the large amount of connections that exist between concepts in Mathematics, and the importance of students having a conceptual understanding of Mathematics being as a large web of interconnected concepts, do you think that the creation of a good domain model for Mathematics is

(a) More **important** than for a lot other subject domains
(b) More **difficult** to create than for a lot other subject domains?

One of the best known adaptive learning systems for Mathematics was Active Maths which has been described in Melis et al's 2001 paper titled ActiveMath: A Generic and Adaptive Web-Based Learning Environment. I understand that this system worked by having a learner model that was populated by the responses to a self-assessment set of questions provided to the learner throughout the Active Maths learning process. Learning scenarios and learning goals are chosen by the learner who is then led on a guided tour through an electronic book.

Reference:

Melis, E., Andrès, E., Büdenbender, J., Frischauf, A., Goguadze , G., Libbrecht, P., . . . Ullrich , C. (2001). ActiveMath: A Generic and Adaptive Web-Based Learning Environment. *International Journal of Artificial Intelligence in Education, 12*, 385-407, Retrieved from http://www.ijaied.org/pub/1142/file/active.pdf

4b.2 In relation to ActiveMath,

(a) Were you **aware** of this **adaptive learning system for Maths?**
(b) Was this one of the more important adaptive learning systems that were developed for Maths in the past 15 years?
(c) Were there other noteworthy adaptive learning system for Maths that were developed in the last 15 years?

In this 2001 paper that describes how **ActiveMath** works, the user model is described as being very rudimentary. However, the domain model and pedagogical model are described by the authors as being more sophisticated. They state (and I quote):

> "In ActiveMath the knowledge representation is separated from the system's (presentational) functionalities. This separation is a key for the multiple use of the same knowledge representation in different contexts, for reusing and combining knowledge from different sources, and for managing knowledge with different systems and for different functionalities.
> Abstractly, the knowledge representation of the course content is a standardized semantic xml expressing objects and their relations as well as meta data. This is stored in a data base. Moreover, pedagogical knowledge is formalized in so-called pedagogical rules."

I am fascinated by this idea that it may be possible to represent a domain model by using semantic xml to represent concepts as meta data and represent learning objects for the concepts as meta data and store both sets of data in a database. Then the meta data for the concepts would be stored in fields in the database and connections between the meta data concepts would be represented as relations between fields in the database. This architecture that I describe achieves separation between concepts, relations and concepts.

4b.3 In relation to the design model I have just described

(a) Is it a sensible design?
(b) Has it already been implemented?

In relation to this design model, I think it would accommodate a simple numeric overlay user model, the type described in the classic 2007 paper by Brusilovsky and Millan's titled *User Models for Adaptive Hypermedia and Adaptive Educational Systems* and described earlier in Section 3 of this interview. However, I'm not sure how to design or implement a pedagogical model or pedagogical engine. I discuss these two idea later in this interview.

I have just referred to the use of semantic XML for representing Mathematical knowledge in a domain model. There is a very interesting paper from 2013 by Christophe Lange titled Ontologies and languages for representing mathematical knowledge on the semantic web. In

this paper Lange argues (and I quote) “the services for the Web of Data will benefit from a deeper representation of mathematical knowledge”.

Reference:

Lange, C. (2013). Ontologies and languages for representing mathematical knowledge on the semantic web. *Semantic Web, 4*(2), 119-158.

In relation to Mathematical Knowledge Management (**MKM**), Massimo Marchiori refers to “those Web technologies that could be potentially low-hanging fruits: RDF, OWL, XML-Schema, XML-Query and Functions and Operators.”

Reference:

Marchiori, M. (2003, February). The mathematical semantic web. In *International Conference on Mathematical Knowledge Management* (pp. 216-223). Springer, Berlin, Heidelberg.

4b.4 (a) Are you aware of some or all of the following Web technologies for Mathematics on the web: Web Ontology Language (**OWL**), Resource Description Framework (**RDF**), XML-Schema, XML-Query, OpenMath, MathML?

(b) Do you see a use for any or all of these Web technologies in the domain model for post-primary Mathematics that I hope to eventually build?

Section 5a – Draft Specification (PDF), Unpacking Learning Outcomes and Repacking Learning Outcomes (Microsoft Excel)

We will now use the computer to have another look at the learning outcomes in the new Draft Specification for Junior Cycle Mathematics. We will then look again at the **45 unpacked learning outcomes** in my **Microsoft Excel** spreadsheet. You have already seen both of these in the screencast.

5.1 Do you think that the **learning outcomes** in the **mathematics syllabus** should be the principal data source for a **domain model**?

5.2 Should there be any other data source for a **domain model** and if so, what?

5.3 Having watched the **screencast**, did you understand the **unpacking process** from the **6 learning outcomes** in the **Draft Specification** to the **45 learning outcomes** created by me? Any comments?

5.4 Which set of **learning outcomes** do you think will be more beneficial for the teaching, learning and assessment of **Junior Cycle Mathematics** and why:
- the **6 long paragraph** based learning outcomes that are in the **Draft Specification** or
- the **45 short sentences** created by me to describe these **learning outcomes**?

5.5 Having watched the **screencast**, have you any comments on the **repacking process** from **45 learning outcomes** to **33 learning outcomes**? This was achieved by amalgamating the topics patterns and functions.

5.6 Having watched the **screencast**, have you any comments on the **repacking process** from **33 learning outcomes** to **23 learning outcomes**? This was achieved by amalgamating linear, quadratic and exponential from separate topics to one topic.

Section 6 - Domain Model (GAM Authoring Tool)

We will now use the computer to have another look at the **domain model artefact** created by the **GAM Authoring Tool**. First, we will look at a short screencast, set to music, which follows the development of this domain model. At the end of the screencast, we will look at an image of the entire domain model.

6.1 Do you think that the **visual display** for this version of the **domain model** is **easy to understand**?

6.2 Do you think that the **concepts** in this version of the **domain model** are **correctly sequenced**?

6.3 Do you think that the **concepts** in this version of the **domain model** are **correctly connected**?

6.4 Do you think that this **visual display**, extended to include the entire Junior Cycle Maths Syllabus, could be used as a **domain model representation** in an overall **Adaptive Learning System for Junior Cycle Mathematics**?

Section 7a - Domain Model (Mindomo Organigram 3)

We will now use the computer to have another look at the **three domain model artefacts** I created using the **Mindomo** mind mapping tool. We are now looking at a graphic of the domain model created using **Mindomo** that contains 45 learning outcomes represented by words or short phrases. I have called this mind map (or concept map) **Mindomo Organigram 3.** Incidentally, it is not in the survey that was sent to 8 branches of the Irish Mathematics Teachers' Association earlier this month (March 2018).

7.1a Do you think that the **visual display** for this version of the **domain model** is **easy to understand**?

7.2a Do you think that the **concepts** in this version of the **domain model** are **correctly sequenced**?

7.3a Do you think that the **concepts** in this version of the **domain model** are **correctly connected**?

7.4a Do you think that this **visual display**, extended to include the entire Junior Cycle Maths Syllabus, could be used as a **domain model representation** in an overall **Adaptive Learning System for Junior Cycle Mathematics**?

Section 7b - Domain Model (Mindomo Organigram 2)

We are now looking at a graphic of the domain model created by me using **Mindomo** that contains 45 learning outcomes represented as labels or codes such as 1a-1. For example, 1a-1 means "represent linear patterns and relationships in tables". This is the same as the artefact we were looking at a few moments ago except I use codes rather than words and short phrases for the learning outcomes. I have called this mind map (or concept map) **Mindomo Organigram 2** and it is in the survey that was sent to 8 branches of the Irish Mathematics Teachers' Association earlier this month (March 2018).

7.1b Do you think that the **visual display** for this version of the **domain model** is **easy to understand**?

7.2b Which of these two Mindomo domain model artefacts do you prefer: the artefact using words or short phrases or the artefact using labels such as 1a-1?

Section 8 - Domain Model (Mindomo Organigram 1)

In a moment, we will examine the third and final **Mindomo** domain model artefact. This artefact was achieved by amalgamating linear, quadratic and exponential patterns and functions into a single topic. This process was examined when we looked at the Microsoft Excel listings of the learning outcomes a few minutes ago.

We are now looking at a graphic of the domain model created by me using **Mindomo** that contains approximately 23 learning outcomes represented by words or short phrases. These are the same 23 learning outcomes you saw in the **Microsoft Excel** spreadsheet a few moments ago and is similar in style and layout to the last organigram. I have called this mind map (or concept map) **Mindomo Organigram 1** and it is in the survey that was sent to 8 branches of the Irish Mathematics Teachers' Association earlier this month (March 2018).

8.1 Do you think that the **visual display** for this version of the **domain model** is **easy to understand**?

8.2 As a result of amalgamating the concepts associated with linear, quadratic and exponential patterns and functions, this **Mindomo** domain model artefact contains 20 fewer learning outcomes than the first two **Mindomo** artefacts that we examined a few minutes ago. I think that the previous two **Mindomo** artefacts can be used to ensure that all 45 learning outcomes are **taught and assessed separately**. However, this third and final **Mindomo** artefact could be used to **teach linear, quadratic and exponential patterns and functions in a systematic fashion**. This is where I can see the **Teaching Model** component of an Adaptive Learning System interacting with the Domain Model component. Assessment would of course take place via the **User Model** component. Does this make sense? Any comments?

Section 9 - Domain Model (Excel Spreadsheet for Rhumbl)

We are now looking at a Microsoft Excel spreadsheet template provided by MIT Mapping Labs as part of the data input component of their Rhumbl software application. I entered the

topics and learning outcomes onto this template. You have already seen this Rhumbl spreadsheet in the screencast.

9.1 Do you think that the **matrix of Topics and Learning Outcomes** in this spreadsheet template designed as part of Rhumbl is easy to understand?

9.2 Do you think that the **topics** and **learning outcomes** are **correctly connected** using the digit 1 to indicate a connection?

Section 10 - Domain Model (Rhumbl Map)

We will use the computer to have a look again at the **domain model artefact** I created using the **Rhumbl** concept mapping tool. There are two different map views: by **topic** and by **learning outcome**.

We are now looking at the **Rhumbl** map graphic that is the output from the spreadsheet input we looked at a few moments ago. I would like you to take a few minutes to look at and evaluate this Rhumbl domain model artefact using the two different map views: by **topic** and by **learning outcome**. This Rhumbl map is in the survey that was sent to 8 branches of the Irish Mathematics Teachers' Association earlier this month (March 2018).

10.1 Do you think that the **map views** for this version of the domain model are **easy to understand**?

10.2 Do you think that the **learning outcomes** in this version of the domain model are **correctly connected** to the **topics**?

10.3 Which of the two map views do you prefer: by **topic** or by **learning outcome**?

Section 11 – Learning Outcomes and Topics

11.1 What do you think teachers should use as the **main framework to teach** the new Junior Cycle Maths course that commences in September 2018

(a) Text book **topics** (chapters) and **sub-topics** (sections)
(b) The new **syllabus learning outcomes**
(c) A larger set of **unpacked learning outcomes**, when available, as described in my screencast?

11.2 What do you think students should use to **frame their learning** for the new Junior Cycle Maths course that commences in September 2018?

(a) **Text book topics** (chapters) and sub-topics (sections)
(b) The new **syllabus learning outcomes**
(c) A larger set of **unpacked learning outcomes**, when available, as described in my screencast?

Section 12 - Patterns and Functions

12.1 Do you think that teachers should **present 'Patterns and Functions' as a single topic** using a unified set of learning outcomes as presented in the domain model artefacts and described by me in the screencast?

Section 13 - Sequencing and Connecting Concepts in Mathematics

13.1 Do you think Junior Cycle Mathematics should be taught and learned as a hierarchical system of sequenced concepts?

13.2 If 'Yes', can you explain why it should be taught this way and give an example of parts of the Junior Cycle Mathematics course that can be taught in this way?

13.3 If 'No', can you explain why it should not be taught in this way?

13.4 Do you think Junior Cycle Mathematics should be taught as a system of connected concepts?

13.5 If 'Yes', can you explain why it should be taught this way and give an example of parts of the Junior Cycle Mathematics course that can be taught in this way?

13.6 If 'No', can you explain why it should not be taught in this way?

Section 14 - Future Adaptive Learning System for Post-Primary Mathematics

14.1 Do you think that a Domain Model is necessary to create an Adaptive Learning System for Mathematics?

14.2 Do you think that an Adaptive Learning System, with a core Domain Model, could enhance the teaching and learning of Junior Cycle and Leaving Certificate Mathematics?

14.3 Do you think that an Adaptive Learning System would be a more effective tool than a textbook for teaching Mathematics as a system of connected concepts?

Section 15 – New Entrant Mathematics Teachers / PMEs

15.1 Do you think that an Adaptive Learning System, with a core Domain Model, could help these new teachers and PMEs to make connections between concepts within and across strands?

15.2 Do you think that if such an Adaptive Learning System is created that this should be used by the colleges of education that prepare students to be post-primary teachers of Mathematics?

Section 16 – Comparison of the 3 Domain Model Artefacts

15.1 Which representation of the domain model did you prefer and why:
- the visual display containing the line and patterns/functions created by the GAM Authoring Tool. (This was the first map type you saw).
- the three mind maps created with Mindomo containing the coloured learning outcomes/concepts. (This was the second set of map types you saw).
- the concept maps, by topic and by learning outcome. (This was the last map type you saw).

15.2 Do you think that an electronic textbook that mimics the traditional hard copy version, with chapters, topics and sub-topics is preferable to a map-driven digital system that would use some or all of the maps we have explored here today?

Section 17 – SEN Students

18.1 Do you think that it is important that a Maths e-Learning system is designed to benefit SEN students?

18.2 Do you think that a domain model driven adaptive learning system for post-primary Mathematics that creates individual learning pathways for each student would be desirable and/or beneficial for SEN students who are withdrawn from class for extra Maths and therefore have more than one Maths teacher?

Section 18 – eAssessment Mk2

It seems to me that electronic assessment is of immense importance to a learner model that is configured to place a significant emphasis on prior learning. However, many if not most eAssessment components of digital learning systems use multiple choice, cloze questions or drag and drop. I think that more advanced eAssessment technologies are required to handle unstructured text answers, handwriting recognition and assessments that use dynamic geometry software such as GeoGebra. **NUMBAS**, created by the Newcastle University, is a sophisticated web application for Maths eAssessment. Online tests can be created that assess a question in parts and can assess questions involving student use of GeoGebra. NUMBAS uses open source software. Therefore it can be customised.

Reference:

Newcastle University (2017, April 8). *Numbas: really versatile maths e-assessment*. Retrieved from https://www.numbas.org.uk/

18.1 Are you familiar with **NUMBAS** and if so do you think it could be used to populate the **user model** of an adaptive learning system?

WIRIS is a **MOODLE plug-in**. Quizzes created by it allow for a variety of test responses such as True/False, Multiple choice, Matching, Short answer, Essay, Embedded answers (Cloze). It also features handwriting recognition so that a student can answer questions using natural handwritten responses.

Reference:

WIRIS. (2017, April 8). *Global solution for math and science*. Retrieved from http://www.wiris.com/en

18.2 Are you familiar with **WIRIS** and if so do you think it could be used to populate the **user model** of an adaptive learning system? It integrates with many popular LMS such as MOODLE, Canvas and Schoology.

TAO (Testing Assisté par Ordinateur) started in late 2002 as a joint project between the public research centre **Henri Tudor** and the **University of Luxembourg**. It is open source and freely available to the education community worldwide. It was used in PISA in 2012 with Mathematics and Complex Problem-Solving tests delivered electronically. It was awarded the PISA 2015-CORE2 contract to develop the global management and assessment platform for OECD.

Open Assessment Technologies. (2017, April 8). *TAO*. Retrieved from https://www.taotesting.com/

18.3 Are you familiar with **TAO** and if so do you think it could be used to populate the **user model** of an adaptive learning system?

Section 19 – Learning Objects

You co-authored a paper in 2007 titled *From Learning Objects to Adaptive Content Services for ELearning*. This dealt with learning objects. David Wiley wrote a book chapter titled *Learning Objects and Instructional Theory* in Reigeluth et al's 2009 book titled Learning Objects and Instructional Theory. Wiley refers to the IEEE Learning Technology Standards Committee in this book and provides a definition of learning object taken from IEEE. I have gone direct to the pertinent IEEE website to quote this definition and some extra material. Here is the quotation:

> "This standard will specify the syntax and semantics of Learning Object Metadata, defined as the attributes required to fully/adequately describe a Learning Object. Learning Objects are defined here as any entity, digital or non-digital, which can be used, re-used or referenced during technology supported learning. Examples of technology supported learning include computer-based training systems, interactive learning environments, intelligent computer-aided instruction systems, distance learning systems, and collaborative learning environments. Examples of Learning Objects include multimedia content, instructional content, learning objectives, instructional software and software tools, and persons, organizations, or events referenced during technology supported learning. The Learning Object Metadata standards will focus on the minimal set of attributes needed to allow these Learning Objects to be managed, located, and evaluated. The standards will accommodate the ability for locally extending the basic fields and entity types, and the fields can have a status of obligatory (must be present) or optional (maybe absent). Relevant attributes of Learning Objects to be described include type of object, author, owner, terms of distribution, and format. Where applicable, Learning Object Metadata may also include pedagogical attributes such as; teaching or interaction style, grade level, mastery level, and prerequisites."

I would like to talk to you a bit about learning objects, granulation, SCORM, Tin Can API and Learning Tools Interoperability (LTI) developed by IMS Global Learning Consortium.

Brusilovsky, P., Wade, V., & Conlan, O. (2007). From learning objects to adaptive content services for e-learning. Architecture solutions for e-learning systems, 243-261.

Wiley, D. A. (2009). Learning Objects and Instructional Theory. In A. A. Carr-Chellman & C. M. Reigeluth (Eds.), Instructional-design Theories and Models Volume III: Building a Common Knowledge Base. New York: Routledge.

19.1 How important are **learning objects** in adaptive learning systems?

19.2 How important is **granulation** in relation to **learning objects** in adaptive learning systems?

19.3 How important is **SCORM** (developed by ADL) and its successor **Tin Can API** or **xAPI** (developed by Rustici Software) in relation to **learning objects** in adaptive learning systems?

19.4 How important is **SCORM** (developed by ADL) and its successor **Tin Can API** or **xAPI** (developed by Rustici Software) in relation to **Learning Record Store (LRS)** in relation to the **user model** in adaptive learning systems?

19.4 In your opinion, is it useful to use or integrate any of the current **Learning Management Systems (LMS),** that may possibly use SCORM or xAPI. with adaptive learning systems?

Section 20 – Authoring Tools

You co-authored a paper in 2015 with your colleagues Seamus Lawless and others titled *A Review of Personalised E-Learning: Towards Supporting Learner Diversity* in which you documented the history of authoring tool development from AHA! To the GRAPPLE tools (De Bra) and ELM-ART, Knowledge Tree, etc (Brusilovsky). You also looked at current authoring tools and lamented the dearth of suitable authoring tools for adaptive learning.

In 2016 you co-authored a paper with your colleagues Aoife Brady and Owen Conlan here in the ADAPT Centre in TCD titled Lesson Planner Tool for Supporting Teachers to Create Pedagogically Sound Learning Resources in which you evaluated a lesson planner tool. You stated (and I quote):

> "Teachers typically have the domain expertise and formal or informal pedagogical knowledge to create quality learning resources. However, they lack the tools and often the specific knowledge of online pedagogical approaches that make it time efficient for them to do so."

O'Donnell, E., Lawless, S., Sharp, M., & Wade, V. (2015). A Review of Personalised E-Learning: Towards Supporting Learner Diversity. *International Journal of Distance Education Technologies, 13(*1), 22-47. doi:10.4018/ijdet.2015010102

Brady, A., Conlan, O., & Wade, V. (2016, July). Lesson Planner Tool for Supporting Teachers to Create Pedagogically Sound Learning Resources. In *Advanced Learning Technologies (ICALT), 2016 IEEE 16th International Conference on* (pp. 295-299). IEEE.

I used the latest version of the authoring tool (the GAM Authoring Tool) that emerged from the GRAPPLE project for this MSc research study. According to the coder on this latest version it still doesn't work on a web server. Moreover, in my opinion the design paradigm (hierarchical accordion menu of concepts) is not fit for purpose in relation to designing a domain model for Mathematics. I believe that a more appropriate authoring tool should create a visual concept map knowledge representation. I think it is also essential that the map creates a back-end database of this semantic web of connected concepts.

20.1 What are the latest authoring tools one should consider for developing an adaptive learning system, with domain model/user model/teaching model?

20.2 I have used Adobe Captivate and I believe that Articulate Storyline is similar. I believe that these popular eLearning tools are also not fit for purpose. Any comments?

20.3 Fishtree appears to be a tool for creating adaptive learning content. My understanding is that it also has LMS features and that DCU are trialling it. Any comments?

20.4 There is an open source responsive eLearning development tool called Adapt. Three leading eLearning companies, Learning Pool, Sponge UK and City & Guilds Kineo are the founding members of this innovative open source eLearning authoring project. Are you aware of this tool and do you think it is a candidate to build an adaptive learning system for post–primary Mathematics?

20.5 Do you think that authoring tools are subject agnostic or should a specific authoring tool be developed to create adaptive learning systems for Mathematics.