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Personalised Authentic assessments with Synchronous Learning Activities: a Framework for Teaching Visualisation and Graphics

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Abstract

We present an activities framework for learning visualisation and computer graphics. The framework pivots around the academic developing an authentic learning scenario that is personalised for every student, followed by a suite of synchronous learning activities. The authentic assessment helps set the scene and motivate the learners, activities bring the students together to work on an aligned sub-task, while personalising the task enables each student to discuss their work without worrying about plagiarism. We demonstrate how we have applied the structure in two modules; first a third-year degree level module in computer graphics rendering and second an information visualisation masters module. In this paper we present the framework and discuss our experience with using it.

CCS Concepts

• ***Human-centered computing*** → ***visualisation;*** • ***Computing methodologies*** → ***Computer graphics;*** • ***Applied computing*** → ***Distance learning;***

1. Introduction

We present a framework to enable authentic assessments that utilise synchronous, shared and engaging exercises for use when teaching visualisation, computer graphics and related subjects. Using an authentic assessment also means that the teacher needs to think about the scenario first, then organise the material to make sure that the students know how to solve the task. Consequently teachers may need to re-consider how they teach the module. With traditional assessments a teacher would set the content of the unit and then examine or assess the materials with tests and tasks that follow the taught material. Traditional tasks tend to reveal what learners can remember, recall and what they have learned. In contrast, authentic assessments mirror different challenges and priorities that are found in the world, encouraging learners to conduct research, write, revise, critique, discussion and engage in collaboration, etc. [DHS00].

Authentic assessments assess a task that students would find in the workplace. Real-life situations can be brought into the classroom in different ways. One approach (and the one that we use here) is to first describe a scenario, and then divide the work into separate tasks. The assessment encourages learners to think beyond the limits of the taught unit [Wig90]. Through our framework we hope to encourage teachers of visualisation and computer graphics subjects to use 'authentic assessments', and place them at the heart of the taught material. Furthermore, we advocate and challenge teachers to re-consider, re-structure and adapt their teaching to fully pivot around an authentic assessment.

The framework is based on four parts: personalising the task to every student (P); pivot the assessment around an authentic (A) task, which is based on a real-world problem that students could face when they leave their academics studies. Support the task with synchronous (S) learning activities (S), that bring everyone together. PASS is an acronym to remind academics of the parts: to think about how the assessment is going to be personalised, and what authentic assessment scenario is going to be used.

We present the paper in three parts: (i) we explain the pedagogic background and explore related work (Section 3); (ii) present the framework and elaborate the ideas, provide guidance for its use and discuss issues (Section 4), and (iii) describe how we have used the framework across two academic modules: third year Computer Graphics and Visualisation module (taught for undergraduate BSc computer science students) and an Information Visualisation unit (taught at Masters level), (Sections 5 and 6). Finally we discuss the work and conclude (Section 7).

2. Background

As teachers we want to develop individuals who are knowledgeable in computer graphics and related topics, but also have the skills necessary to design and develop the next generation of graphics software. Learners need to become independent creative thinkers, who can tackle new problems and design appropriate solutions, and develop knowledge, skills and attitudes necessary for their future professional life. Consequently, teachers need to develop learning environments where "every person is inspired to grow creatively" [Rob01] and enable learners to empower themselves to learn new material, apply the knowledge they have gained and think for themselves [RT13] whether taught on campus or remote.

We have been teaching graphics and visualisation classes for over twenty years, and considering the pedagogic delivery of it. We

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have been recording lectures, making them available for students to view, and giving students assessments based on the content. However, Covid-19 forced us to change our traditional delivery method; moving from a typically didactic teacher centred delivery to a student centred one. Consequently, we needed to consider the structure of the delivery, and make it appropriate for online use. We had been using activities in our learning, such as Critical Thinking Sheets [RR20, RR19] and coding exercises [Rob22], and had been structuring the assessments in stages and using the Explanatory Visualisation Framework (EVF) [RRJH18]. But we wanted to organise the activities with the lesson content in a closer way, and drive the material through a meaningful task; in particular use tasks that students may find in their workplace. Furthermore, like with the Explanatory Visualisation Framework [RRJH18] we wanted to personalise the tasks, so that students could work offline, compare notes and help each other, but without the challenge of plagiarising work.

To achieve these goals, we restructured our teaching around (1) an authentic assessment, (2) gave each student a personalised subject and (3) developed a set of weekly activities that brought the students together in one group. While some of the lecture material would be remote, and the students would be working remotely they would still be able to interact with each other. Furthermore, we hoped that if we could get the learners to think about the work of the module beyond the classroom they would be more likely to interact with each other. If students are given an individualised task, they can discuss the issues freely with their peers, without issues of plagiarism.

3. Related Work

The use of a personalised learning task [CKM06] was important. When every student chooses their own 'mini challenge' they become responsible for their challenge. They own the idea, it becomes a mini-project and they hopefully will get excited over the work and do better. It is difficult sometimes for students to make up a suitable challenge. Consequently we provide a list of topics to choose. But, students can define their own topic (under guidance from the teacher) if they choose to do so. However in practice we have found that students rarely choose their own topic. We follow a project based learning approach (PBL) [Bel10, KMW16], which is personalised, where students choose a specific topic (from a list) but they all follow the same set of tasks in the same order.

While all learning can be considered as a personal experience, because students need to organise their own study and make effort to learn the material [Tob00], some learning environments allow students to follow their own paths. Learner personalisation can range from selecting questions from a larger set of questions, setting individualised topics, to allowing students free reign in their studies [Kep14]. In this instance, we are not advocating students to control their own learning in a fully unstructured way, on the contrary we are guiding the students through the tasks and the whole cohort achieves the tasks at the same time. Our rationale is that students are more committed to the work when they can make their own choices [ALWW20], they are more motivated to study, accompanied with the authentic nature of the scenario students see value in the task for their future career.

Furthermore, we are a proponent of *active learning* strategies; methods that encourage students to take an active role in their learning and reflect on what they are achieving [BE91]. Ours is an experiential learning approach [KK05] where students engage with the process and develop their own skills of discussion, creative thinking, design, development and implementation [RRJH18]. We do not only want learners to memorise and repeat information they have learned, but to apply, analyse and synthesise solutions [Kra02]. Moving from the intellectual to enactment in practice [Ken99]. With active learning, students participate in activities beyond passively listening [MJ93]. We give the students a weekly set of tasks, include lecture recordings, notes and research papers, with a synchronised activity. Students study alone, but are brought together in one synchronised virtual classroom to tackle the tasks. This strategy is particularly suitable for students in graphics, visualisation and design, because students take an active part in their own learning, they can refine their skills and improve their adeptness in the subject [RRJH18]. We also allow students to talk with each other online; they discuss the topic but also chat about the course in general. In this way, we try to bring a sense of *community* to online-learning.

We developed the acronym PASS as an aide memoir; representing **P**ersonalising tasks, **A**uthentic assessment, **S**ynchronous activitie**S**, which is explained in Section 4. The ideas evolved through trying to organise the teaching unit for remote delivery due to the Covid-19 pandemic. We drew on our past experience with creating teaching, design and learning activities. These include the Five Design-Sheets [RHR16, RHR17], Explanatory Visualisation Framework [RRJH18, RJHR16] and Critical Thinking Sheet (CTS) [RR20]. We rearranged the unit and delivery of the material around the authentic assessment. We were also driven because of our need to translate to remote (off campus) teaching, move away from unseen examinations, and wish to engage with the students to develop a sense of community. We have used the PASS framework in two modules (units of work) each are 20 UK credits, a third year Computer Graphics and Rendering module, and an Information Visualisation module that is taken by masters students in advanced computer science.

Running teaching activities, within the subjects of computer graphics and visualisation, is becoming more common. For instance, a workshop on 'Visualisation Activities' was held during both the 2020 and 2021 IEEE VIS visualisation conferences [HBH*20]. Activities have been designed for different purposes, for example: brainstorming using cards (e.g., vizitcards [HA17]), making [Low16], construction using tokens [HCT*14], informal sketching [Bux10], design sketching (e.g., the Five Design Sheet (FdS) [RHR17]) or the Critical Thinking Sheet [RR20, RR19], to research activities (e.g., on visualisation tools [RSDB20]).

There are many different frameworks that could be followed, or used as a structure for a computer graphics unit of teaching. These include models such as the decision processing models by Simon [Sim73] (Intelligence, Design, Choice, implementation and review), the Explanatory Visualisation Framework (research, report, design, plan, develop and reflect) [RRJH18], Munzner's nested model [Mun09], McKenna et al. [MMAM14] (understand, ideate, make, deploy) and the nine-stage design-study model by Sedlmair et al. [SMM12]. In fact they all share similar traits. They all elaborate around the progression of four stages: research, design, development and reflection. We incorporate this flow of parts into our authentic assessment task. The difference with PASS to these methods is that the whole learning unit pivots off the authentic assessment. We believe that it is important to first develop the authentic assessment and create the scenario, then arrange the order

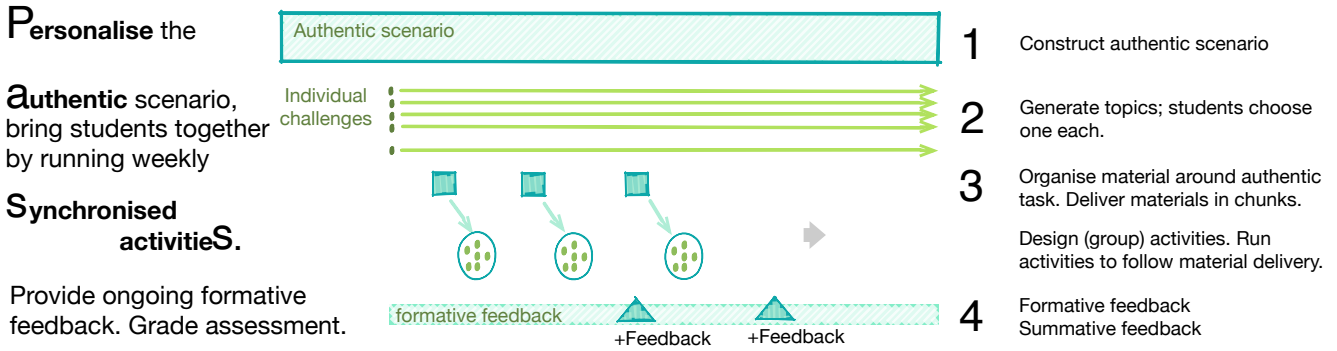

Figure 1: *The PASS framework helps to organise the taught unit around an authentic assessment. First design the scenario, then consider how it can be personalised to each student, organise the material around the scenario. Deliver the material in chunks (lesson plus activity and feedback). Finally provide formative feedback and evaluate the students' work.*

of the taught material to fit. We also focus on remote teaching and encourage remote activities.

Authentic assessments are realistic problems that someone could find in their workplace. These open-ended questions help "students rehearse for the complex ambiguities of the *game* of adult and professional life" [Wig90]. Challenges that are constrained, narrow, or converge students to one solution are not well-suited. What is required are divergent challenges, that open up a broad set of possible alternative (and equally suitable) solutions. These types of challenges are often called 'ill-structured' [RKH*14]. This means that the challenges should be less rigidly structured (rather than ill-structured in the sense of being badly-thought out). The open-ended nature of authentic questions allow students to develop competencies that they would use in real-life. Authentic assessments promote higher order thinking, they encourage students to develop a deep understanding of the issues around the topic, and connect the ideas being taught in the course beyond the classroom, they also can help students converse with each other and help to support student achievement [NW93]. If students see value in the teaching, and that they are learning skills they will need, they will engage with the material and be motivated to learn the material.

4. The PASS framework

In this section we explain the four parts and elaborate the ideas. We have structured this section to guide other people to follow this method, and present strategies to guide teachers through the different parts. Figure 1 shows a schematic picture of the framework.

Traditionally when a module is put together, the teacher will write the assessments last, after the lecture notes, slides and so on have been created. However, with an authentic assessment approach, we propose that a different approach is required. We believe it is important to start by considering the assessment first, before writing the slides and notes. This is necessary because the assessment provides a structure and defines the order that the taught material will need to follow. This structure can also be given to the students, which will provide a simple structure that can be easily understood by the students. Subsequently we suggest that academics:

- decide on the **authentic** scenario,
- consider how to **personalise** it,
- order the education material around this structure,
- organise **synchronous** sessions that engage students and bring them all together;
- create **activities** that allow students to reflect and construct knowledge around the content, and provide ongoing formative feedback from activities, and summative feedback from tasks.

There should be an obvious pairing between chunks of material and the activities. In other words, the teacher delivers a block of material that is reinforced by constructivist activities on that material. This could be implemented in several ways. For example, when teaching our Computer Graphics and Rendering unit, we recorded and delivered lectures, notes and research-papers were provided at the beginning of the week, and we ran the activity at the end of the week. With the Information Visualisation module, the education materials were posted to the learning site one week (Blackboard) and activities were run during the following week.

For our work, we split the assessment into four parts: (i) research and analysis, (ii) design, (iii) implementation, and (iv) reflection. We use the structure from the Explanatory Visualisation Framework [RRJH18]. In the first part students research the topic, do analysis, and submit a written report. They need to demonstrate that they understand the issues of the topic, are knowledgeable about related work, and can organise the material in a clear way. In the second part they explore design alternatives (we use the Five Design-Sheet methodology [RHR16, RHR17]). Finally, students implement their solution and reflect on their work.

4.1. Personalise – generate individual topics

We personalise the general authentic assessment [CKM06], through a project based learning approach [Bel10, KMW16], where students select their own 'topic'. Topics are problems that students would solve. Duncker [DL45] defines a problem with a starting state, a goal and an action that moves you closer to your goal. Topics should be a short paragraph, with enough information to express the idea. We need to define topics that contain enough detail that a student knows about the challenge, and what they should achieve. The teachers' challenge is to frame the topics, such that students can complete the task in the given time [Ent93]. Our guidance is to write a general statement (of the challenge) in one sentence, followed by a second sentence that qualifies details of the first.

For example, in visualisation one challenge we used was to "visualise UK bird data". This defines the main problem domain (a

design study to create visualisations that displays UK bird data) and gives the overarching challenge (a system to load data, map it, and demonstrate bird locations and their quantities over years). We can make this challenge even more specific by adding a second sentence, such as "with an interactive comparison view, that shows declining against increasing bird populations". Here the second sentence adds further functions: interaction and a comparison view. These questions are still open-ended, as they give a huge range of opportunities and design-choices. How is the bird data displayed? Maps, charts, tables, and so on, or a bespoke display. How do you show comparison, and what interaction is added? Taking ideas from the Explanatory Visualisation Framework (EVF) [RRJH18], many tasks can be created around explaining or demonstrating how you could build something. For example, with the Computer Graphics and Rendering module (see Section 5) we asked students to explain how they could build a virtual reality system to perform some task. One task was to "Create an animation (showreel) that will demonstrate how a virtual medical trainer could be built". The qualifying sentence could be "that will "be used for image guided laparoscopic surgery". Another was to develop an "immersed personal trainer for first aid", and so on.

We create a list of topics, such that every student can choose one. We allow students to define their own topics under guidance by the teacher, but in reality few students propose their own topic. Depending on how many people there on the course, it could be difficult to create a topic for each student. However, we highly encourage teachers to prepare a list of topics. We suggest that topics are then presented in subject or domain groups. This allows students to choose a type of challenge, such as gaming, business, medicine, nature and so on, and then their specific topic challenge.

Before we publish the list of topics we explain the process: that students choose one topic, and they are choosing in a first-come-first-served basis. The best way, we have found, is to list the topics (one per line) on a shared spreadsheet, that is open to every student in the University without login, and students place their name at the end of the line, claiming that topic. While a few students may complain about this process, you have given them fair warning of your strategy, and because there are probably other similar topics, students are able to choose another one. We set a deadline for all students to choose their topic, take questions from students, allocate topics to students manually if they miss this deadline, finally publishing the complete list to the student cohort.

Because we get students to choose a topic at the start of the process, this can represent a bootstrapping problem. Will students know the topics that they are choosing? Will they know what they entail? To overcome this challenge, we delivered an introductory lecture. In this interactive lecture, we spent one or two minutes per challenge. We organised the challenges into groupings of similar tasks to help structure the lecture. We used a virtual whiteboard to explain the topics, sketching and talking about each in turn, added in videos for some, and asked questions of the students to make it more interactive. This (for the teacher) became a fun interactive lecture. The students liked this approach, as demonstrated by some students saying 'thank you' and 'it was great' as they left the session.

4.2. Delivery of material and Activities

We found that organising our graphics teaching in weeks was useful. We originally structured the material around the topics (merging weeks together), but students asked for it to be placed back. While we structured the Blackboard material by weeks, we added the topics to each title. We also group together in chunks the lesson, activity and feedback. In this way teachers can group lectures, activities, questions and answers, etc. in one place. By releasing the material weekly, it gives the online students an idea of progression. They feel that they are moving through the material. In addition, we posted at least two notifications per week. The first explaining the work for the week, and second presenting answers to questions that were asked.

Designing appropriate activities for students is not necessarily easy to achieve. Because we were working in a fully-online environment, we needed to develop activities that could be done in smaller groups of about five students. We were using the Blackboard management software, with the Collaborate extension, where we can easily group the students in separate virtual breakout rooms. This worked exceptionally well. The only challenge was that late arriving students need to be manually added to a room. We also needed a shared virtual space, to allow students to interact and easily share their thoughts. We wanted an easy way to write and position virtual sticky notes, sketch pictures, import computer graphics images, and to create simple data visualisations. We chose to use Miro board (`http://miro.com`). All students worked on the same board – a large zoomable space – but we prepared frames (areas on the whiteboard space), labelled by group1, group2 and so on.

We started the session with a short ten minute presentation about the task, before going into the break out rooms. We used different Miro boards for each activity but the same password for every board. We developed every activity with the same general structure: a 100 minute session, with a 25 minute introduction to the activity, 45 minutes in breakout groups of about 5 students, 15 minute feedback, and 15 minute summary session led by the teacher. Students ran the 45 minute activity on their own, with the teacher going round each group in turn. Students in the group sessions ran through three tasks. We encourage students to have their microphones on, to talk as they work through the tasks, chat over text message, and make notes on Miro as they proceed. The first task (5 minutes) was to introduce each other (if needed), discuss the broad ideas and how they will tackle the problem. With Task 2 (15 minutes) students performed various tasks, often this involved researching on the Web, placing images or sticky notes on the shared board, before affinity diagramming their ideas as a group. The third task for the final 15 minutes often involved repeating the second, and deciding on an a orator to feedback to the group. After completing the 45 minutes, we reconvened and received feedback from one person from each group. Finally we would discuss the session and give feedback on the work achieved.

4.3. Formative and Summative Feedback

The open-ended nature of the authentic task means that the teacher needs to give ongoing feedback to students. On campus experiences enable students to relate to teachers before, during and after sessions, also students locate offices, phone the academic, email and so on. However Covid-19 meant that academics were remote, sitting at home. Students could not easily turn up. To enable students to communicate with the teacher, we:

- Started the session early, welcoming the students and made casual conversation.
- Recorded the activities, and stopped the recording early at the

end of the session, closed the formal session and offered students to chat at the end.
- Responded to and communicated with students on chat (our University uses Microsoft Teams for meetings).
- Held specific drop-in sessions to answer queries about the tasks.
- Convened one-to-one video calls for students who wanted more help.
- Replied to emails and gave feedback through email.

Email communication was particularly time-consuming, especially when students wanted feedback on their written work. But it was important to allow students to communicate in different ways. We noticed that some students did not like video call, while others did not chat, or like email.

5. Using PASS in Computer Graphics and Rendering

We used PASS in our third year Computer Graphics and Rendering module (taught for undergraduate BSc Computer Science students). We submitted a minor changes form, under our Covid-19 regulations, to remove the formal examination and change to the authentic assessment.

Figure 2: *The letter used in the authentic assessment task, from the CTO of the imaginary company who develops virtual instillations. The idea is to make a convincing scenario.*

5.1. Scenario

We developed the scenario around a company building virtual reality installations. Each student has a topic – their own challenge topic to tackle. We classified the areas, including medical, environmental, art, games, home, education and so on. The idea is that students research the topic, find research-papers, and think about their solution. Their final output is a showreel (short video) that explains their technical solution. In our scenario we did not get the students to build their immersive/virtual reality solutions.

We created a company director and logo. We wrote "*consider you have just been employed by an imaginary company called Immersive Environments (iEn). This company has been made up for the purposes of this assessment, however there are many companies who do these solutions, such as Mechdyne or Daden. This (imaginary) company develops bespoke virtual and immersed reality solutions.*" With instructions that a client has asked iEn to develop a "high-quality computer graphics immersive solution", and that the student needs to report to their director, write a research report, create a design document to explore alternative solutions, and develop explanatory animation (showreel) that will be shown to the client, and accompanying reflective report. We created a logo for iEn and included a letter from their chairman, Figure 2. There are many companies that we could add to this list, however adding two specific examples helps exemplify the type of company we are referencing, and they can lookup other similar companies.

For first part, we get students to perform research and investigate related work, and summarise the material. The 1000 word research study (about two pages with a third of references) is structured and graded as follows:

- Title, Student name,
- Introduction (10%)
- Related work (25%)
- Who, What, Why, When (20%) and How (15%)
- Ethical and sustainability issues (10%)
- References (10%)
- Appearance, layout and flow (10%)

Students then perform a 'design study', which contains (i) the Five Design-Sheet method [RHR16], (ii) a storyboard to plan their animation and (iii) a written commentary (about 1 page) that explains their proposed solutions with any technical details. Graded as follows:

- Five design-sheet (75%, i.e., 15% for each sheet)
- Storyboard (15%)
- Technical details and commentary (10%).

Task 3 is to create an Explanatory animation of their solution. We are not expecting students to implement their solution, instead students explain how they could implement it. Students can include a rendering of their design, text in their animation, etc. The animation would be used shown to the client. Graded as follows:

- 25% for explanation: clarity of storyline, correctness, technical detail, effectiveness of communication, etc.
- 25% for graphics assets created and used
- 25% for animation crafting, collation, animation principles followed and storytelling
- 25% for design, appearance, colours used, story flow

Finally, students submit a two-page reflective report, where they reflect on all of their work in the module.

5.2. Learning outcomes

This module has five learning outcomes.

(LO1) Explain, present and demonstrate understanding of computer graphics. To be able to illustrate and explain concepts, discuss their advantages and be able to judge the best solution.

(LO2) To be able to analyse problem domains and to prepare, plan and design, and create a computer graphics system that uses graphics.

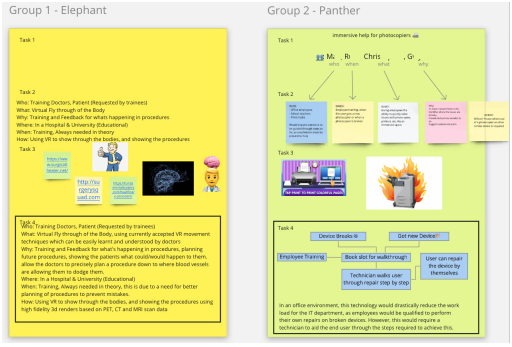

Figure 3: *The result of two groups, who worked on the Five W's activity. It shows that the students added pictures, additional sketches and words.*

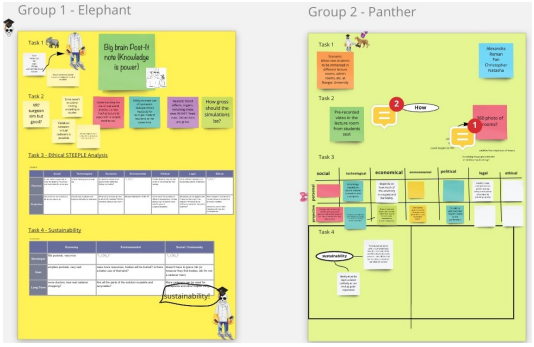

Figure 4: *The result of two groups, who did the ethics and sustainability activity. It shows students working through STEEPLE.*

(LO3) To create and/or explain an appropriate solution.
(LO4) To critically assess alternative solutions, and device if a solution meets the criteria.
(LO5) To perform research on an in-depth aspect of computer graphics.

With the four tasks, each task focuses on one or more of the learning outcomes. The research task, fulfils the research learning outcome (LO5). The 'design study' encourages students to analyse a solution (LO2) and create appropriate solutions (LO3). The explanatory showreel means that students have to demonstrate their understanding of the concepts (LO1) and demonstrate whether they are suitable (LO3). While the final two-page reflective report allows student to present again their understanding of the solution (LO2) and reflect on the appropriateness of their solutions (L04).

5.2.1. Personalise

We had seventy students registered on the module and wrote a list of eighty topics. We created the topics in domains, including medical, business, transport and travel, environment. For example:

- Demonstration of flooding events, for planning of housing development. To be used in area council meetings for about ten people.
- Virtual artist. Allowing artists to collaborate on large scale art projects of art works over two meters tall, while immersed together.
- Remote GP surgery. Doctors providing immersive, realistic remote patient care.

Two students proposed their own topic, with two further students adapted some of the proposed topics.

5.3. Delivery of the taught material

We recorded the lectures and uploaded them to Panopto (the streaming service that the University uses). This meant that students could follow the lectures in their own time. We divided the material into the four parts, to follow the authentic assessment. To address the first part, we start with research methodology, design and overview of immersive, augmented, extended reality. We discussed user behaviour and perception within different realities. To address the design and implementation we discussed both design methodologies (presenting the Five Design-Sheet methodology [RHR16]) and detail technologies. We have a large section on graphics hardware (to help students know how they would implement and render solution). We cover mobile devices, screen technologies, CAVEs [CNLP*93], powerwalls [CPS*97] and so on. We expand the students' knowledge of rendering algorithms, that they first covered in a graphics algorithms course the previous year. We discussed Z-buffer, Ray tracing and methods to speedup these algorithms, such as through bounding box and parallelisation. We include a large section on modelling, covering grammar based systems (e.g., Lindenmayer systems), models from data (Marching Cubes [LC87] and Volume Rendering [DCH88]). In the final section we cover animation strategies and how to create explanatory showreels.

5.4. Activities

Apart from the first few weeks and last week, we held activities. For the first two weeks we used the class setting to introduce the authentic assessment, material and structure of the work. In the second week, we did a quick poll of questions and answers. Just to get everyone involved, and have a quick activity. This allowed students to have seen more taught content before we launched into the activities in earnest. In the last week (of the semester) we held a question and answer session, to answer questions before the final assessment deadline. The activities followed the taught content. For example, to follow the lectures on the Who, Why, What, When, How, question we held an activity on the five W's. We gave the students a topic that had not been chosen by other students, so that the participants could research and discuss relevant answers. Figure 3 shows the results of two groups. In the week where we discussed ethics and sustainability, we followed it with an activity on these topics. We follow the STEEPLE acronym (Social, Technological, Economic, Environmental, Political, Legal, and Ethical). Students were allocated a topic, and discussed in groups issues and opportunities using the STEEPLE acronym (we show some results in Figure 4). This was a challenging week, as the computing students struggled with the ethical sustainability challenges. This made the discussion at the end of the session more important.

5.5. Student engagement and feedback

Overall we interacted with about one third of the cohort outside the interactive sessions. For instance, for the research report, we gave written feedback to 15 students, in advance of the submissions, mostly suggesting ways to add more detail and improve the objectivity of the text. We text-chatted with 6 students (about 9%)

and had video calls with a further 4 students. Likewise with the activities, about 30% of the students were vocal, and spoke on the audio, a further third use the text chat, and a third were silent. Obviously students react differently in online teaching, and we have noticed that some students who were vocal in the campus setting were very quiet online. One student said "I really like the activities, they are hard, but make us think", another said "I really like progressing in weeks, it gives me a good idea of what we have achieved".

6. Using PASS in an Information Visualisation module at Masters level

In the Information Visualisation module we used a different **authentic assessment**. We asked students to design and code a new data-visualisation of chosen data and present it as a poster. This scenario is similar to presenting research at a conference in a poster presentation. Students must analyse their data, visualise it, discuss what the visualisations mean, and present their work in a poster. As with the first scenario, students follow the same four stages: research, design, implement, reflect, but in this assessment we grouped them together into two parts. The technical design plan (TDP) contains the research, data analysis and design, it is realised as an academic paper. We get students to use the ACM SIGCONF conference consolidated template. Because they are masters student, they are more experienced, and we introducing them to research methods. Likewise the poster is formatted to be suitable for a conference, with the University logo, student name, title, abstract, and so on.

To **personalise** this task, we let students choose a different dataset. We describe to the students that they need to choose data that is complex, but not too large to make it an impossible task. We suggest over 2000 data entries, with over 5 categories. We guide students to a list of example (open source) datasets that we have found, or they choose their own. Because every student has their own data, they can discuss their project with their peers, without implications of plagiarism.

We ran weekly **synchronous activities** in the seminar slot. We structure the material in ten weekly chunks: introduction, history, data, storytelling and semiotics, perception, visualisation techniques, design, layouts and posters, evaluation, and interaction. The activities for the material were lagged by a week. This occurred because the slot was scheduled on a Wednesday, and there was not enough time for students to see the material and prepare for the session. We followed the same activity structure as mentioned above, with introductory presentation, 45 minute breakout room task, feedback and summary. After the week discussing the history of visualisation, and inspired by the VisTools activity [RSDB20], we ran to organise different tools and methods to create visualisations (Figure 5). After the week focusing on data, students performed a data-gathering and quick visualisation activity. Students first collected data from the internet (choosing from a set of topics, such as man-made landmarks of the world, large mammals, cruise ships, big buildings, largest computer screen). Students summarised and tabularised data. Before moving onto a visualisation of that data.The second task was to create small visualisations/pictures in Miro that describe a particular data variable (Figure 6). Finally students submitted their technical design plan and their final poster.

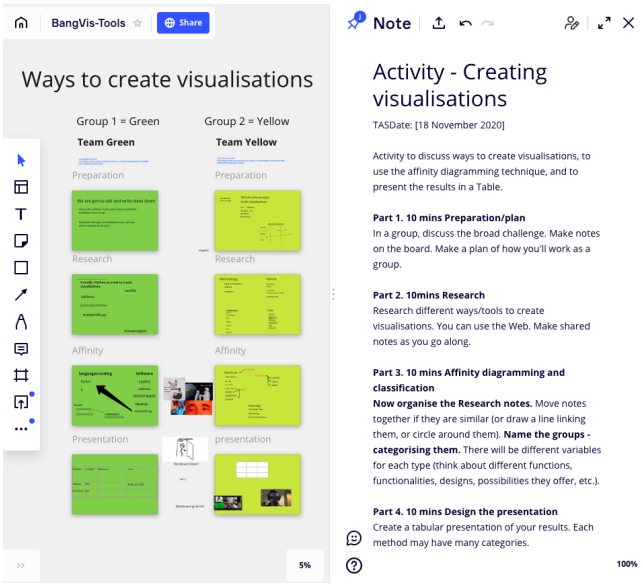

Figure 5: *Screenshot of Miro, from the result of two student groups who explored different ways to generate visualisations (left) and the instructions for the activity (right).*

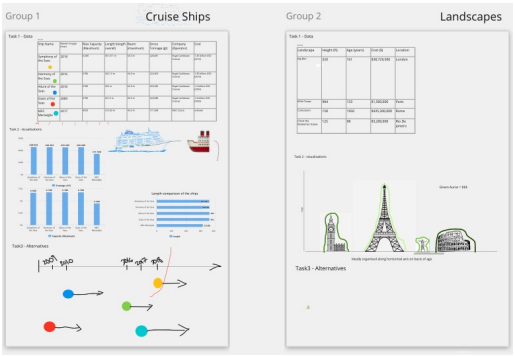

Figure 6: *Screenshot of Miro, showing the results of students performing the data-gathering activity on cruise ships and landscapes.*

7. Discussion, lessons learnt and conclusions

Creating an authentic assessment is not necessarily an easy task. First defining an assessment that is "authentic" is subjective [GBK04]. One task may be suitable for one set of students, but less so for others. Second, while authentic assessments do help to motivate the work, some students may not see the worth or relevance of the task for their situation. Third, the nature of running the task in this way, will probably mean that the taught unit (module) needs to be adapted, and furthermore that the teacher needs to interact with the students, which can be more time-consuming than with traditional chalk-and-talk lectures. However we believe that the benefits outweigh the negatives, and even if students do not understand the relevance of the task, the structure of the delivery helps students to plan their work better, and concentrate their efforts on the individual tasks.

Consequently, as a teacher, we need to make sure that the assessments are relevant, and actually would be challenges that the learners could face beyond the course. The first task for a teacher is to create a suitable scenario. Writing authentic assessments take

time. Teachers need to carefully consider and create a suitable scenario. Obviously assessments need to be written clearly and will require many revisions before they are suitable for student use. Furthermore, most academic institutions peer evaluate the assessments, before they are published to the students. This is a useful process and helps to improve the quality of the output. On the other hand, there can be challenges when using an authentic assessment.

Accordingly, spending time preparing the scenario will save time later, and we propose that teachers should contemplate the following parts:

1. **Understand how the subject is used in practice**. It would be difficult to create a suitable authentic assessment without knowing how the topic is used in the professional community. Consider how you can make it authentic. For example, an artificial task would be to get students to write an essay on a made-up topic, an authentic task would be to find a writing competition and get students to submit to that competition.
2. **Develop the assessment around project-based-learning tasks: research, design, develop and reflect.** This allows the students to discover more about a topic, explore potential alternative solutions and implement one solution before reflecting on what they have achieved.
3. **Explain the scenario so that students can run through the scenario in their mind**. They need to visualise the assessment functioning — acting out the scenario in their mind — by placing themselves in the scenario and walking through the parts (Swaffield [Swa11] names it *conceptualising the objectives*). Using this strategy teachers can discover problems or issues with the ideas, and help justify the ideas to their academic peers.
4. **Provide clear guidance on the actors in the system**. If the scenario takes place in the real-world then people involved would clearly understand the different roles (client, employer and manager, etc). We need to make the roles of the individual players of the scenario clear, or get the students to define them as part of the exercise. E.g., who is the client, director, developer.
5. **Express a divergent task allowing creative thinking to occur, while being framed** in a way that keeps the students focused on a particular goal [RRJH18]. Convergent tasks converge onto one answer, while divergent tasks require students to think creatively, and ideate several alternative potential solutions.
6. **Make the assessment fulfil any learning outcomes of the unit.** Hopefully the learning outcomes (LOs) are clearly written and describe what students need to achieve.
7. **Enthuse about the process**. Teachers need to be committed to the process, available to answer questions, and give ongoing formative feedback to students. If teachers are not committed to the process, then neither will be students.

Our above general advice helps to create appropriate assessments, but it can still be difficult to create something suitable. We add three further ideas to help develop the scenarios.

8. **Make a plan**, which includes the material to be taught, how it will be delivered, deadlines for submitting parts of the work, and even your workload and when you need to run different parts of the unit.
9. **Break the assessment into stages.** This helps students to spread the work. It may be convenient to consider tasks for every week. Often universities limit the quantity of assessments that can be included in a unit. Subsequently, splitting the scenario into two or three parts is useful; set different deadlines for each part (Figure 1 shows two formal evaluation stages).
10. **Make up an imaginary company and give it a name.** For example, when you are presenting the work, you can consider that a student had joined a company, and was required by a client to do a piece of work (with you as the client). Better still, connect with a real company. The representative could present the topic in a video, advise students, or perhaps evaluate the final submissions, which will give more authenticity to the task.

The Covid-19 pandemic has changed the way academics teach. While we are now starting to return to campus teaching, we have learnt many new techniques and structures that we should continue to use. The use of flipped classrooms, with the taught content being recorded, and followed by interactive seminar sessions, is a useful strategy that we can employ back in the classroom. The use of recording the lectures, helps students to have a resource that they can return to. The activities help students learn and reinforces ideas taught in the course. And especially the use of authentic assessments, helps to structure the work and engage students with a challenge that they will probably find when they leave higher education. So, while the pandemic has forced many teachers to re-consider their teaching philosophies, this is not a bad situation. We do not believe that teaching at University level we will ever return fully to the old didactic delivery.

The structures and processes that we have presented here, have worked well with our students. Most students engage with the topic and have worked through the material. However, there are still a handful of students who do not engage with the material and do not communicate in the activities. Students are individuals, have different personalities and abilities. Some flourish in a campus setting, while others struggle with it, similarly in an online setting there are some students who do not manage to interact with the material. With our attendance records, we communicate with these students and enquire their reasons. On the whole, these students, for a variety of reasons, do not seem to like the remote teaching style, or online engagement. However, they have submitted their assessments, and so clearly had been working on the ideas in their own time, merely not engaging in the classes.

We have presented a framework using authentic assessments, and synchronous learning activities. Our aim is that the simple four-part structure can help other academics to follow a similar approach. We demonstrate the idea through our own teaching, and have used the method to teach an undergraduate computer graphics module and a masters data-visualisation module. We believe that the style of interactive synchronous sessions, underpinned by an authentic assessment works well for these visual subjects. But also believe that the ideas could readily be transferred to other topics.

References

[ALWW20] ALAMRI H., LOWELL V., WATSON W., WATSON S. L.: Using personalized learning as an instructional approach to motivate learners in online higher education: Learner self-determination and intrinsic motivation. *Journal of Research on Technology in Education 52*, 3 (2020), 322–352. doi:10.1080/15391523.2020.1728449.

[BE91] BONWELL C. C., EISON J. A.: *Active Learning: Creating Excitement in the Classroom. 1991 ASHE-ERIC Higher Education Reports.* ERIC, 1991.

[Bel10] BELL S.: Project-based learning for the 21st century: Skills for the future. *The Clearing House 83*, 2 (2010), 39–43. doi:10.1080/00098650903505415.

[Bux10] BUXTON B.: *Sketching user experiences: getting the design right and the right design*. Morgan Kaufmann, 2010.

[CKM06] CORBALAN G., KESTER L., MERRIËNBOER J.: Towards

a personalized task selection model with shared instructional control. *Instructional Science 34* (2006), 399–422. doi:10.1007/s11251-005-5774-2.

[CNLP*93] CRUZ-NEIRA C., LEIGH J., PAPKA M., BARNES C., COHEN S. M., DAS S., ENGELMANN R., HUDSON R., ROY T., SIEGEL L., ET AL.: Scientists in wonderland: A report on visualization applications in the cave virtual reality environment. In *Proceedings of 1993 IEEE Research Properties in Virtual Reality Symposium* (1993), IEEE, pp. 59–66.

[CPS*97] CZERNUSZENKO M., PAPE D., SANDIN D., DEFANTI T., DAWE G. L., BROWN M. D.: The immersadesk and infinity wall projection-based virtual reality displays. *ACM SIGGRAPH Computer Graphics 31*, 2 (1997), 46–49.

[DCH88] DREBIN R. A., CARPENTER L., HANRAHAN P.: Volume rendering. *ACM Siggraph Computer Graphics 22*, 4 (1988), 65–74.

[DHS00] DARLING-HAMMOND L., SNYDER J.: Authentic assessment of teaching in context. *Teaching and Teacher Education 16*, 5 (2000), 523 – 545. doi:10.1016/S0742-051X0000015-9.

[DL45] DUNCKER K., LEES L. S.: On problem-solving. *Psychological monographs 58*, 5 (1945), i.

[Ent93] ENTMAN R. M.: Framing: Toward clarification of a fractured paradigm. *Journal of communication 43*, 4 (1993), 51–58.

[GBK04] GULIKERS J. T., BASTIAENS T. J., KIRSCHNER P. A.: A five-dimensional framework for authentic assessment. *Educational technology research and development 52*, 3 (2004), 67. doi:10.1007/BF02504676.

[HA17] HE S., ADAR E.: Vizitcards: A card-based toolkit for infovis design education. *IEEE Transactions on Visualization and Computer Graphics 23*, 1 (Jan 2017), 561–570. doi:10.1109/TVCG.2016.2599338.

[HBH*20] HURON S., BACH B., HINRICHS U., ROBERTS J. C., KECK M. (Eds.):. *VisActivities: IEEE VIS Workshop on Data Vis Activities to Facilitate Learning, Reflecting, Discussing, and Designing, held in conjunction with IEEE VIS 2020, Salt Lake City, UT.* (October 2020), IEEE. URL: http://visactivities.github.io.

[HCT*14] HURON S., CARPENDALE S., THUDT A., TANG A., MAUERER M.: Constructive visualization. In *Proceedings of the ACM conference on Designing Interactive Systems (DIS)* (2014), ACM, pp. 433–442. doi:10.1145/2598784.2598806.

[Ken99] KENNEDY M. M.: The role of preservice teacher education. *Teaching as the learning profession: Handbook of policy and practice* (1999), 54–85.

[Kep14] KEPPELL M.: Personalised learning strategies for higher education. In *The Future of Learning and Teaching in Next Generation Learning Spaces (International Perspectives on Higher Education Research, Vol. 12)*. Emerald Group Publishing Limited, 2014, pp. 3–21. doi:10.1108/S1479-362820140000012001.

[KK05] KOLB A. Y., KOLB D. A.: Learning styles and learning spaces: Enhancing experiential learning in higher education. *Academy of Management Learning & Education 4*, 2 (2005), 193–212.

[KMW16] KOKOTSAKI D., MENZIES V., WIGGINS A.: Project-based learning: A review of the literature. *Improving schools 19*, 3 (2016), 267–277.

[Kra02] KRATHWOHL D. R.: A revision of bloom's taxonomy: An overview. *Theory Into Practice 41*, 4 (2002), 212–218.

[LC87] LORENSEN W. E., CLINE H. E.: Marching cubes: A high resolution 3d surface construction algorithm. In *Proceedings of the 14th Annual Conference on Computer Graphics and Interactive Techniques, (SIGGRAPH)* (New York, NY, USA, 1987), ACM, pp. 163–169. doi:10.1145/37401.37422.

[Low16] LOWGREN J.: On the significance of making in interaction design research. *Interactions 23*, 3 (Apr. 2016), 26–33. doi:10.1145/2904376.

[MJ93] MEYERS C., JONES T. B.: *Promoting Active Learning. Strategies for the College Classroom.* ERIC, 1993.

[MMAM14] MCKENNA S., MAZUR D., AGUTTER J., MEYER M.: Design activity framework for visualization design. *IEEE Transactions on Visualization and Computer Graphics 20*, 12 (Dec 2014), 2191–2200. doi:10.1109/TVCG.2014.2346331.

[Mun09] MUNZNER T.: A nested process model for visualization design and validation. *IEEE Transactions on Visualization and Computer Graphics 15* (Nov 2009), 921–928. doi:10.1109/TVCG.2009.111.

[NW93] NEWMANN F. M., WEHLAGE G. G.: Five standards of authentic instruction. *Educational leadership 50* (1993), 8–8.

[RHR16] ROBERTS J. C., HEADLEAND C., RITSOS P. D.: Sketching designs using the five design-sheet methodology. *IEEE Transactions on Visualization and Computer Graphics 22*, 1 (Jan 2016), 419–428. doi:10.1109/TVCG.2015.2467271.

[RHR17] ROBERTS J. C., HEADLEAND C. J., RITSOS P. D.: *Five Design-Sheets – Creative design and sketching in Computing and Visualization*. Springer International Publishing, 2017. doi:10.1007/978-3-319-55627-7.

[RJHR16] ROBERTS J. C., JACKSON J. R., HEADLEAND C., RITSOS P. D.: Creating Explanatory Visualizations of Algorithms for Active Learning. In *Posters presented at the IEEE Conference on Visualization (IEEE VIS 2016), Baltimore, MD, USA* (October 2016).

[RKH*14] ROBERTS J. C., KEIM D., HANRATTY T., ROWLINGSON R., WALKER R., HALL M., JACKOBSON Z., LAVIGNE V., ROONEY C., VARGA M.: From Ill-defined Problems to Informed Decisions. In *Fifth EuroVis Workshop on Visual Analytics (EuroVA),* (Swansea, UK, 9Ð10 June 2014), Pohl M., Roberts J., (Eds.), Eurographics Association, pp. 7–11. doi:10.2312/eurova.20141138.

[Rob01] ROBINSON K.: *Out of Our Minds: Learning to be Creative*. Capstone, 2001.

[Rob22] ROBERTS J. C.: Active learning activities in a collaborative teacher setting in colours, design and visualisation. *Computers 11*, 5 (2022). doi:10.3390/computers11050068.

[RR19] ROBERTS J. C., RITSOS P. D.: Critical thinking sheets: Encouraging critical thought and sketched implementation design. In *EduCHI 2019 Symposium: Global Perspectives on HCI Education, CHI Conference on Human Factors in Computing Systems* (2019).

[RR20] ROBERTS J. C., RITSOS P. D.: Critical Thinking Sheet (CTS) for Design Thinking in Programming Courses. In *Eurographics 2020 - Education Papers* (2020), Romero M., Sousa Santos B., (Eds.), The Eurographics Association, pp. 17–23. doi:10.2312/eged.20201029.

[RRJH18] ROBERTS J. C., RITSOS P. D., JACKSON J. R., HEADLEAND C.: The explanatory visualization framework: An active learning framework for teaching creative computing using explanatory visualizations. *IEEE Transactions on Visualization and Computer Graphics 24*, 1 (2018), 791–801. doi:10.1109/TVCG.2017.2745878.

[RSDB20] RIDLEY A., SCHÖTTLER S., DADZIE A.-S., BACH B.: The vistools marketplace: An activity to understand the landscape of visualisation tools. In *VisActivities: IEEE VIS Workshop on Data Vis Activities to Facilitate Learning, Reflecting, Discussing, and Designing, held in conjunction with IEEE VIS 2020, Salt Lake City, UT.* (October 2020), IEEE. Workshop organizers: Samuel Huron, Benjamin Bach, Uta Hinrichs, Jonathan C. Roberts, Mandy Keck. URL: http://visactivities.github.io.

[RT13] RYAN A., TILBURY D.: Flexible pedagogies: new pedagogical ideas. *Higher Education Academy, London* (2013).

[Sim73] SIMON H. A.: The structure of ill structured problems. *Artificial Intelligence 4*, 3-4 (1973), 181–201.

[SMM12] SEDLMAIR M., MEYER M., MUNZNER T.: Design study methodology: Reflections from the trenches and the stacks. *IEEE Transactions on Visualization and Computer Graphics 18*, 12 (2012), 2431–2440.

[Swa11] SWAFFIELD S.: Getting to the heart of authentic assessment for learning. *Assessment in Education: Principles, Policy & Practice 18*, 4 (2011), 433–449. doi:10.1080/0969594X.2011.582838.

[Tob00] TOBIN D. R.: *All learning is self-directed: How organizations can support and encourage independent learning*. American Society for Training and Development, 2000.

[Wig90] WIGGINS G.: The case for authentic assessment. *Practical assessment, research, and evaluation 2*, 1 (1990), 2. doi:10.7275/ffb1-mm19.