An emerging learning design based on analogical reasoning

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This paper presents a beta version of a generic learning design based on analogical reasoning. The value of applying principles of analogical reasoning, informed by key literature, is explored. The need to work collaboratively, not only with field experts but also teachers themselves is also discussed. This relationship is evidenced through the contribution of pre-service teacher participants who took part in a recent study which focused on their experiences in designing and implementing a learning design based on well researched learning strategies. Participants chose to implement their own contextualised analogical reasoning online tasks in school-based learning environments and the crucial role of the teacher to facilitate learning of target concepts is highlighted.

Keywords: analogical reasoning, learning design, K-12, LAMS

Introduction

This paper introduces a LAMS-based learning design informed by a well-known learning strategy grounded in the research literature in science education – *analogical reasoning*. This design was created through consultations with pedagogical and subject specialists, and 'field tested' with student teachers as part of a recent study situated in pre-service teacher education. The study investigated the efficacy of situating prospective primary and secondary teachers as learning design authors and examined how the process of authoring and implementing a contextualised learning design might help 'build bridges' between theory and practice in their Education courses. Reported elsewhere (Kearney, Prescott & Young, 2008) are findings related to the ways in which the pre-service teachers' developed new understandings of online and face-to-face teaching approaches and sophisticated insights into the specific learning strategies informing their designs. Also, Kearney and Young (2007) report on the pre-service teachers' perceptions of the useability of LAMS from a 'teacher-as-designer' perspective and their perceptions of LAMS as a teaching tool in K-12 contexts. In this paper, we discuss the background to one of the three designs offered to the teachers: analogical reasoning tasks. We draw on data from the study to illustrate how the pre-service teachers used the design and, in particular, their extensions and variations in content, structure and pedagogy as a result of working in an online environment. Finally, we present a beta version of a generic learning design based on analogical reasoning.

Background

Over the past decade, the field of educational technology has endorsed constructivism as a suitable referent for the development and meaningful use of appropriate software in education. The core view of learning from a constructivist perspective suggests that learners actively construct (rather than acquire) their own knowledge, strongly influenced by what they already know. Learning is a social process of making sense of experience, constructing new representations of reality and further negotiating meaning through social activity, discourse and debate (Tobin & Tippins, 1993). In this paper, learning is viewed from this constructivist perspective.

Effective learning strategies informed by a constructivist perspective have been extensively reported in the maths and science education literature, particularly strategies that support students' understanding of difficult concepts that are often encountered in these domains (eg. Baird & Northfield, 1995; Skamp, 1998; Treagust, Duit & Fraser, 1996). More recently, researchers have explored the underpinning

learning strategies and support structures incorporated in exemplary online learning designs, particularly in tertiary education (Agostinho, Oliver, Harper, Hedberg & Wills, 2002). These web-based learning sequences take advantage of the online medium to make accessible effective learning strategies, supported by appropriate structures and resources (Oliver and Herrington, 2003). For example, *multimedia-supported predict-observe-explain (POE) tasks* (Kearney, 2002a) used the well-researched POE learning strategy (White & Gunstone, 1992) to effectively scaffold students' learning in an e-learning environment, presenting digital demonstrations set in real-life contexts as stimuli for their learning. The online environment gives students extra control over the pacing of these POE tasks and facilitates peer discussions. Indeed, the use of digital media to present demonstrations has significant affordances for students' observation processes (Kearney, 2002b).

Analogical reasoning is another well-researched and popular learning strategy used in science education (Harrison & Treagust, 2006; Treagust 1995). Analogical reasoning supports learners' use of a familiar base analog to explore an unfamiliar 'target' concept or phenomenon. Analogies are an effective resource to clarify and refine students' understanding of science concepts, provided that shared and unshared attributes of the analogy and target concept are understood. The use of analogies can help students visualise abstract concepts and also enhance motivation (Duit, 1991). Teachers must select an analog with which students are familiar, potentially providing a 'bridge' between students' prior knowledge and the unfamiliar target concept (Treagust, 1995). If supported by appropriate teacher mediation, the analogy can become a tool to help students recall, access scientific explanations and enable student expression of ideas (Aubusson, Fogwill, Barr & Perkovic, 1997). However, problems arise when students are unable to distinguish between the concept being studied and analogies and sometimes the analogy can end up confusing students (Treagust, 1993). To avoid students constructing alternative conceptions, limitations of analogies must be carefully explained and explored during the learning process (Glynn, 1991).

To support teachers in using analogical reasoning effectively and systematically in the classroom the *Focus-Action-Reflection* (FAR) guide to teaching with analogies was developed (Treagust, 1998). In the pre-lesson *Focus* stage (amongst other details for teachers), students explore their own existing ideas about the target concept. In the *Action* (or mapping) phase, students are introduced to the analog – it is critical that students are familiar with this analogy and potential exists for students to explore multiple (and useful) relations between it and the target concept. Students and teachers then discuss and map 'like' and 'unlike' characteristics of the analog and target concept. Finally, in the *Reflection* phase, students reflect on the clarity of the analogy and usefulness for understanding the target concept. This guide (especially the *Action* and *Reflection* phases) informed the structure of the researchers' initial specific contextualised learning design discussed below.

Outline of study

The study that informed the beta learning design flagged in this paper was of an interpretive qualitative nature (Mason, 1996; Merriam, 1998). In this study, pre-service teachers created specific online learning tasks based on a well-researched learning strategy aligned with the constructivist philosophy underpinning their maths and science education subjects. The principal aim of this study was to investigate the participants' understanding and experiences during the design and implementation of their designs and explore the links between theory and practice which emerged as a result of this process.

One of the learning strategies used by these pre-service teachers was analogical reasoning. LAMS (version 1.0 at the time of the study) was used as a 'test-bed' for the teachers to contextualise and implement their specific learning designs. LAMS was chosen primarily because its intuitive drag and drop authoring environment was considered user-friendly for novice (student teacher) participants; it was freely available as open source software; provided local support and has shown positive signs for engaging the teaching community (Masterman & Lee, 2005; Russell, Varga-Atkins & Roberts, 2005). To develop participant confidence and competence with the LAMS software, introductory workshops were conducted and participants were given links to relevant articles and resources. The researchers also placed several model LAMS sequences on the 'public' section of our project's LAMS account (viewable only to project participants), thereby allowing the participants to engage in existing sequences from a student's point of view (ie. learner mode); de-construct the sequences from a design perspective (in author mode);

and also learn about the particular learning strategies informing each design. One of these models was based on the analogical reasoning literature and constituted our first attempt at a (contextualised) LAMS-based analogical reasoning learning task. The development of this model is discussed in further detail below.

Once acquainted with the LAMS tool and their chosen learning strategy, each participant independently created their own contextualised learning design. These designs were developed specifically to be used during each participant's school-based practicum, hence following a similar 'virtuous circle' approach discussed by Dalziel (2006) whereby teachers firstly use the LAMS environment as learners, followed by the design of their own sequences, followed by implementing their sequence as teachers with their own students. Participants shared their draft and final designs with their peers in the 'public' section of our LAMS project space.

In this paper we specifically draw on data that emerged from the participants' experiences in designing and implementing their analogical reasoning online task and our analysis of their final designs which (in conjunction with an expert in the field and related literature) facilitated the development of the beta generic design presented later in this paper. All names in this paper are pseudonyms.

A specific contextualised learning design based on analogical reasoning

A specific (contextualised) learning design which was developed around the principles underpinning analogical reasoning was created by the authors in the initial stages of the project as a model for the project participants. This process involved consultation with critical friends of the project, including subject and pedagogical experts in the Faculty of Education, UTS. One major informant was Associate Professor Aubusson who has carried out science education research on this strategy (eg. Aubusson et al., 1997; Aubusson & Fogwill, 2006) in school and tertiary contexts.

Similar to the rationale for multimedia based POE tasks (see Kearney, 2002b), the researchers considered an online environment was justifiably suitable for an analogical reasoning based design. An online environment such as LAMS can scaffold this process, giving students extra control over the pacing of their analogical reasoning task and encouraging them to do their own (initial) mapping, facilitated by their teacher. The online environment can present difficult-to-set-up, expensive, time consuming or unsafe scenarios as 'analogs', set in real-life contexts as stimuli for their learning (eg. see discussion of the 'water waves' task below). Importantly, this environment can facilitate peer and teacher (face-to-face and online) discussions before, during and after the online task.

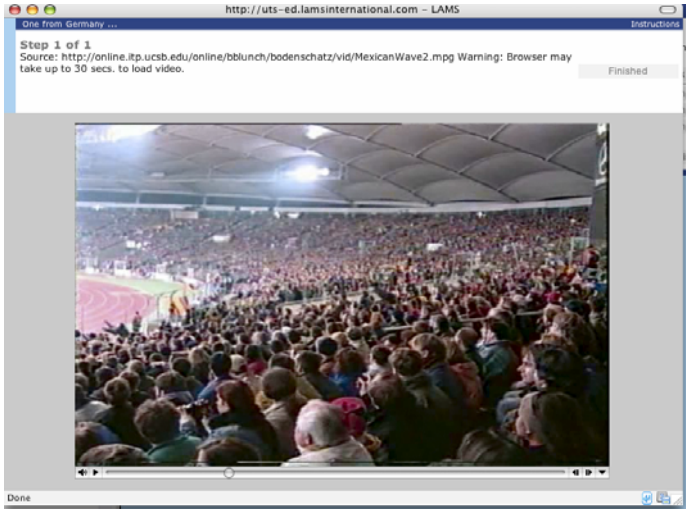

Fig. 1. Video of Mexican Wave (analog) in model task
Source of video: http://online.kitp.ucsb.edu/online/bblunch/bodenschatz/vid/MexicanWave2.mpg

The contextualised LAMS-based task created by the research team was intended to model good practice with analogical reasoning for middle school science students studying 'transverse waves'. The *Focus-Action-Reflection* (FAR) guide (Treagust, 1998), as discussed previously, informed our initial design. The model task was pitched at science learners to extend their knowledge of wave properties (target) by mapping the similarities and differences between water waves and (human) 'Mexican waves' (analog) as seen at sporting events. Sample screen shots are shown below, including a video of a Mexican wave to prompt students' familiarity with the analog (Fig. 1) and the crucial mapping stage (Fig 2).

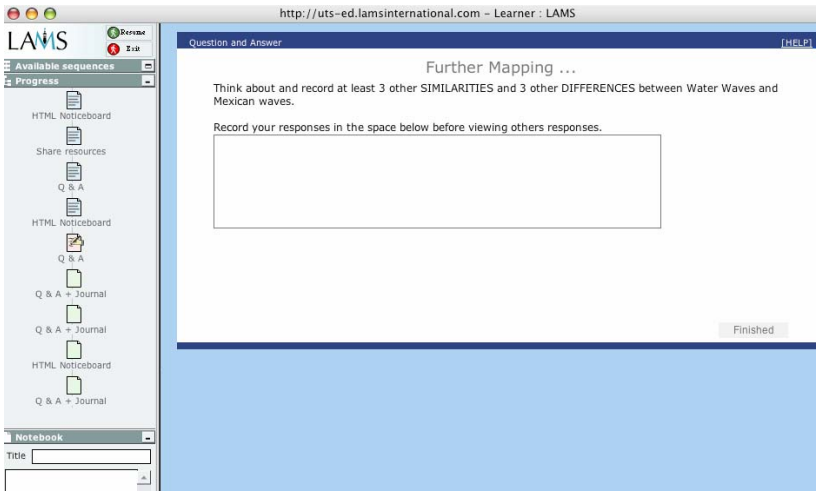

Fig. 2. Students prompted to think about relational features of analog and target

Student teachers initially engaged with this task as learners before looking at the authoring mode of LAMS to analyse and 'deconstruct' the design. In conjunction with their reading and other professional learning opportunities discussed in the previous section, they then used LAMS to create their own contextualised learning design based on the analogical reasoning strategy.

Pre-service teachers' use of the design

Noteworthy facets of the pre-service teachers' work is presented in this section. Not only was the LAMS environment important to the development of their analogical reasoning based designs (see Kearney & Young, 2007), the participants were also mindful of the greater context in which the learning task would take place and the role of the classroom teacher in facilitating learning. It was the pre-service teachers' rationales, reflections and implementation of their contextualised learning designs that was particularly useful to the researchers, rather than the content of the tasks themselves. We focus particularly on two participants: Lisa, a prospective secondary Maths teacher who designed and implemented an analogical reasoning task for her Year 7 students studying integers; and Eleanor, a prospective primary teacher in the final year of her degree, who designed her analogical reasoning task for use with her Year 2 students studying possum habitats.

Both Lisa and Eleanor implemented their task towards the end of a unit of work as a way of helping students to further explore concepts that had been introduced in earlier lessons on their school-based practicum. They stressed the importance of using new media to help their students' visualisation processes, especially in the initial stages of the analogical reasoning procedure. Although many participants in the study used external sources of media, some (including Eleanor) created their own. Eleanor wanted her students to have the confidence to explore similarities and differences between the analog and target concepts and did so by incorporating her Year 2 students' work samples into the design. She took photos of their previous work on human habitats for inclusion in her online task designed to

help them learn by comparing human habitats (analog) to possum habitats (target concept) (Fig 3). She reasoned that this would not only help her students to visualise links between the base analog and target concepts but also create learner ownership of the task: "I feel that by incorporating photos of their work samples … gave them a sense of ownership and respect of their learning." (final survey). A screenshot of her design in the LAMS authoring mode is shown in Fig. 4, including the important 'mapping stage'. Eleanor also highlighted the self-pacing nature of the online environment that in her view discouraged more didactic teaching methods: "The fact the kids were able to work at their own pace on the computer meant there wasn't a teacher at the front doing all the teacher talk" (Eleanor, final focus group).

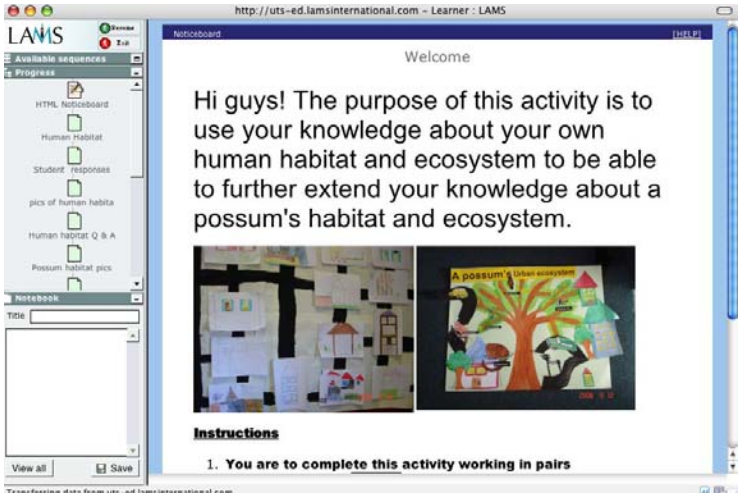

Fig. 3. First Page of Eleanor's task (LAMS learner mode) containing her children's work samples

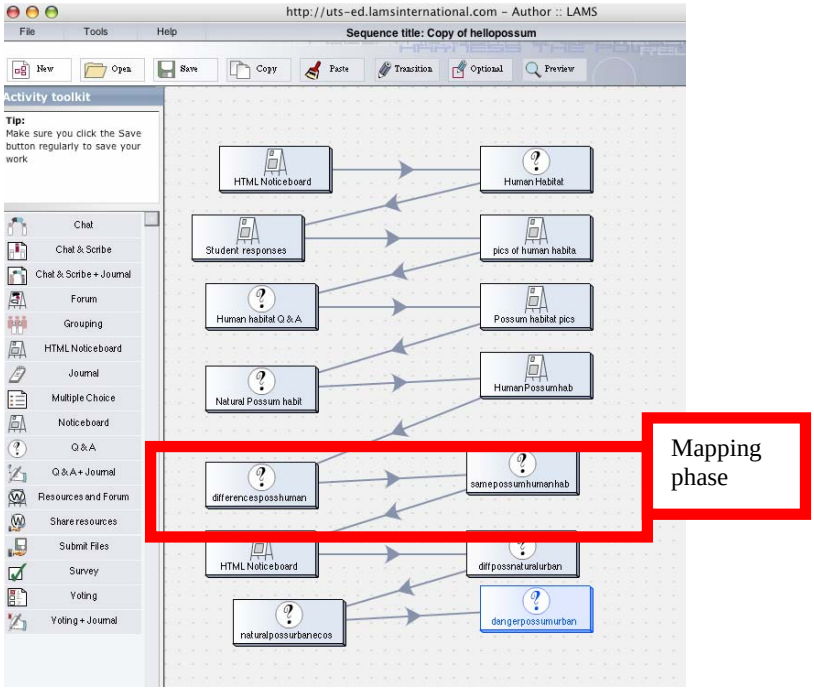

Fig. 4. .Screenshot of Eleanor's task (LAMS author mode) with 'mapping' stage highlighted

Lisa also valued the role of media in her task designed to help her Year 7 Maths students add and subtract with positive and negative numbers. She emphasised the use of photos and video to help the students visualise the comparison of positive and negative integers (target concept) with fairies and monsters (analog) (Fig. 5). Although the researchers found Lisa's analogy rather contrived, she expressed similar views to Eleanor about including new media to prompt students' mapping of attributes.

Lisa went a step further in her task design and also tried to get the students to create their own (*learner-generated*) analogies towards the end of her task. However, students were not familiar with this process (it was the first time they had used teacher-generated analogies!) and they struggled to create any meaningful analogies. However, this valuable variation on the analogical reasoning strategy has been discussed in the literature (eg. see Aubusson & Fogwill, 2006; Cosgrove, 1995) and we flag this option as an important variation in our generic design presented in the next section.

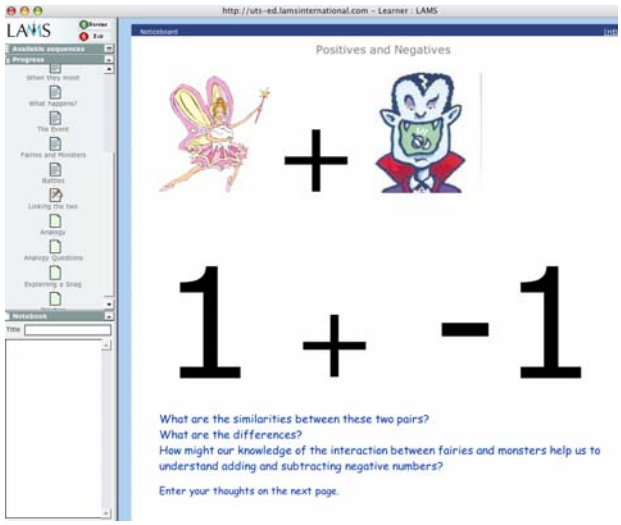

Fig. 5. Sample page from Lisa's task (LAMS learner mode)

Lisa's LAMS task was delivered in the schools' computer labs, enabling her to set up a collaborative learning environment whereby students were required to work with a partner to facilitate learning conversations "before sharing them on the public noticeboard." (Lisa, rationale) (Fig. 6). Both Eleanor

Fig. 6. Students in Lisa's class worked in collaborative pairs at the computer

and Lisa, emphasised the crucial nature of their role as a teacher and commented during subsequent opportunities for reflection how they might improve their classroom approaches next time. For example, Lisa was concerned with the way her students 'connected' with her analogy and thought more guidance was needed:

> The presence of a teacher to provide further guidance where needed or perhaps a discussion about the task afterwards is valuable to helping all students to get the most out of the

> activity… In the future, I would be really careful about giving students enough information to follow the reasoning, but not just handing it to them, and also in emphasising where the analogy breaks down. (Lisa, survey)

Both participants placed a similar emphasis on following up their analogical reasoning task with a class discussion of their responses. In her journal, Eleanor showed concern for the possibility that an analogy may cause confusion in students' thinking:

> It was definitely a successful way of getting the kids to learn the content, by getting the students to indicate the similarities and differences. However the only error or difficulty that the students sometimes came across is that they sometimes may have gotten the analogies confused and hence had a misconception about the content. (Eleanor, final survey)

She suggested teacher (face-to-face) mediation as a possible solution. Indeed, many participants came to better understand their key teaching role as they 'enacted' their designs mostly in a face-to-face school learning environment. The importance of this role came as a surprise to them as they typically thought of online tasks in isolation from a teacher. This was particularly the case with the analogical reasoning tasks. We stressed this mediatory teaching role in our beta generic learning design.

Discussion

Participants' experiences as 'teacher designers' contributed valuable, practical insights into the potential of expanding and developing the analogical reasoning strategy in an online (LAMS-based) learning design. For example, the potential for using students' own work as content in these tasks; rationalising the creative use of media to enhance students' visualisation processes; and the possibility of encouraging student-generated analogies. Although the team was aware of some of these issues (eg. student-generated analogies has been discussed in the literature extensively), the study gave us an opportunity to consider these ideas in real contexts. Although the student teachers' designs were sometimes contrived, their school-based implementation revealed insights into related pedagogical approaches in both primary and secondary computer-mediated learning settings, highlighting the crucial role of the teacher in this strategy. A detailed analysis of these teaching issues is discussed elsewhere (Kearney, Prescott & Young, 2008) but it became obvious that significant teacher mediation is needed at key points in the analogical reasoning sequence if students are to really use the analogs as a thinking tool and avoid the well known traps of forming alternative conceptions. Other pedagogical approaches used by the pre-service teachers affirmed our initial design. For example, the notion of students working collaboratively to initiate learning conversations worked well.

The implementation of the learning tasks in an authentic school-based context (on practicum) sparked further debates about design issues such as the whether students should discuss and map like and unlike attributes simultaneously or separately (ie. as different 'steps' in the LAMS sequence). Also, whether it is beneficial for students to 'see' other groups' mappings (eg. using the Q&A LAMS tool) after their own initial mapping attempts. Although we were able to agree on certain issues, others require further evaluation.

A beta generic learning design based on learning with analogies

Although the study primarily focused on the pre-service teachers' professional learning (Kearney, Prescott & Young, 2008), it also involved the research team reflecting on relevant literature, building a model contextualised analogical reasoning task, and effectively conducting preliminary 'field tests' with the student teachers (and their K-12 students). Feedback and further critical collaborative reflection (Bullough & Gitlin, 1991) amongst the research team and critical friends of the project has facilitated the creation of a beta generic learning design based on analogical reasoning, visually represented in Fig. 7 using a learning design visual sequence (Agostinho, Harper, Oliver, Hedberg & Wills, in press). Informed

by these processes, this beta learning design incorporates several key features to facilitate student learning:

- a 'grey area' option in the mapping phase for students to record features they are not certain about ie. where the correspondence between the base analog and target concept is unclear. This important step has been discussed by Aubusson et al., 1997;
- an opportunity for students to review and change their 'mappings' as necessary after the teacher facilitated class discussion;
- an emphasis on the crucial mediation role of the teacher at key points in the sequence. While analogical reasoning has been found to be a very powerful approach to learning abstract science concepts, it is clearly not without risks (more so than many other strategies!) and can easily lead to confusion when student learning is not appropriately scaffolded. For example, a big danger is students misappropriating the "wrong" attributes from the analog and applying them to the target concept, leading to reinforcement or development of alternative conceptions.

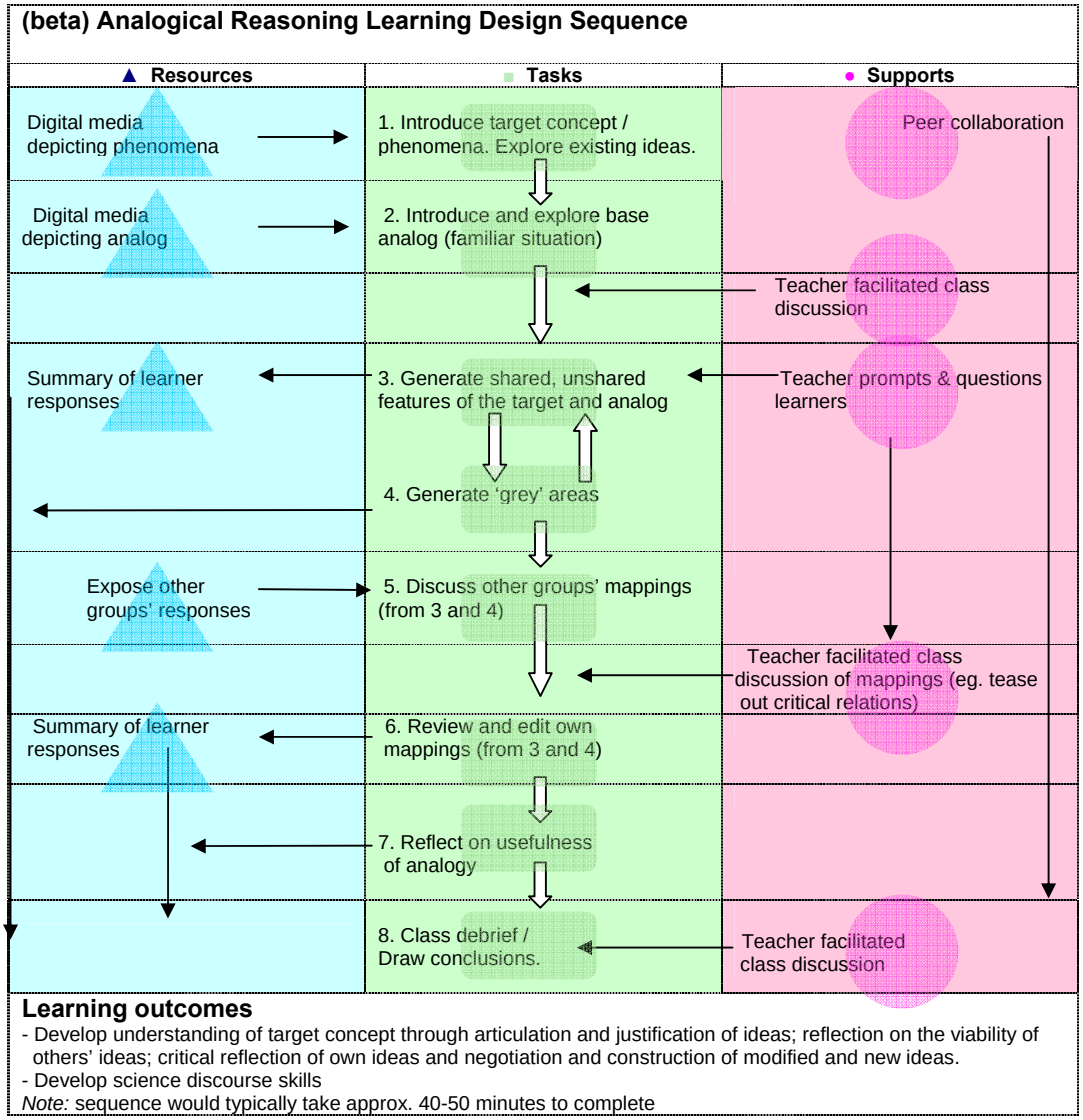

Fig. 7. (beta) Analogical Reasoning Learning Design Sequence

This learning design is by no means prescriptive—while such a model provides a useful guide to structure a learning experience based on analogical reasoning, account still needs to be taken of the learners'

specific characteristics and needs, the environments in which the learning will (and could potentially) take place and the strengths of the classroom teacher. Further variations and extensions of the design might include:

- the inclusion of student work to enhance student ownership of task content (as informed by Eleanor's task);
- the use of follow-up information, tutorials etc. (after step 8). Although this was a popular suggestion from many pre-service teachers both in this study and also a similar past study (Kearney, 2006), we see such an option as separate from this specific learning design and an optional variation depending on the task purpose and context of the teaching situation;
- the use of *student-generated analogies* (eg. in a similar way to Lisa's task). This option is discussed in the literature (eg. Cosgrove, 1995; Pittman, 1999) and needs careful consideration based again on the learners' background, familiarity with working with analogies, existing level of understanding of the target concept etc. Another exciting option here is the use of student-generated or teacher-student co-generated role-plays (as analogies), where learners use their original analysis to generate new role-plays to represent new and emerging ideas (Aubusson & Fogwill, 2006).

This beta design will inform the creation of (LAMS-based) 'e-templates' for other teachers to use in a similar fashion to the 'e-templates' created by Kearney and Wright (2002) for the *multimedia-based POE* design. These templates can be used as a starting point (or at least a 'talking point'!) for teachers wanting to adapt this generic design to build their own analogical reasoning tasks set in their own contexts.

Conclusion

A beta generic learning design based on analogical reasoning has emerged through an iterative cycle of consultation with the literature, especially the constructivist literature from the science education field; consultation with and critical collaborative reflection amongst subject and pedagogical experts; and 'field tests' with pre-service teachers and their students. We drew on data from a recently completed study in teacher education to show that pre-service teachers can play a role in the formative assessment of new designs. Further evaluation of this design involving both practising and pre-service teachers, and feedback from the LAMS community will form the next cycle in the development of this emerging learning design. This study also raises the question of how other established, well-researched classroom learning procedures (e.g. see Baird & Northfield, 1995) might inform useful generic online learning designs for teachers to adapt to their specific contexts.

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