Multimodal Mastery Learning

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***Abstract*—Educators frequently encourage and value the use of a variety of media in student work, as learners design their knowledge representations using rich, multimodal sources and embedding multiple types of complementary media—photographs, diagrams, tables, data visualizations, videos, and raw datasets. The pedagogical and cognitive benefits of shifting meaning representation across a range of integrated modalities enriches their understanding. In this paper we present our experiences and findings from a case-study in which graduate learners are engaged in the creation of knowledge artefacts as part of their evidentiary work in an online environment. The e-learning portal we created supports and enables the incorporation of all types of new media through its "Creator" interface as they move incrementally towards subject-matter mastery. We present the rationale behind our design, together with methodologies employed to encourage the creative use of diverse yet complementary media. Finally, we present results from qualitative data collected and analysed regarding the use of rich, multimodal sources, as we come to a close with a number of conclusions and recommendations.**

***Index Terms*—multimedia, e-learning, mastery learning, e-learning affordances**

I. Introduction

The use of multimedia and multimodal resources is commonly associated with teaching aids and presentation support materials to accompany, complement and enrich the delivery of some topical content. The presenter or educator is attempting to inform, introduce or demonstrate a concept or a process to learners by suitably pitching the content, as well as adapting the delivery to a target audience. The adoption of different resources, could also be intended to have a rhetorical, graphic or inspiring effect. It could be the case that educators are attempting to achieve all these goals through their e-learning courses, optimising the impact of their delivery, as well as ensuring that the learners are extracting maximum benefit. Consider flipping the scenario and applying the same conceptual reasoning to learners producing and delivering their evidentiary work in the form of knowledge artefacts created through rich digital media and multimodal resources. The reason they would do so is not only to perform well, but also to contribute to the library of educational resources they share with their peers in their academic programme. Additionally, such a task enables them to effectively practice and refine their creative skills as well as master the subject matter through the different representations that multimodal composition empowers them to achieve. Students are able to shift from one mode to another complementary one, as they represent what their knowledge, thereby intensifying and amplifying their learning.

This paper will specifically address multimodal meaning as an e-learning affordance, in an effort to add value to the entire e-learning experience. Numerous online courses delivered over our e-learning portal, called Common Ground Scholar (CGScholar), developed with specific semantically-designed capabilities that are grounded within a reflexive pedagogical rationale. Our philosophy is based on Bloom's theoretical recommendations on how to aim towards mastery learning, together with an educational model of new learning affordances, made feasible through new media. One such affordance relates to multimodal meaning within the context of optimising the learners' cognitive awareness. Carlin-Menter argues that such practices that focus on varying semantic architectures assist students to better understand the metacognitive tasks required to express themselves and represent their thinking.

In this paper, we discuss how we enable multimodality within the online portal as learners are encouraged to employ a variety of modalities to represent their submitted work. In the next section we elaborate on the concept of multimodal meaning, giving a broader background to our rationale, followed by a detailed description of the new media and e-learning affordances model upon which the online portal is based. Section IV presents the practical aspect of how multimodality is made possible within our online environment, as we employ qualitative data analysis of survey results collected at the end of three graduate online courses. Finally, we close the paper with conclusions about the design of pedagogy and research recommendations.

II. Background

Mastery learning involves giving students the opportunity to demonstrate mastery of content at different time intervals before moving on to the next topic.

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According to Bloom, the "basic task in education is to find strategies which will take individual differences into consideration but which will do so in such a way as to promote the fullest development of the individual" (p. 3). He also stated that when given sufficient time and corrective feedback in a timely manner, students achieve a specified level of content knowledge for each topic prior to the next progression. Studies indicate that in comparison to traditional approach (e.g. teacher-centred method), the mastery learning approach yields better student retention, more effective transfer of knowledge, greater interest and positive attitudes from students because they are given wider opportunities to demonstrate mastery of content.

In the online learning environment, formative assessment enables students to test their understanding at intervals and instant feedback can improve their mastery of a topic. Online platforms also give instructors opportunity to focus more on content delivery and save time from repetitive marking and record keeping. A wide range of studies have found online settings to be beneficial to mastery learning .

In the meantime, in the online setting, we observe a great utilization of multimedia to deliver various types of content. The term "multimedia" refers to the use of texts, graphics, animations, video and audio in an integrated way that assists the delivery of structured and diversely presented meaning. Multimedia has a significant role in every domain of our lives and therefore, its widespread use nowadays also affects the educational domain and the way we teach and learn. Learners are able to represent their meanings in multiple ways, using text, images, videos and sound. Moving from one mode to the other can enhance and deepen learning . Moreover, multimedia promotes and reinforces interactivity between learners and with the content, as well as adding flexibility to the way messages are delivered. One of the most significant attributes of using multimedia in education is the fact that they address the diverse needs and interests of students by increasing their motivation towards learning. However, the use of multimedia in education should not be considered as panacea to cure every defective part of the domain. On the contrary, multimedia, if not used towards a direction of authentic and transformative learning, could reproduce and intensify some old-fashioned practices of the didactic pedagogy. As a consequence, the use of multimedia in education should not be considered as a collage of media. It should be a way of expressing and communicating content to others, constructed in a meaningful and purposeful way in regard with the text.

III. New Media

The education system is being revolutionized by educational technologies realized by e-learning ecologies. E-learning ecologies, according to Cope and Kalantzis, serves as a metaphor to understand the learning environment as an ecosystem, incorporating complex interactions among human, textual, discursive and spatial dynamics. Not only do e-learning ecologies impact learners' configurations of space, but also their relationships, the textural forms of knowledge to which they are exposed, the types of knowledge artefacts that they create and the way the outcomes of their learning are measured.

Cope and Kalantzis [2] operationalize the idea of e-learning ecologies by heuristically segmented them into seven "new learning" affordances, namely, ubiquitous learning, active knowledge making, multimodal meaning, recursive feedback, collaborative intelligence, metacognition and differentiated learning. In the CGScholar environment, the seven affordances represent an "agenda for new learning and assessment" that redefines the relationships between knowledge and learning, recalibrating traditional modes of pedagogies in an effort to create learning ecologies which better suit the educational needs and goals of our time.

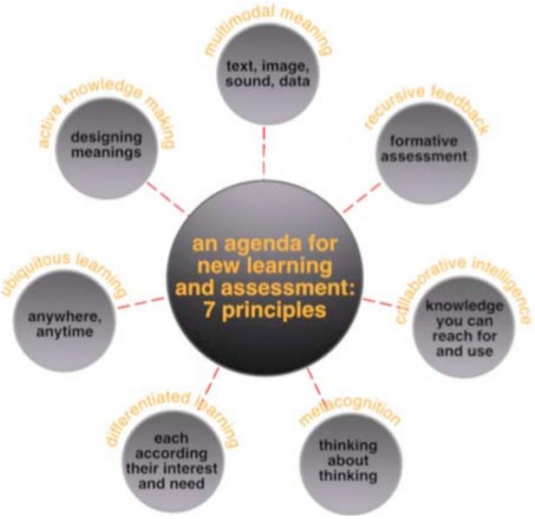

Figure 1. The seven e-learning affordances

Fig. 1 depicts the seven affordances that also constitute the basis for the reflexive pedagogical rationale and mechanisms of learning analytics, emphasized in the CGScholar environment. This paper elaborates on the third e-learning affordance, multimodal meaning.

We have witnessed an acceleration in the processes of digitization since the turn of the new century. Different forms of representations, i.e. written texts, images, audios, video and dataset, are no longer separated from each other. Instead, they are converging, overlaid and mixed on screen. Multimodal meaning refers to the use of new media resources, "Today's learners need to be able to use digital media to juxtapose and link text, diagram, table, dataset, video documentation, audio recording and other media. Across all subject areas, meaning making and knowledge representations are supported and enhanced today by digital production skills and technologies" (p. 123). Working in the 21st-century web communications, students can represent their meanings independently and simultaneously in different modes, and each mode complements the others -- each can show the same topic in a different way; and each "is also an irreducibly different mode of representation".

Learners in CGScholar environment employ Updates and Creator to complete weekly and term assignments.

Within every community, Updates partly function as a blog, and can include embedded video, audio, data and external links, e.g. for admins to share course contents, or notify a deadline or an agenda, and for learners to present on chosen and assigned topics, providing comment areas below to facilitate peer-to-peer and student-with-admin discussion. Creator, for term papers, is a semantic editor and multimodal working space, which goes beyond the word processor. Digital objects, including image, audio, video, text, math, live links, dataset and embedded external media, from YouTube videos to GitHub code, can be all inserted inline within the body of the text.

IV. Case Study

The CGScholar platform described in the previous section was used within a Global Health course taught at the University of Illinois Urbana-Champaign. Its location in a cloud computing context and the ability afforded by multimodality allow students to explore other socio-cultural context of health without the need to travel. The instructor made use of several videos from Sierra Leone to introduce students to different health systems in the context of disease burden and infrastructure to support health needs. This enabled the students to experience and visually relive the message the instructor wished to convey utilising the most appropriate medium to do so. The students could in return generate updates and projects using the appropriate medium each thought best. Some employed an image, others an audio file, while others added a link to a resource or submitted plain text. Having the options to utilize various types of media elements in CGScholar allows students to better express their opinions, enhancing their thinking and understanding. Their peers, as well as tutors, are at liberty to comment, give feedback, add additional content to supplement the original work, while others to support their argument. This creates a healthy ecosystem of knowledge sharing and crowdsourcing that all the students and teachers benefit from. Peer reviews and expert reviews also form part of the CGScholar environment in an effort to embolden and enrich the entire educational experience. The following analysis were possible through the continuous data collection capabilities of CGScholar that records millions of data points through every online course. Such analytics are also visible to the learners and tutors in the form of an Aster graph (Fig. 2)

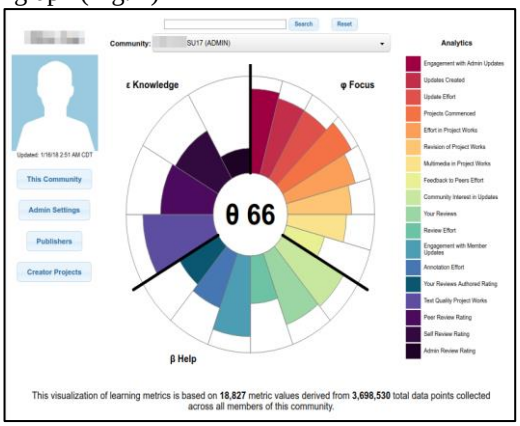

Figure 2. Statistical information through an Aster plot

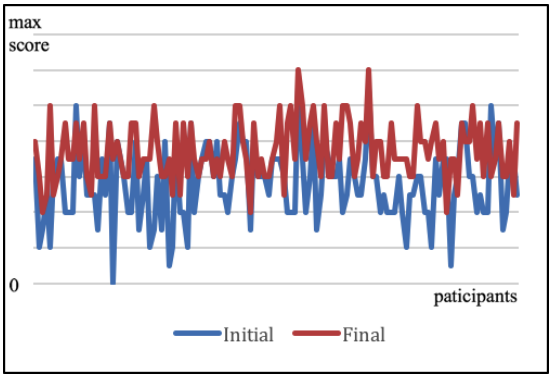

Figure 3. Comparison between initial and final expert scores

The first analytical exercise was to statistical analyse, employing SPSS software, the results accumulated from two sets of review results submitted by experts at the beginning and at the end of the project, giving us the possibility to investigate any changes. During this period all the students made extensive use of CGScholar and submitted experiential work employing a variety of modalities to express their thoughts respectively. The results, depicted in Fig. 3, show that the final assessments clearly follow the initial ones with a percentage increase of approximately 30% on average. What is also evident from this chart is the wider range of distribution of the initial scores, compared to a more compact and cohesive set of values ranging within the final scores. This aligns with the "mastery" notion of Bloom's, with a wider range of course participants achieving mastery objectives than would be the case if their papers had simply been submitted, without opportunity for peer review and revision. Similar analysis from other courses confirmed these results and motivated us to pursue further investigations.

Figure 4. Word cloud resulting from qualitative analysis

The second exercise consisted of a thematic analysis methodology, using the nVivo software on the post-course survey results that students were asked to complete. Amongst the survey questions we asked the participants to express their opinion on the multimodal facilities provided within the CGScholar environment. The outcome of this qualitative analysis can be seen in Fig. 4 where an overall student satisfaction, focussing on the use of rich modalities, is apparent. The peer feedback itself can be

considered a modality in its own right as it allows both the reviewer and reviewee to express and appreciate respectively the thoughts to and from a peer. The feedback of some students speaks for itself as quoted below:

Student 1: "I like the ease of incorporating multimedia as well as peer feedback through additional use of media"

Student 2: "What I like about CGScholar is how it represents a 'social media' type platform in which students can make posts and comment on others while scrolling through the update feed."

Student 3: "I really appreciate that the emphasis was not just on 'learning' in the traditional sense, but also being a producer of knowledge. This forced me to new heights."

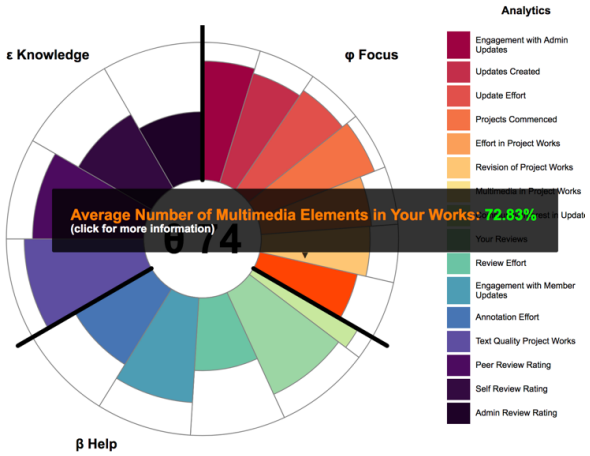

Figure 5. Statistical information about each petal

TABLE I. PERCENTAGE USE OF MULTIMODAL FUNCTIONALITY

Functionality	*% Use*
Multimedia elements	72.83%
Reviews completed	81.42%
Peer-reviews done	80.95%
Updates done	83.06%
Revision changes performed	79.26%
Views to updates	87.98%

The third and final empirical analysis performed was to analyses the percentage time that students engaged in the creation and authoring of multimodal artefacts. The statistical tool shown earlier in Fig. 2 allows learners and tutors to interactively access such information about their performance and that of the class respectively. Each petal delivers percentage information about each activity once a user browses over it (Fig. 5). In this case study we investigated the class as a whole rather than individual students and tabulated the results in Table I. The class statistics are relatively high as a score of 80% or higher is considered an 'A' at academic level. The inclusion of multimodal meaning is encouraged and since it is included as one of the petals in the Aster plot, then it also contributes to the overall assessment. Such practices have not only help elevated the quality of the learners' contributions but facilitated the peer-review process as feedback and updates were performed at a high percentage in an attempt to raise the overall quality of each academic contribution. To note that all the updates and contributions are considered rich academic content that are stored and indexed as part of the courses content itself.

V. CONCLUSIONS

New media offer students the possibility to refine and represent their understandings in multimodal ways, where traditional textual knowledge can be supported by image, diagram, video, visualization, dynamic dataset, and embedded external media. In this paper, we have described a new e-learning environment for multimodal knowledge representations, CGScholar. Our trials have demonstrated the capacity for students to create a new genre of multimodal work, offering students opportunities to represent their understandings that far exceeds those of traditional word processors. The richness evidenced in their submitted work is statistically measured, as well as their affinity to employ the adequate medium to express whatever they need to transmit to their peers and tutors has also been recorded through the final survey. The analytics tool itself represents a number of significant developments in the field of assessment and learning analytics, as it captures individual and whole cohort progress in learning with a level of granular detail not previously achievable. The visualized synthesis offers learners a clear view of their progress towards instructional objectives or "mastery. Such an approach to learning analytics can serve a number of important functions, supporting the assessment of higher level epistemic performances such as critical, creative or design thinking, and supporting learning which involves active knowledge making rather than traditional assessments based on memorization and the generation of correct answers.

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