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Using technology to encourage self-directed learning: The Collaborative Lecture Annotation System (CLAS)

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The rapidly-developing 21st century world of work and knowledge calls for self-directed lifelong (SDL) learners. While higher education must embrace the types of pedagogies that foster SDL skills in graduates, the pace of change in education can be glacial. This paper describes a social annotation technology, the Collaborative Lecture Annotation System (CLAS), that can be used to leverage existing teaching and learning practices for acquisition of 21st Century SDL skills. CLAS was designed to build upon the artifacts of traditional didactic modes of teaching, create enriched opportunities for student engagement with peers and learning materials, and offer learners greater control and ownership of their individual learning strategies. Adoption of CLAS creates educational experiences that promote and foster SDL skills: motivation, self-management and self-monitoring. In addition, CLAS incorporates a suite of learning analytics for learners to evaluate their progress, and allow instructors to monitor the development of SDL skills and identify the need for learning support and guidance. CLAS stands as an example of a simple tool that can bridge the gap between traditional transmissive pedagogy and the creation of authentic and collaborative learning spaces.

Keywords: self-directed learning (SDL); lecture annotation; learning analytics; motivation; self-management; self-monitoring; metacognition.

Introduction

More than four decades ago, adult educator Malcolm Knowles (1970) argued that the Information Age and the speed of technological development would necessitate constant re-training and re-skilling in most careers. Knowles maintained that to meet future workforce requirements, individuals would require the skills, attributes and dispositions that would allow them to assess their current level of skills and knowledge, and determine their ongoing learning requirements as they progressed through their professional careers. This notion of need for continuous learning (formal, non-formal or informal), with an emphasis on learner independence, has been captured in the term 'lifelong learning'. As Sharples (2000) argued there is no authoritative definition of lifelong learning. However, the intent of the concept of lifelong learning is well captured by Candy (2000) in noting that the pace of "social, technological, cultural, economic, legal and educational change …emphasizes the need for people who are adaptable and responsive; in short, who are capable of continuing lifelong learning" (p. 102). While education policy and vision statements have rapidly embraced the *ethos* of lifelong learning, it is questionable whether contemporary teaching practice has fully achieved the goal of developing in students the skills necessary for lifelong learning - that is, the skills that allow them to become self-directed and social learners (McWilliam, 2011). This failure is not the result of any lack of appreciation of the importance of developing self-directed learners, but instead most likely reflects the reality that any change in pedagogical practice necessitates a change in our teaching habits (McWilliam, 2005). And habits are notoriously difficult to

change.

Few educators would deny the importance of implementing teaching practices that aim to promote and foster the skills associated with becoming autonomous, self-directed learners, as demonstrated by the depth of educational research and discussion in the field of self-directed learning (for review see Knowles, Holton & Swanson, 2011). Although the premise of SDL is now well accepted, there remains much debate over an authoritative definition. Knowles (1970) first defined SDL as:

> The process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing learning strategies, and evaluating learning outcomes. (p. 7).

Although the definition of self-directed learning (SDL) has evolved since Knowles's early work, the core message has remained the same. That is, the primary responsibility for learning resides with the learner (Merriam & Caffarella, 1991). This does not imply that SDL is a solitary and isolated process. Rather, SDL is characterized as comprising the skills and abilities necessary for engaging in independent and social learning processes as determined by the individual learner (Brookfield, 2009).

Where early researchers approached SDL from sociological (e.g. Tough, 1971) and pedagogical (e.g. Knowles, 1970) perspectives, the field has since expanded to include psychological dimensions (Pilling-Cormick & Garrison, 2007). Building on the work of Long (1989) and others (e.g. Brookfield, 1986), Garrison (1997) proposed that the kind of educational experiences which effectively promote and facilitate SDL are those that motivate learners to engage in continued learning, and that offer learners opportunities to practice self-management and self-monitoring. Contemporary educational structures and pedagogical practices, on the other hand, remain entrenched in an industrialised model (i.e. a model that emphasises linearity and standardisation) (Robinson, 2000), and learning environments remain overwhelmingly content-centric and transmissive (Conole & Alevizou, 2010). Short of revamping entire educational systems, do tools and approaches exist that can enable and foster SDL outcomes even within the constraints of contemporary learning environments?

We argue in this paper that SDL skills can be developed and promoted within such environments through careful design of interactive tools that extract the artefacts of existing practice to encourage self-management, self-monitoring and motivation (core factors in Garrison's 1997 SDL model). As an example of such tools, we describe an in-house developed educational technology, called the *Collaborative Lecture Annotation System* (CLAS). This web-based annotation resource has been designed to leverage the primary products of existing pedagogical practice (lectures) and student learning approaches (note-taking and review of important highlighted points) in a manner that encourages both the development of lifelong learning skills and reflection on teaching practice. We begin the paper with an overview of the basic architecture and functionality of CLAS, before discussing the theory and principles that underpin it and that have informed its design and functionality. We conclude by suggesting future directions and research related to the application of learning analytics, media and social annotation tools in order to provide further impetus for pedagogical change.

How the Collaborative Lecture Annotation System (CLAS) Works

CLAS allows annotation of educational media

CLAS is a web-based video annotation tool, designed in the first instance to enable students to flag points in a video that they believe to be significant for their learning. Using CLAS, students can annotate lecture videos in the same way that they highlight important sections in text passages within a prescribed course reading. CLAS can be used in the classroom during live lecture presentations that are also recorded and uploaded at a later stage for student and instructor review. Alternatively, students and instructors can use CLAS to interact directly with any previously uploaded multi-media content (e.g. podcasts, vodcasts, or lecture capture). In essence, CLAS has been designed to allow for a cohort of students to share annotations, review peer annotations and allow for instructor feedback in the one collaborative space.

During a lecture, or during later review of a captured lecture or other multimedia resource, all learners can add a 'point-based' (flag) annotation (via laptop or mobile device) to indicate that something of personal significance or importance occurred at that specific point in time (Figure 1) (Risko, Foulsham, Dawson, & Kingstone, In Press). Each individual point-based annotation is time-stamped (post login), and later synchronised with the recorded lecture (post upload). During the lecture, or at a later time, students can also add textual annotations for

personal review and reflection or for sharing with peers post-lecture (Figure 1).

On completion of the lecture or lecture review, student individual annotations are saved in a file on the server. All student annotations are graphically presented in an individual annotation timeline (see Figure 1). Students can navigate through their individual timeline by clicking on the specific annotation points. Clicking in the annotation timeline repositions and plays the video (i.e., the lecture) from the point in time corresponding to the selected region. This feature allows students to click on the points in the lecture that they had previously indicated were important and be taken directly to those points in the lecture video. Additionally, when all student annotation timelines are presented, students can readily navigate and review areas of the lecture or multimedia resources that may have fallen outside of their consideration earlier.

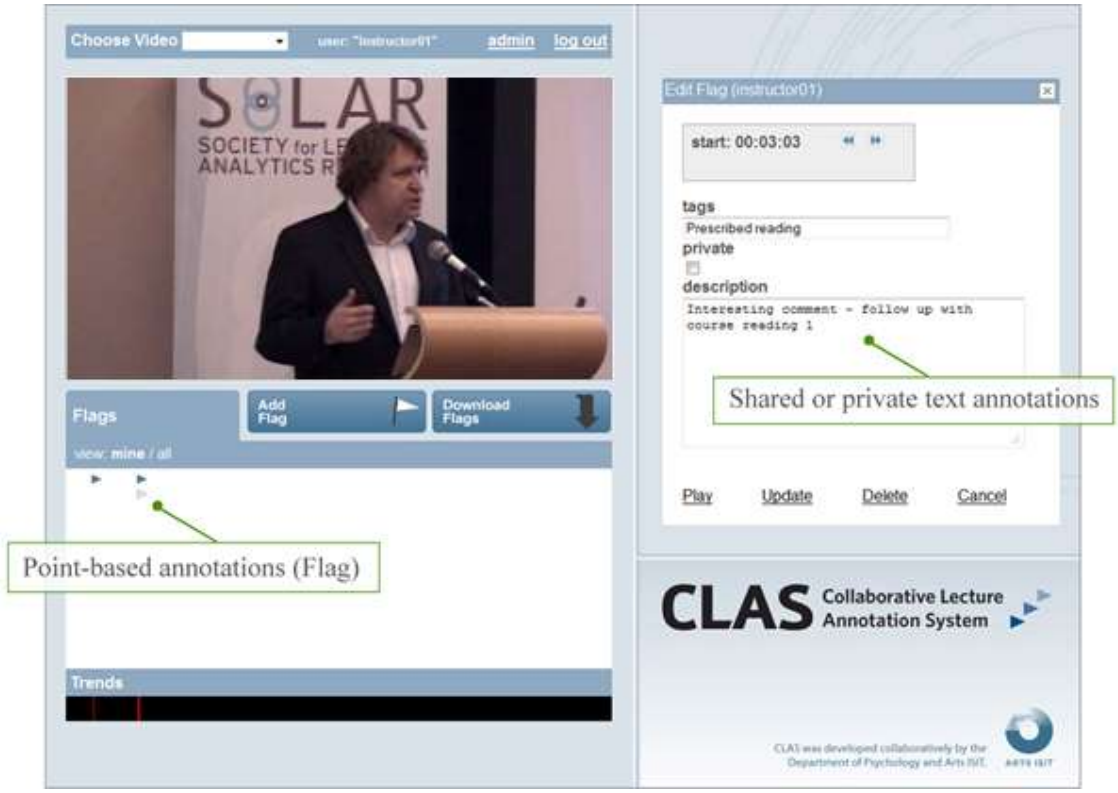

Figure 1: Point-based annotations that are aligned with the video time stamp. This figure illustrates the application of CLAS during a live recorded presentation.

Learners and teachers can view group annotations

Most importantly and whether it is used with live lectures or archived media, CLAS allows both learners and instructors to 'see' areas of learner convergence and divergence with respect to key points in, for example, a lecture presentation (Figure 2). This information can be used by both students and teachers to evaluate learning progression and the effectiveness of the presented materials (Risko et al., In Press). For example, students can assess their own interpretation of important points against those of their peers; instructors, meanwhile, can determine whether students are recognizing and understanding important concepts or material in their lecture materials (identification of areas of convergence and divergence; Figure 2). In this way, visualization and interpretation of captured student interactions can inform decisions regarding future teaching strategies and practices in order to address any identified gaps in the learning process or student understanding (Risko et al., In Press).

Figure 2: Point-based annotations from a student cohort indicating sites of convergence and divergence.

CLAS analytics allow sophisticated student tracking and support

Learning analytics relates to the collection, analysis, reporting and interpretation of user data in learning and teaching contexts (Siemens & Long, 2011). Data may include, for example, learner tracking data in a learning management system or library resource. Analytics models are used to discover patterns, learning and teaching information and social connections particular to individual learners and to learning communities. While this emerging inter-disciplinary field has the potential to support and improve learning and teaching practice and institutional decision making, institutional implementation of learning analytics methods thus far has largely been directed towards decision-making around student admissions, and predicting student attrition rates. Learning analytics nevertheless offer learners new opportunities for tracking their own progress and can motivate students to invest new effort in their learning (Fritz, 2011; Macfadyen & Dawson, 2010). They also permit predictive modeling of student success/failure and can allow educators to identify, early, those students requiring additional learning support (Ferguson, 2012).

CLAS provides learners and teachers with a set of data visualizations and analytics (Figure 3) that may assist in the evaluation of student understanding and guide the learner towards core SDL outcomes. CLAS provides the functionality to analyze:

- the changes students make to their lecture annotations after viewing aggregated class data;
- the number of times an individual accessed a particular lecture or media resource;
- student 'dwell time' on a particular media resource;
- the length of textual annotations made by users;
- outliers (students whose flags and/or annotations differ significantly from their peers) (Figure 2).

For learners, comparison of personal data with group data can act as a strong motivator to sustain or increase contribution to and engagement with the class learning community (Gibbons, Blanton, Gerrard, Buunck, & Eggleston, 2000), and can serve to promote self-reflection.

For educators, learning analytics data can assist with identification of individual students who may need additional learning support. Such data can also allow educators to assess the impact of teaching activities or resources and offer critical feedback on student and cohort understanding. For instance, a review of annotations may indicate a common misunderstanding of the core concepts provided within a lecture. Conversely it may also indicate strong understanding with minimal outliers requiring further follow-up. Within the large class context, instructional feedback of this kind is critical for ensuring that each lesson is well scaffolded and builds on student understanding, rather than being tied strictly to a curriculum schedule.

Figure 3: Example analytics on user annotations and interactions.

Design of the CLAS Tool

CLAS was designed with the goal of creating opportunities for students to acquire and practice skills of self-directed learning within existing and often fairly 'traditional' learning contexts. It offers features that are designed to facilitate educational experiences which motivate student engagement, and which promote self-monitoring and self-management – the three core dimensions of Garrison's framework for self-directed learning (1997). To this end, three central principles shaped its design:

1. Learning for the 21st century requires SDL skills and attributes. Educational practice is, however, slow to change (Bates, 2000). Rapid promotion of SDL skills and attributes calls for the implementation of new tools and processes that can leverage existing teaching and learning practices within the current educational landscape.
2. The integration of CLAS into teaching and learning practice must motivate student engagement with learning materials, peers and learning opportunities; and must provide opportunities for self-management of learning resources and activity engagement.
3. CLAS must include features that provide instructors and students with the ability to monitor/ self-monitor learning progression.

Principle 1: Leverage existing teaching and learning structures

Although much continuing educational practice operates on the assumption that learning is largely an individualized activity, current learning theory contends that learning is, overwhelmingly, a social process (Bandura, 1977; Vygotsky, 1978). McWilliam (2011) emphasizes this point, noting that past and future models of education need to move away from individualized instruction (lecture) and re-engage with the idea of a 'café society'. She writes: "When we ignore the educative traditions of café society, we fail to appreciate that *the proper location for lifelong learning is better understood as the café, not the school*" (McWilliam, 2011, p.2). Reflecting contemporary educational theory, McWilliam's 'café' represents the multiplicity of possible sites for learner engagement - sites for dialogue and sharing of social and cultural perspectives that facilitate the collective construction of knowledge. The traditional lecture format, however, offers only limited opportunities for diverse discussion and debate.

CLAS has been designed to facilitate both self-directed and collaborative learning opportunities using easily captured video- or audio- recordings of in-class lectures, and offers the possibility of turning transmissive pedagogy and solitary learning into moments of rich engagement. The tool was designed to make the extraction of key content from multi-media (e.g. lecture capture, vodcasts, podcasts, etc.) a more collaborative and interactive process for students, who can annotate a lecture video either with a simple flag or with their own expanded reference notes. The one-click point-based annotation allows students to highlight important sections of the lecture or video without undue cognitive load or disrupting flow.

CLAS facilitates the sharing of student annotations, and allows benchmarking of progress and understanding against that of peers. While this tool is only a partial substitute for more discursive peer to peer engagement, it represents a significant step in leveraging the artifacts of the lecture format to provide a more socially grounded learning experience. For instructors, CLAS joins the group of available easy-to-use tools that encourages experimentation as they navigate the transition from transmissive pedagogy to creation of a more authentic and collaborative learning space.

Principle 2: Motivate learner engagement, create opportunities for self-management

The importance of motivation in influencing student learning is well established (Pintrich & Schunk, 1996). While educators may disagree about whether motivation must originate in the student, or whether it can or should be imbued by the teaching/learning process (Ramsden, 1997), there is little debate about the importance of motivation for future academic success (Dweck, 2000; Hodges, 2004; Pintrich, 1999). Proficiency in SDL necessitates not only a certain degree of motivation to engage in the learning process, but also the capacity to assess achievement and performance against established criteria or goals (Nicol & Macfarlane-Dick, 2006). Garrison (1997) separates the dimension of motivation into two sub-components: motivation to select and establish "goals and intentions" (p. 27) for learning; and "task motivation" – the motivation to 'stay on track' and complete the required learning activities.

A key element influencing student task motivation is feedback. While student motivation to persist is also influenced by a range of intrinsic and extrinsic factors (e.g. grades, future career goals, instructor, assessment), it is critically impacted by the level and quality of feedback received (Butler & Winne, 1995). More traditionally, learner feedback has been provided via a set of assessment tasks (formative and summative). Self-reflection, and peer engagement can, however, offer additional opportunities for learner feedback and can therefore assist with maintaining task motivation and persistence. CLAS was designed to promote peer-peer interaction and collaborative and active construction of knowledge through sharing of annotations and multi-media resources. These forms of social interactions present additional opportunities for students to obtain feedback and assess their level of understanding against group norms. Depending on course design, CLAS can also provide additional opportunities for private or public instructor feedback, via textual or video annotations.

Learning analytics derived from CLAS activity offer a further source of potentially motivating feedback to learners. By aggregating student annotation timelines, CLAS gives all learners the opportunity to observe, compare and evaluate the level of their engagement efforts, and overall learning annotations with those of peers. For learners, this form of social comparison provides a critical source of feedback that can motivate continued engagement and learning (Fritz, 2011; Gibbons et al., 2000). Although learning analytics data do not provide low performing students with guidance on specific learning strategies to adopt, they do indicate the sites of difference in the perceived importance and written annotations occurring between students (figure 2). This process of social comparison is now being adopted across the field of learning analytics and educational data mining - that is, the comparison of an individual's level of engagement with course materials and activities presented in a learning management system against that of peers. For instance, the Purdue University Signals project makes use of group comparison data to provide automated early warning signals to students regarding their progress in a particular course (Arnold, 2010).

In addition to encouraging student motivation, CLAS allows students to self-manage their own engagement with available learning resources and with peers. The degree and style of interaction with each captured lecture or media resource depends entirely on the needs and preferred learning strategy of the individual student. For example, learners may or may not choose to share their own annotations with others; they may simply review their own 'highlights', and/or can choose to search and browse group annotations based on social tagging (see figures 1 and 2). Depending on assessment tasks and learning activities designed by the instructor, CLAS offers additional possibilities for learner engagement: captured video from class activities may be used for self-reflection, peer review or instructor feedback; compiled personal or group video annotations may form the basis for self-reflection or collaborative writing.

A core goal of CLAS is to build on 'traditional' lecture content, and offer learners an enriched set of opportunities for more socially oriented and participatory learning. As with all socially mediated technologies, the greater the number of students engaged in the process, the greater the number of learning resources generated. The increased numbers of available resources provides a direct positive feedback loop for further enhancing motivation.

Principle 3: Offer tools for monitoring and self-monitor learning

Perhaps the strongest benefit that CLAS offers learners is the capacity for self-monitoring: reflection on new information (meta-cognition) gained through adoption of a particular learning strategy (cognition), and the subsequent construction of personal meaning (Garrison, 1997). Meta-cognitive proficiency, in particular, is tightly correlated with academic success and problem solving ability (e.g. Butler & Winne, 1995; Pintrich, 1999; Zimmerman, 2002; Zimmerman & Schunk, 2001). The capacity for self-monitoring has direct impact on the level and quality of study and therefore, overall learning progression and academic achievement (Dunlosky & Thiede, 1998). Kruger and Dunning (1999) elaborate this point, noting that "the skills that engender competence in a particular domain are often the very same skills necessary to evaluate competence in that domain" (p.30). More simply put, poor performers also have poor self-evaluation skills. As with all aspects of education, not all students enter university as adept learners with a high level of meta-cognitive capacity. However, this meta-cognitive proficiency can be improved through on-going training and feedback (Thiede, Anderson, & Therriault, 2003).

The CLAS workflow directly provides a self-monitoring and feedback strategy intended to hone student cognitive and meta-cognitive processes. CLAS allows learners to create defined point-based annotations and textual annotations on meaning and relevance, with the goal of encouraging learner self-reflection, benchmarking and collaborative opportunities. In the first instance, and as described earlier, learners have the option of reviewing and comparing their own flags and textual annotations with those of individual peers. With particular reference to textual annotations, the CLAS tool provides students with a corpus against which to compare and clarify their perception and understanding of key concepts in captured lectures (or other multi-media content).

In addition, CLAS develops aggregated group annotation metrics for further comparison. These are calculated by recording the frequency of individual annotations that occur in a particular time bin – currently 10 seconds in length – and dividing this by the total number of group members, giving a relative measure of perceived importance for each time segment of a lecture or resource. This group graph offers a consensus representation of the important elements in the media under consideration. CLAS then allows students to review their individual point based annotations against the aggregated group graph (Figure 4). While not implying that the group consensus is always 'correct' presentation of these data is intended to prompt student reflection on their individual input and understanding relative to that of the group. The creation of such a 'feedback loop' provides learners with a level of internal validation that is essential to self-monitoring, and also provides opportunities for external guidance from the instructor (who may also review individual performance and group norms).

For instructors, CLAS also provides data on the extent to which students review and alter their initial responses (point-based annotations). These captured data allow instructors to better track the outcomes of self-monitoring within their class(es). Records of frequency and timing of student actions upon self-reflection can serve as an indicator of development of meta-cognitive proficiency.

Overall, CLAS has been designed to capture, aggregate and re-present data to learners, creating opportunities for review, reflection and benchmarking that assist in shifting the responsibility of learning from instructor to learner, regardless of the pedagogical approach adopted in delivery of in-class lectures. The implementation of CLAS can actively encourage individual self-monitoring of learning progression, and can motivate students to alter their learning strategies in order to achieve their learning goals.

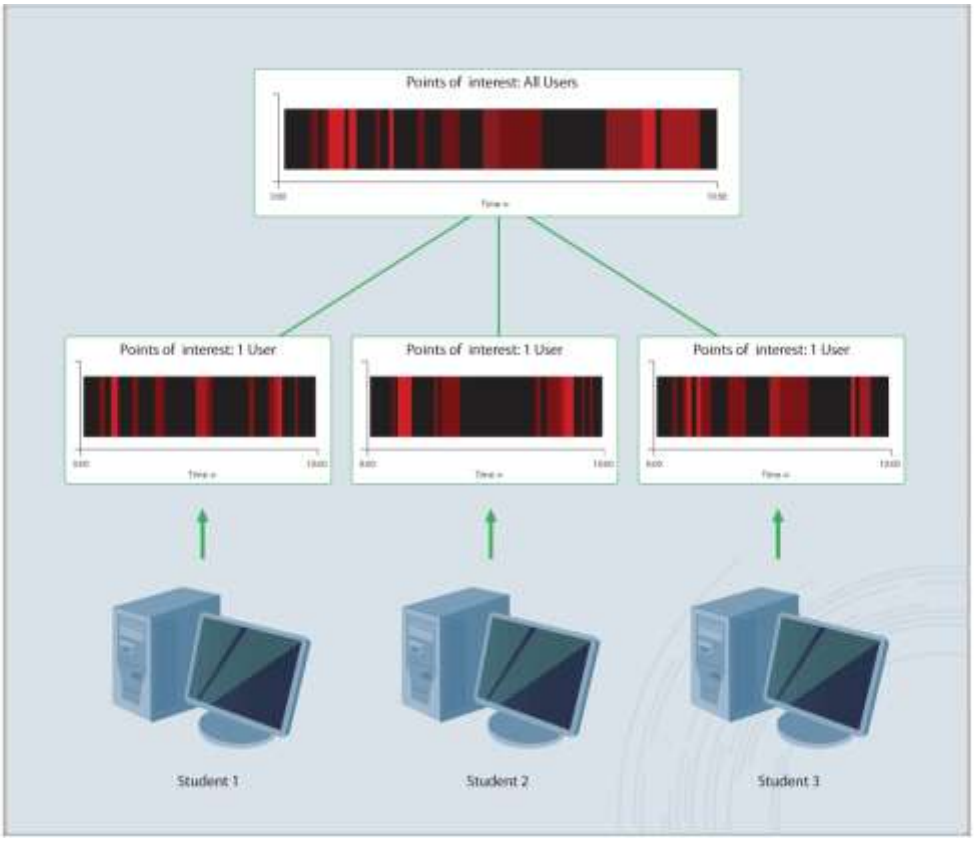

Figure 4: Relative measure of perceived importance for each video time segment.

Conclusion

The CLAS tool represents a starting point for leveraging existing teaching and learning practices to better promote and foster the necessary 21st Century skills within today's learning environments. Despite calls for changes to pedagogical practice to give new graduates the skills they need to become self-directed lifelong learners, the lecture remains the primary pedagogical approach in institutions of higher around the world. While technology adoption may have increased, there is scant indication that a pedagogical tipping point will be reached in the near future to dramatically change this transmissive model of education practice (Conole & Alevizou, 2010). This reality calls for the implementation of approaches that will allow learners to leverage 'traditional' lecture based instruction towards new ends. In this paper, we have outlined a technology that allows learners to annotate captured lectures and other multimedia content, and to share and reflect on these annotated learning resources as part of an enriched educational experience. The technology was developed with Garrison's (1997) multidimensional view of SDL in mind, and with the goal of creating – through the implementation of relatively simple technologies – opportunities for learners to build on lecture materials and develop skills necessary for self-directed learning (self-management, self-monitoring and motivation). Adoption of the CLAS tool is underway in a number of disciplinary areas in our institution, embedded in a variety of different course designs and activities. Ongoing research will seek to monitor and assess the impact of CLAS use on student learning and skills development.

Of great interest, also, is the learning analytics functionality of the CLAS tool, and the additional potential that it offers for students to take greater responsibility for their learning and for instructors to monitor the development of necessary SDL skills and evaluate areas of learning support and guidance. Within the field of learning analytics, the impact of giving data to learners (rather than simply to instructors and administrators) is in its infancy. Further empirical research is required to better understand the relationship between CLAS analytics and aspects such as student motivation, and meta-cognitive proficiency.

While presentation of learning analytics data may be significant for student motivation (as described above), the field of learning analytics also has much to offer educators in terms of predictive modeling and early identification of students requiring personalized learning support. By interrogating the data evolving from user interactions in various educational technologies it is possible to establish patterns of behavior and groupings of

students based on lead indicators of academic performance. An understanding of the significant variables leading to high and low academic performance, may, in turn, permit early targeted learning support. Moreover, learning analytics data may allow assessment of student capacity and maturity for self-direct learning. This is hinted at by Biswas *et al.* (2010) who evaluated student self-regulated learning strategies through analysis of activity logs. Two important conclusions can be drawn from the Biswas *et al*. (2010) study. First, student application of self-regulated learning strategies is positively correlated with performance. Second, students employing (or not employing) specific learning approaches can be identified through analysis of activity log data. What this study and many others relating to learning analytics demonstrate is the capacity for student online interaction data to provide significant lead indicators of meta-cognitive skills (Biswas et al., 2010; Kinnebrew, Biswas, & Sulcer, 2010), academic performance (Finnegan, 2006; Macfadyen & Dawson, 2010) and learning support (Dawson, 2010). We anticipate that ongoing investigation of the learning analytics data generated by the CLAS tool and related applications will continue to expand our understanding of the utility of learning analytics data for supporting teaching and learning.

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