Learner Interaction Monitoring System (LiMS): Capturing the Behaviors of Online Learners and Evaluating Online Training Courses

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Abstract—The Learner Interaction Monitoring Systems (LiMS) is a web-based application that can interface with any web-based course delivery platform to transform the online learning environment into an active observer of learner engagement. In this paper we describe how the LiMS ‘event capture model’ collects detailed real-time data on learner behavior in self-directed online learning environments, and interprets these data by drawing on behavioral research. We argue that LiMS offers education and training managers in corporate contexts a valuable tool for the evaluation of learner performance and course design. By allowing more detailed demonstration of ROI in education and training, LiMS allows managers to make the case for web based courseware that reflects appropriate and evidence-based instructional design, rather than budgetary constraints.

Keywords—online behavior, student performance evaluation

I. CONTEXT: THE NEED TO DEMONSTRATE RETURN ON INVESTMENT IN ONLINE EDUCATION AND TRAINING

Businesses around the world are increasingly recognizing the need to support continuous professional development and skills acquisition and foster lifelong learning in their workforce, in order to maintain competitiveness in the global marketplace. Many have recognized the potential benefits of online training and education: the flexibility offered by the web-based learning environment allows working adult learners to engage with course materials “any time, any place, any path, any pace” [1]. Well-designed online training courses promise to make education and training available in ways that fit the busy work and life schedules of employees, and almost two decades of research into online learning has demonstrated that there is no measurable significant difference in learning outcomes between face to face and online learning modalities [2,3]. In the corporate context, where exam results and course grades rarely exist as measures of learner achievement or effective online course design, it falls to training and education managers to identify reliable and valid approaches to evaluating both course design and learner performance, in order to demonstrate a significant return on the sizable investments needed to implement high quality online learning. Unfortunately, few easily implementable approaches exist. As [4] notes, “in spite of the best efforts of organizations and the professional trainers’ associations, there are significant problems in evaluating the true impact of [online] training”.

Similarly, while the value of feedback from and to learners in educational settings is well-established (see, for example, [5]), most corporate training departments lack the tools to gather accurate learner feedback (direct or indirect) about their online learning experience or activities. Such information is critical in evaluating whether training courses are meeting corporate educational needs and goals. In the absence of evaluative tools that return meaningful and easily interpretable data, corporate training departments are more likely to deliver web based courseware that simply reflects budgetary restrictions, rather than appropriate and evidence-based instructional design.

II. BEYOND THE LMS: THE LEARNER INTERACTION MONITORING SYSTEM (LiMS)

To meet the need for a robust web-based training evaluation tool, we have developed the Learner Interaction Monitoring System (LiMS) application. LiMS is a two-part web-based plug-in application that can interface with any web-based course delivery platform to transform the online learning environment into an active observer of learner engagement with course materials. Unlike the minimalist tracking tools packaged with standard Learning Management Systems (LMSs), LiMS purposely captures fine-grained data on learner activity and behaviors within the learning environment, turning the course itself into an active receiver of indirect learner feedback. Given that most web-based corporate training is self-paced, self-directed and is not instructor-led, this capacity already makes LiMS unique.

Typically, LMSs capture only very limited learner performance data such as student scores and course
completion status. At best, such data merely demonstrate base-level learner participation. Until recently, this has been sufficient in the business environment, where the primary role of an online course has been to satisfy regulatory training requirements.

While some LMSs now capture and archive more extensive learner tracking data, they offer only very limited data reporting options, and access to archived data has only been possible via slow and cumbersome manual processes [6-8]. Even more problematic is the reality that existing commercial LMSs provide little or no guidance for educators and managers to indicate which (if any) of the captured tracking variables may be pedagogically meaningful - that is to say, which of the available data points are indicative of student participation in educationally purposeful activity that may contribute to their learning or success [8]. Today, training administrators are nevertheless expected to evaluate learner competence and course effectiveness by examining primitive or largely inaccessible data sets, in the absence of any interpretive guidance.

The Learner Interaction Monitoring System (LiMS) now offers administrators a means of capturing rich and detailed real-time information about individual learner behaviors in an online learning environment, and makes use of evidence-based interpretive approaches to permit meaningful evaluation of learners and courses. As [9] notes “...you can always choose not to analyze data you have collected, but you can never analyze what you do not collect”. Most LMSs fail to collect data that can reveal information about both learners and course design. By collecting user course engagement events, such as mouse clicks or movements acting upon individual page elements such as buttons, checkboxes and lists, LiMS ensures that the detailed course interaction data of the user experience is captured for reference. Going far beyond the capture of simple event sequencing, LiMS also captures data reflecting the variable behavioral characteristics of those actions such as duration, timing and response latency. Much like a teacher in a live classroom, LiMS virtually “watches” what the student is doing in an online class and commits those actions to memory by recording the behavioral data to an SQL database. Importantly, LiMS implementation and continuing development builds on existing research to permit pedagogically meaningful interpretation of captured data.

III. PRINCIPLES UNDERPINNING LiMS DEVELOPMENT

LiMS leverages a growing body of research confirming the relationships between online behaviors and learner performance, and builds on the resultant understanding that learner behavior in online learning environments offers a rich source of indirect feedback on both their learning strategies and experience, and effectiveness of course design.

Web analytics uncover online indicators of learner performance

In the past decade, the field of ‘academic analytics’ has emerged, as a small number of investigators have begun to employ business intelligence tools and processes in the analysis of data sets captured by institutional LMSs [10]. Studies of interactive, instructor-facilitated online courses in the higher education sector have begun to demonstrate significant positive correlations between selected simple measures of student engagement with online course content, tools and peers, and a student’s ultimate achievement in a course, as measured by final course grade [8, 11-13]. While this work has highlighted the real relationships between online behaviors and learner performance, the level of individual learner analysis remains crude. Moreover, the cited studies reveal that in the group-study contexts of higher education, learner-learner interaction measures are the best predictors of success. Continuing work in this line has less to offer the world of self-directed online education and training.

LiMS allows fine-grained analysis of learner behavior

LiMS builds upon the basic findings of academic analytics, and extends these to the world of online corporate training by developing a detailed map of an individual learners engagement with online course materials, coupled with evidence-based interpretation. In face-to-face training environments, educators intuitively evaluate learners or lessons by observing learner activity and reactions. Learners may demonstrate interest in a subject, for example, by contributing verbal comments or by identifying themselves as eager to participate by raising their hand. Disinterested or disengaged learners are often quiet, and reluctant to engage in dialogue. Proponents of alternate assessment approaches propose that multiple behavioral indicators can and should be employed to evaluate learner performance and the effectiveness of teaching methods [14]. They point to psychological research that supports pedagogically meaningful interpretation of a range of learner behaviors - see, for example, [15] and [16] on the significance of response time or ‘response latency’. Such research suggests that in the classroom, as well as online, the timeliness and sequence of a learner’s actions contribute to an individual’s learning profile. They argue that motivated educators can make use of such observations to adjust their teaching techniques and approach in order to better engage the quiet or struggling student, as well as to acknowledge and further challenge the interested. To date, visual observation of learner engagement has been largely unavailable in asynchronous learner-directed online training environments. We contend that new methods of capturing learner behavior data, such as the online behaviors recorded by LiMS, can provide some of the same valuable information as live teacher observation and can permit richer more fine-grained evaluation of learner performance online. The separation in space and time between the learner and teacher (or instructional designer) in distance learning contexts, first characterized by [17] as ‘transactional distance’, is routinely positioned as problematic. Echoing
[18], [19] points out, however, that in online learning environments this exact condition of relative isolation may permit revelation of the learner’s “true self” and allow individuals to express “phenomenally real aspects of self not often or easily expressed to others.” In the unmonitored isolation of a self-directed online course, the supposedly unobserved actions of a learner may reveal behavioral information that is much more reliable than data collected via self-reporting and self-evaluation mechanisms.

IV. FROM DATA TO INTERPRETATION

“Data by itself is not information. For [an] evaluation to be credible, it has to inform and have an impact.” [9]

The LiMS “Event Capture” Model

In a LiMS-enabled learning environment, start time is captured as soon as a learner opens a web-based course page. All elements (radio buttons, text boxes, hyperlinked text, etc) are identified on the page and reported to the database. For comprehensive elements (select boxes, list boxes, etc) each possible individual selection is recorded as an attribute of that parent element. All text (initially visible) is word counted, to allow calculation of a predicted reading completion time. Each ‘event’ - mouse click, mouseover, response change - is captured and the time noted, to establish whether the event was ‘early’ or not. Hyperlinked URLs are captured when the text is selected – ‘time opened’ is stamped (as well as ‘time closed’, to establish length of time of event). When elements are interacted with by the mouse, the duration of the event is captured and a ‘behavior’ is assigned to that duration (i.e. pause, hover, etc).

At the completion of each online training experience, LiMS assigns a ‘behavioral grade’ to the learner reflecting their approach to the training material when compared to a standard established by LiMS itself. At course completion, each learner, by default, is assigned a beginning learning behavioral grade of A+. As the learner’s course behavior is reviewed by the LiMS engine, the grade is impacted by interpretation of captured criteria: 1.) Did the learner consistently read all of the text on each page? 2.) Did the learner access optional content when available? 3.) Did the learner answer all questions correctly? 4.) Did the learner access optional content that offered guidance to answering questions correctly? 5.) Did the learner adjust their behavioral approach during the course thereby positively impacting their performance?

LiMS adjusts the learner’s grade using an algorithm that computes a final assigned ‘grade’ reflecting their behavioral approach to online training materials.

A descriptive profile of the learner is generated based on the course grade and the behavioral data, and is posted on the student’s report page. For example, text-based reported may include statements such as: “Student X rarely accesses optional data even when it might result in performance improvement”.

LiMS implementation can then be customized to allow educational designers to ask targeted questions about learner choices within a course, or to track learner behavior in relation to key course material items or events of interest. In relation to learner behaviors, for example, educators may wish to ask questions such as: Are learners spending sufficient time reading particular core course text materials? Do my learners display differential response latency to key questions, and can this provide insight into comprehension or decision making style?

Additional comparison measures permits benchmarking against peers or course norms.

1) Example: Reading Time

The time interval between reading completion and initiation of a sequential event (for example, completion of a quiz), may be a useful discrepancy indicator in learner or course evaluation. Native speakers of English in North America typically read at a rate of 250-300 words per minute, when reading for comprehension [20]. LiMS assumes a baseline reading rate of 300 words per minute, or 5 words per second, allowing the calculation of predicted reading time for all text-based course materials. As a learner moves through web-based course text, LiMS not only captures reading times for text blocks, but offers interpretive analysis describing whether a learner appears to be proceeding normally, too slowly or too quickly through reading materials. Such information can then be considered in relation to learner performance (if reading is apparently completed ‘too quickly’, is a learner giving insufficient time to the task?) and to course design (if learners regularly take too much time on selected text blocks, do these need rewriting for clarity?).

2) Example: Response latency

Similarly, response latency may also function as a discrepancy indicator. Research suggests, for example, that response latency “may be a useful measure for behaviors that serve an automatic function” [21]. That is to say, where response to an item (for example, a quiz question), is slow (shows increased response latency), it can be hypothesized that the responder (the learner) is experiencing a dilemma. Consider, for example, a web based Ethics course in which a learner is asked to make a decision about whether or not to accept a small gift from a vendor despite company policy strictly forbidding gifts. Reading the question and selecting an answer is expected
to take no more than 12 seconds, whether the learner agrees with the statement or not. If the time to complete the task falls within the expected time period, then the learner can be assumed to be committed to their answer, regardless of their selection. If the task completion time was longer than expected, we might infer a struggle in choice selection, indicating a cognitive or behavioral dilemma.

In this scenario, there may be value in investigating why the learner took extra time answering the question. Research has demonstrated, for example, that response time for wrong answers is longer than for correct answers [15] and that “respondents holding unstable attitudes need more time to respond to an opinion question than respondents who hold stable attitudes.” [16]. Further investigation may be needed to discover whether course materials explaining company policy are insufficiently clear, or whether a particular learner is in genuine disagreement with or confusion about the policy.

3) Example: Using additional resources

Continuing with the above scenario, suppose the question was reconstructed as: “Would you consider accepting a gift under $100 from a vendor?” This time the organization’s policy information about receiving gifts is hidden in a popup window. A button labeled “additional information” is included on the page that, once selected, reveals the organization’s gift receiving policy. This additional interactive option introduces the possibility of considering additional behavioral indicators: Did the learner display interest in “additional information”? If selected, was the additional content open long enough to be read or closed instantly? If the button was not selected, what was the sequential action? In other words, adding additional learning resources offers greater potential for behavior tracking and interpretation.

Integrating course materials and learning activities into online courses using more sophisticated media and tools (linked resources, multi-media, interactive activities) not only engages learners more effectively, but it also creates richer and more sophisticated opportunities to capture business intelligence and gain insight into learner behavior and course effectiveness. Highly interactive courses are more expensive to design and implement. Failure to follow evidence-based instructional design principles, however, not only reduces educational effectiveness but also means that meaningful opportunities for real-time learner performance and course evaluation are lost.

V. CONCLUSIONS

The supposedly unobserved nature of the learner experience in the online training and education environment affords unique possibilities for evaluation. Capturing the sequence, duration and timing of user interactions with course materials and learning opportunities in real-time permits the development of a learning behavioral profile of each individual, and interpretive metrics can be run on the performance of individuals, groups, and course content and structure. Collection and analysis of robust data sets permits greater intelligence, responsiveness and reactivity to be integrated into web-based courses. LiMS paves the way for truly evaluating students and coursework with data resources to support robust training development that is at once engaging, productive and fiscally valuable.

Moreover, we believe that there is enormous potential for real-time intervention within a course that is “LiMS enabled”. As the observer of student interactions, LiMS data can provide the resources for a course to become a ‘coach’ or learning facilitator. By accessing captured student behavioral data the possibility exists to programmatically customize the online training environment in real-time, thereby adjusting the manner in which content is presented on screen or altering the functionality of a course.

If the expense of online training cannot be validated “those investments in training will be more likely [sic] rejected by the organization’s senior management” [4].


Fig. 2. The LiMS reporting interface

LiMS provides important justification for the budgets necessary to build dynamic courses in supportive environments. It provides a solid and multidimensional route to more effectively demonstration of ROI by coupling its analytic and interpretive capabilities to well designed interactive courseware and allow educational managers to mine the resultant intelligence. Early adopters of LiMS are working with our programmers and interface designers to enhance the presentation of behavioral data, as we continue to refine the tool.


[13] J. Campbell, "Utilizing Student Data within the Course Management System to Determine Undergraduate Student Academic Success: An Exploratory Study," PhD, Purdue University, Indiana, USA, 2007.


