SNAPP: A Bird's-Eye View of Temporal Participant Interaction

AneeshaBakharia
Centre for Educational Innovation
and Technology, University of Queensland
Australia
aneesha.bakharia@gmail.com

Shane Dawson
Faculty of Arts, University of
British Columbia, Canada
Faculty of Education, University
of Wollongong, Australia
shane.dawson@ubc.ca

ABSTRACT
The Social Networks Adapting Pedagogical Practice (SNAPP) tool was developed to provide instructors with the capacity to visualise the evolution of participant relationships within discussions forums. Providing forum facilitators with access to these forms of data visualisations and social network metrics in 'real-time', allows emergent interaction patterns to be analysed and interventions to be undertaken as required. SNAPP essentially serves as an interaction diagnostic tool that assists in bringing the affordances of 'real-time' social network analysis to fruition. This paper details the functional features included in SNAPP 2.0 and how they relate to learning activity intent and participant monitoring. SNAPP 2.0 includes the ability to view the evolution of participant interaction over time and annotate key events that occur along this timeline. This feature is useful in terms of monitoring network evolution and evaluating the impact of intervention strategies on student engagement and connectivity. SNAPP currently supports discussion forums found in popular commercial and open source Learning Management Systems (LMS) such as Blackboard, Desire2Learn and Moodle and works in both Internet Explorer and Firefox.

Categories and Subject Descriptors
H.3.4 [**Social Networking**]: Social network analysis.

General Terms
Social network analysis, analytics, network learning, learning management system, graph theory, visualisation, computer supported collaborative learning, evaluation, discussion forum.

Keywords
Learning Analytics, Inferring social networks.

1. INTRODUCTION
Socio-constructivist theorists advocate for the use of collaborative learning activities as a process for promoting student understanding. Although traditionally, collaborative learning activities were conducted in on-campus settings, there has been an increasing shift for these practices to be facilitated through the online context. This has been driven, in part, by increasing student diversity and a demand for greater course flexibility. As such, the adoption of online learning activities for both on and off campus instruction is now commonplace within contemporary education practice.

At many universities the Learning Management System (LMS) is seen as the primary vehicle for enabling online collaborative learning activities. Commercial and open source LMS such as Blackboard, Desire2Learn, Sakai and Moodle are generally centrally run systems that are made available to faculty. Despite the vast array of pedagogical benefits these technologies bring, teachers frequently note that the online environment lacks the student learning cues that are readily obtained in more traditional modes of education delivery (face to face). For instance, the classroom cues that assist teachers in identifying which students require support, are actively engaged or have cognitively "checked out" of the learning activities. These types of formative feedback mechanisms are critical for instructors to better adapt the flow, language, and structure of the lesson in 'real-time' to maintain engagement and better promote understanding. While there exists a vast array of learning cues in the LMS and other integrated student online systems, there is a disconnect between the student tracking and reporting processes and subsequent instructor pedagogical interpretations.

Instructors and tutors require the ability to gauge student activity and interaction so that they are able to better optimize and adapt the learning activities that take place within the online collaborative learning environment. However, current versions of LMS tend to only contain basic interaction statistics such as the number of times a page was viewed, or the number of messages posted or read. These forms of basic content access statistics do not provide the necessary evidence of learner participation and engagement within the learning network. Thus, there are minimal informed opportunities for instructors to identify students requiring learning support, at risk of attrition, or dis-engaged from the learning network. The development of rich student participation and interaction data married with effective and easily interpretable visualization processes, are critical to aid online instructors in their teaching tasks. In this context, Social Network Analysis (SNA) provides a framework for merging both complex group and individual data sets with easily interpretable visual representations.

Numerous case studies have demonstrated the value of SNA as a means to assess participant interaction within online learning environments. For instance, case studies conducted by De Laat and Aviv et al., used SNA to address research questions related to the level of participant activity, identification of central participants and network density. SNA has also been used to assist instructors in identifying isolated students , provide evidence of group cohesion and creativity . While there has been increasing

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applications of SNA for educational purposes, the full potential of SNA for providing ‘‘real-time’’ data remain largely un-realised. This is especially pertinent for online collaborative learning environments .

The importance for providing instructors with ‘‘real-time’’ data related to relationship establishment is critical to inform instructors of any necessary modifications to activities to better scaffold learning content and promote diversity of engagement. There is strong evidence to suggest that within well-structured activities, knowledge construction processes reach higher levels of critical thinking and that students are able to establish and sustain cohesive groups. This evidence serves to substantiate the need for automated SNA tools that are able to deliver ‘‘real-time’’ analytics for tutors and instructors.

The Social Networks Adapting Pedagogical Practice (SNAPP) tool aims to deliver ‘real-time’ social network analysis and visualisation within LMS discussion forums. The discussion forum is one of the most frequently used collaborative tools within an LMS. The manner in which forum threads are displayed however, makes it difficult for instructors to perceive conversation dynamics, and determine whether participants are actively engaged or merely peripheral on-lookers. The first version of SNAPP released in 2008 extracted post-reply data from forum threads, inferred relationships and allowed the SNA data to be exported for further analysis in tools such as NetDraw. During this time, many instructors that used SNAPP were found to import the SNA data into NetDraw for the purpose of scaling nodes and edges according to post and interaction frequency for display on a sociogram. SNAPP proved useful but numerous technical steps were also involved in the export and import of data. In 2009, the Australian Learning and Teaching Council (ALTC) funded a research grant to further research and develop SNAPP for the higher education context. This lead to the development of SNAPP 1.5 which embedded an interactive sociogram within an LMS based discussion forum. SNAPP 1.5 however, only stored the aggregate of interactions between participants up to the date the analysis was performed. During trials of SNAPP 1.5, one of the key features that instructors requested was the ability to filter the social graph by date. SNAPP 2.0 includes the ability to display animations of network evolution. This is achieved by storing the date of each participant’s interaction. The interactive sociogram serves as an alternate representation of the threaded forum that provides insight into participant interaction, emerging patterns and network density. The SNAPP interface is illustrated in Figure 1. SNAPP includes controls that allow the user to interactively filter the sociogram visualisation by date and relationship strength. Node size and edge widths can also be scaled according to post frequency and relationship strength accordingly. The Java Universal Network Framework (Jung) library is used to render the sociograms.

2. IMPLEMENTING SNAPP AS A CLIENT-SIDE BROWSER EXTENSION

There are a diverse set of challenges confronting the development of any analytic solutions for learning and teaching practice. For instance, ensuring that any technical solution is cross-platform, cross browser and compatible with the myriad of LMS available. The LMS landscape comprises both commercial vendors such as Blackboard (including WebCT) and Desire2Learn and open source products such as Moodle and Sakai. Unfortunately, to date there is no common server-side development platform in existence that affords any extensions to target all systems uniformly. The introduction of the Learning Tools Interoperability (LTI) standards may begin to address this issue. However, LTI adoption among vendors and developers is still in its infancy. Presently, each LMS has their own Application Programmable Interface (API), extension framework and is developed in a specific programming language. As the initial version of SNAPP was required to extract social network data for comparative analyses across multiple universities, each using a different mandated LMS, cross-LMS integration was a critical feature to address.

Although, the various LMS extension frameworks allow for new tools to be added, they do not necessarily provide for existing LMS tools to be enhanced. For instance, developing enhancements for LMS based discussion forums or synchronous chat. As a result, developers will often focus on providing an extension in lieu of a direct code modification. Although, this context may differ for the Open Source LMS, there are disadvantages to any code modification in terms of the ability to upgrade to later versions. Thus, a unique feature of SNAPP is the manner in which it seamlessly integrates with the discussion forum and provides the user with interactive sociograms as a visual representation of the student interactions and group dynamics emerging from the implemented learning activities. Without this direct discussion forum tool enhancement, SNAPP’s usefulness as an embedded ‘real-time’ diagnostic tool would be lost.

The SNAPP design team sought to address these development challenges by using client-side browser based techniques. The bookmarklet technique was chosen because it worked in multiple Web browsers, enabled forum data extraction from multiple LMS and allowed the sociogram visualisation to be embedded directly within a forum. Other client-side techniques include native browser extensions and GreaseMonkey userscripts. Both of these techniques however, require administrator access for installation – a privilege not afforded to all academics at universities that mandate the use of a Standard Operating Environment (SOE). Bookmarklet installation merely requires a link to be dragged on to a toolbar (Firefox) or added to a favourites list (Internet Explorer). Thus, the use of the bookmarklet for dissemination, and adoption is not limited or impeded by end-user IT related permissions.

3. FORUM DATA EXTRACTION

SNAPP infers participant relationships from the post-reply data. Discussion forum threads are stored in a database table with each row containing all of the information related to a single participant post. The post title, description, author and date are stored in the database. If the post is not the commencement point of a thread, a reference back to the parent thread in the form of a unique identifier is also stored. Forum posts are essentially stored in this hierarchical manner so that the parent-child relationship between posts and replies can be captured and displayed visually as a threaded tree of messages. Retrieving this information directly from a database using a series of SQL queries is a routine task. However, at the time of SNAPP’s conceptualization, not all LMS vendors made available the captured student interaction data via an API or Web service. However, all LMS do display the required network interaction data when a forum is displayed as a threaded tree with indents inserted to structure the hierarchy of posts and replies. SNAPP uses the Javascript client-side scripting language to retrieve the post-reply data from the threaded tree view of the forum. SNAPP uses the attributes of each post, including the author and date, to produce sociogram and social network metrics within any specified timeframe.

The sociogram produced is in fact an alternate visual representation of the activity in a forum. The threaded forum tree view, displays interaction in chronological order but it is difficult for instructors to rapidly gauge the strength and diversity of the relationships evolving between participants. Recent research involving SNAPP indicates that the use of visualisations such as sociograms provides an easily interpretable interface for instructors . These additional pedagogical insights were previously, neither easily obtained nor obvious from the discussion forum view or student data tracking tables. The sociogram is not a replacement for the threaded tree view. SNAPP is a complementary tool that further aids the analysis and interpretation of the captured interactions and observed social patterns.

4. MAPPING SNAPP FEATURES TO PEDAGOGICAL INTENT

Although the current suite of LMS include student tracking data, business intelligence or learning analytics functionality, the captured and reported data are often presented to instructors in a complex format that is isolated from the specific learning context. The poor reporting and visualization techniques associated with current LMS has resulted in minimal uptake of the included tracking and reporting tools . Broadly speaking, the available analytical tools are most likely to be used by University Administrators seeking information related to adoption rates for return on investment analyses or institutional technology reviews. The translation of interaction data from analysis to informed pedagogical action is for the vast majority of teaching faculty, a complex and potentially labour intensive process . The following sections illustrate how SNAPP attempts to reveal the underlying pedagogical response and action to observed patterns of behaviour evolving from the student interactions.

4.1 Identification of Isolated and Highly Interactive Participants

There is an observed correlation between an individual's connectivity to peers and their overall academic success. As numerous commentators have previously noted, in the world of online learning, attrition rates are frequently reported as higher than their on-campus counterparts. This has in part, been attributed to a lack of connectivity that is both social and academic, with fellow learners and the institution. Thus, any aids that can be afforded to forum facilitators to more accurately identify students that have not connected or have dis-engaged with the learning network early in their academic study, may assist with addressing concerns related to online attrition.

SNAPP has been developed to provide forum facilitators with rapid and easy identification of a participant's overall level of engagement with the student learning network. In this instance, early identification can provide an opportunity for instructors to intervene before students become disenfranchised with the learning process. Isolated students in SNAPP appear as nodes with no connections. This indicates that the participant has submitted a post but no other participants have responded. It can be difficult to identify participants at either end of the interaction spectrum on sociograms especially if the forum contains a large number of users. SNAPP therefore, provides the capacity for users to filter nodes based upon the number of posts. Filtering removes nodes above or below a threshold value. Filtering nodes above a threshold value reveals the participants that are central to a discussion. SNAPP scales nodes based upon the number of posts made by a participant. Connections between nodes are also weighted according to the number posts and replies made between the participants. The reciprocal directionality of the interaction can also be interrogated by passing a mouse over a connection.

4.2 Identification of Patterns and Structural Holes

SNAPP includes various graph layout algorithms to help users discover and interpret emerging network structures. The Fruchterman-Reingold, Kamada-Kawai, Spring and Circle layout algorithms are included to assist with the detection of network patterns for alignment with the teaching intent. For instance, the facilitator-centric pattern arises when there are direct interactions between individual students and facilitator with minimal student to student activity (Figure 1). This pattern has a distinctive star shape and would commonly occur in an FAQ style forum, where the facilitator directly responds to student queries. However, if the intent of the forum is to promote knowledge sharing and construction among participants, then the emergence of the facilitator-centric pattern would be interpreted as undesirable. Identification of this pattern early in the course provides an opportunity for facilitators to introduce alternate learning interventions and then monitor any changes in network composition.

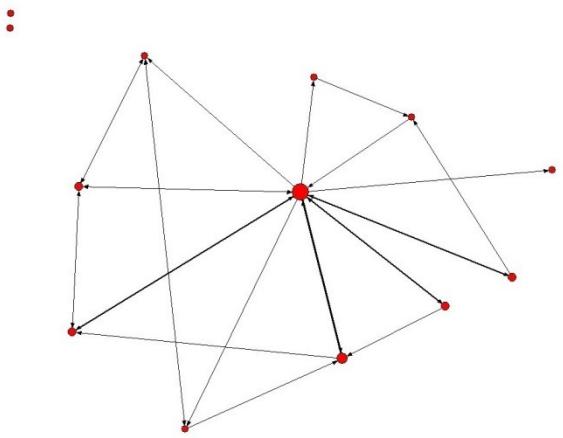

Figure 1. Facilitator centric pattern (Actor names removed).

The presence of structural holes within a network indicates the development of actor sub-groups or cliques. The development of sub-groups may indicate strong bonding among a core set of students. However, the formation of these strong cliques can be to the detriment of other actors attempting to engage. The formation of these groups can also limit the diversity of engagement with peers. For instance, Dawson observed that in large class forums students will form cliques based on perceived academic potential. In essence, high performing students flocked to other high performers to the exclusion of all other potential participants. In these situations, an effective strategy may include assigning participants to new groups and establishing additional group specific discussion forums. Another strategy is to encourage participants to interact across multiple cliques (i.e. bridge structural holes) to foster intergroup idea sharing.

4.3 Ego Network Exploration

A sociogram provides a visual representation of the relational interconnectivity across the entire network and highlights where dense, reciprocal and transitive connections exist. Within large participant cohorts it becomes difficult to gauge the relationship strength and reciprocality at an individual level by looking the sociogram as a whole. As much as Instructors require the capacity to view the entire social network, they also require the ability to analyse the social structures that surround a participant. This is commonly referred to as ego network analysis. An ego network consists of the selected actor and includes all other actors directly linked and their associated relationships with other connected participants. SNAPP incorporates functionality to aid with the exploration of ego networks. Clicking on a participants' node in SNAPP highlights all of the nodes that comprise the immediate ego network (Figure 2).

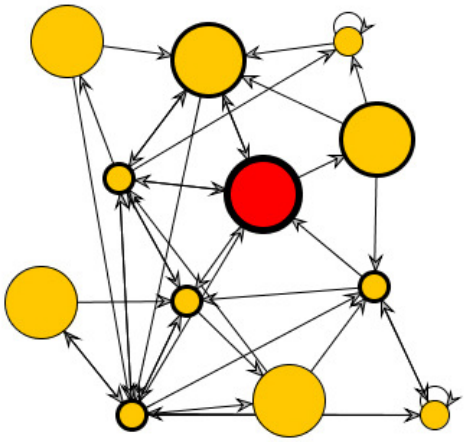

Figure 2. Ego-network illustrating highlighted nodes (Actor names removed).

Ego networks with several strong ties are often considered to be homophilous in nature. In these instances, actors with strong relationship ties frequently share common attributes or interests. While strong ties promote a sense of community they can also reduce the degree of diversity an individual is exposed to. In certain educational contexts (collaborative learning), the development of a heterogenous network is more in line with the overall pedagogical intent. Heterogeneous networks tend to promote a greater number of weak ties and therefore increased access to knowledge and resources. Weak ties are shown to introduce novel knowledge into the network while participants that share strong ties usually have access to the same information . Thus, it can be viewed as advantageous to embed specific learning activities that directly foster interaction between participants from different discipline areas and groups e.g. medical, dental and nursing students enrolled in a mandatory clinical ethics course, to promote the development of weak ties.

Ego network analysis also provides an effective means to evaluate the role an instructor or tutor plays in a network. A sociogram is able to reveal whether an instructor or tutor is central or peripheral to the network, but with ego analysis the types of students that an instructor or tutor interacts with is able to be evaluated. In a study conducted by Dawson, tutors primarily interacted with high performing students despite isolated and low performing students making several unrequited posts. It is common for facilitators to be a necessarily central and dominate actor in the network at the start of a course to establish relationships and promote communication exchanges. However, as the course unfolds the facilitator will gradually move to the periphery of the network to play a more mediating role.

4.4 Monitoring Network Evolution and Discussion Continuity

In the first release of SNAPP, post-reply relationships between participants were aggregated with no date information stored. This limited the sociogram to be a representation of the network, at the last time participants were active in the forum. The temporal nature of interaction was therefore lost. In SNAPP 2.0, individual post-reply interactions are stored with their relevant date and time stamps. In terms of functionality this means that users can filter activity by date and view the resulting visualisation and social network metrics at a specified point in time. An animated view of network evolution is also incorporated to allow for the identification of events leading to the emergence of an interaction pattern. All of the available graph layout algorithms can be applied during the playback of network evolution to aid with the discovery of patterns.

The storage of temporal interaction data also enables the analysis of forum activity over time. Post frequency distribution over the duration of forum activity can be plotted to a graph. This assists facilitators in identifying periods of increased forum activity and in determining the events (e.g. examination period) and interventions responsible for triggering the activity.

SNAPP has been developed to aid with the analysis and interpretation of interaction patterns as a course progresses and class relationships and interactions form. For example, SNAPP can be triggered at any time to display a visualisation of current participant interaction – based on these early analyses alternate interventions can be designed to engineer more pedagogically desirable user engagement activity. SNAPP promotes the use of SNA as a 'real-time' diagnostic tool providing instructors with the insight they require to moderate a forum effectively. Included in SNAPP 2.0 is the ability for instructors to document intervention strategies using the annotations functionality. Annotations are textual descriptions that are stored with a date and time stamp. These annotations are potentially useful for instructors when for reflecting on the impact of implemented moderation strategies.

4.5 Evaluating and Comparing Multiple Forums

Multiple forums are often used over the duration of a course to address a variety of learning objectives. Individual forums are set up to cover different topics and cater for diverse learning needs. Forums may also be setup to encourage online collaboration within groups where access to the forum is restricted to group members. SNAPP is able to conduct analyses across multiple forums as well as individual forums. Viewing the resulting social network visualisation of all activity over the duration of the course provides a high level indication of the network depth, relationship strength and also allows for the identification of central and peripheral participants. The position of instructors and tutors within the resulting network pattern is also crucial to the evaluation. These forms of analyses address questions relating to the interaction characteristics of the facilitators (e.g. a central or peripheral role). Additionally, the analysis of multiple forums provides an indication of which moderation techniques were successful and how these techniques can be improved.

The analysis of where and how students interact in various class forums can reveal much about an individual's motivations and learning preferences. For example, Dawson, et al., observed that students were predisposed to contribute to either learning or administrative focused forums depending on their individual learning disposition. Additionally, in terms of class, and small group work contributions, Marcos-Garcfa et al., compared student interaction within generic whole of class forums and small group specific forums. The authors noted that while a sub-set of students were able to make significant contributions at the class level, they failed to initiate any interaction within the small group work forum. In these cases the students' interactions in the small group work forums were limited as a result of personality conflicts and general dissent. The capacity to monitor both individual and multiple forums provides instructors with a more holistic picture of both the broader class structures and individual student learning.

4.6 Future Directions and Conclusion

Although, SNAPP provides a valuable analytical resource, there remain numerous areas for further development and expansion. SNAPP currently performs social network analysis and produces easily interpreted visualisations of discussion forum activity. However, learning activity design is not an isolated process. The online and offline learning design process involves the integration and coordination of multiple tools both collaborative and individual (for example, assessment, synchronous discussions, academic literacy). In recent years commercial and open source Learning Management Systems have begun to introduce additional tools such as blogs and wiki's either as native applications or extensions. Future releases of SNAPP require the ability to perform analysis within these additional applications as well as across the broad range of collaborative tools that are used within an online learning activity. The future development of learning analytic applications broadly should be guided by an imperative to aggregate from diverse data sets. For instance SNAPP will commence the incorporation of algorithms that are able to infer social relationships originating from blog commenting as well as the knowledge co-construction that occurs within collaborative editing environments such as a wiki.

In addition to social network analysis and visualisation, SNAPP also provides basic metrics of individual participation in the form of the number of posts submitted. Connection strength is currently an aggregate of the number of times participants have actively responded to each other. Passive participation also occurs within a discussion forum where participants read or browse messages but don't respond. The incorporation of passive activity will allow lurkers to be identified and help instructors to compare active and passive participation. Passive participation within forums is not currently tracked within many LMS. There is however scope to implement such tracking within open source systems, Moodle being a prime candidate. SNAPP does not analyse message content and as a result neglects to incorporate references made to other participants within text. The use of computational linguistic techniques such as Named Entity and Anaphoric Resolution need to be incorporated to further improve the accuracy of the inferred social structure.

Due to the complex nature of interactions that occur within collaborative learning environments there is a need for implementing multiple learning evaluation techniques . In this context, there have been numerous frameworks proposed for evaluating computer supported collaborative learning. In particular, Weinberger, et. al, described a multi-dimensional framework involving - participation, epistemic, argumentative and social mode dimensions. While SNAPP produces visualisations and metrics to assist with the evaluation within the participation and social mode dimensions, it presently lacks analytics specific to the epistemic and argumentative dimensions. These later elements can only begin to be addressed through content analysis. In essence, evaluations of the perceived 'quality' of the discussion are frequently overlooked as a result of the labour intensive nature of the process. It is therefore important for automated content analysis techniques to be incorporated within learning analytic tools. The merging of SNA techniques with automated content analysis will provide instructors with a more complete assessment of the individual and group dynamics evolving from the implemented learning design.

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