World Academy of Science, Engineering and Technology
International Journal of Educational and Pedagogical Sciences
Vol:13, No:8, 2019

Interactive Effects in Blended Learning Mode: Exploring Hybrid Data Sources and Iterative Linkages

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***Abstract*—**This paper presents an approach for identifying interactive effects using Network Science (NS) supported by Social Network Analysis (SNA) techniques. Based on general observations that learning processes and behaviors are shaped by the social relationships and influenced by learning environment, the central idea was to understand both the human and non-human interactive effects for a blended learning mode of delivery of computer science modules. Important findings include (a) the importance of non-human nodes to influence the centrality and transfer; (b) the degree of non-human and human connectivity impacts learning. This project reveals that the NS pattern and connectivity as measured by node relationships offer alternative approach for hypothesis generation and design of qualitative data collection. An iterative process further reinforces the analysis, whereas the experimental simulation option itself is an interesting alternative option, a hybrid combination of both experimental simulation and qualitative data collection presents itself as a promising and viable means to study complex scenario such as blended learning delivery mode. The primary value of this paper lies in the design of the approach for studying interactive effects of human (social nodes) and non-human (learning/study environment, Information and Communication Technologies (ICT) infrastructures nodes) components. In conclusion, this project adds to the understanding and the use of SNA to model and study interactive effects in blended social learning

***Keywords*—**Blended learning, network science, social learning, social network analysis, study environment.

I. Introduction

A move towards blended teaching and learning (TNL) is not an option [1]. In the wake of better telecommunication infrastructure (such as 5G) [2] offering better bandwidth, services and mobile applications, the traditional mode of TNL has to evolve to enable educators and learners to benefit from these advances. As in all new environments, the move towards blended TNL is a non-trivial move and demands a careful approach towards the shift. In short, new artefacts in new ICT environment continue to impact the process of TNL and warrants careful investigations.

While there are significant researches into this area [3] – [5], what are not well addressed are the social aspects of learning and the social impacts of computing/information technologies such as popular social media, interactive chat applications and powerful search engines and their interactive effects on TNL activities and processes. An early research [6] has revealed the importance of the social presence model for TNL. Likewise, in the educational discipline, researchers in [4] have recognized that learning is more than an individual activity. Reference [7] underscored the importance of social presence to account for the influences of social networks and relationships. This suggests that in the new blended TNL approach, there is a strong need to better understand the interactive effects as well as the externalities of social learning. Current and future reform efforts must be towards a holistic understanding of blended learning. These efforts press for greater understanding of the TNL processes. On the one end, efforts are geared towards better understanding of teaching processes; on the other end constructive advances are made to improve learning.

The rest of the paper is structured as follows: Section II provides an overview of essential related terms and works; Section III outlines the TNL/environment framework. Based on the framework, Section IV highlights the project methodology, and Section V presents the results and discussion. Section VI summarizes the concluding remarks and future works.

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II. Related Terms and Works

Interactions are commonly encouraged in all forms of TNL. Generally, the need for interactions, usually viewed as a process of sharing, urging and encouragement in the construct of knowledge as part of the overall learning process is well accepted [8]. However, this idea of "interactions" differs from the term and concept of "interactive effects". Hence, in this section and applicable for this paper, we will address some key conceptual elements and outline selected related works to avoid concept misunderstanding and for easy references.

A. Interactions in TNL

Interactions in TNL by common traditions, refers to an action process. Here, one agent interacts with another, usually also another agent of the same genre. The outcome of the interactions give rise to some desired goals. For example, in the case of Teacher-peer interactions [9], when such interactions take place, communication and exchanges are the likely end-results. It is noticed in the past that interactions were commonly accepted to be with a "human" agent. Of late, we are seeing interactions with virtual objects, where one (human) agent would interact with a non-human agent (such as AI agent, smart tutor or simply a chatbot). This offers an interesting and challenging perspective that "interactions" is evolving towards both human and non-human agents, and

efforts should be made to cater to such human and non-human entities. Some of the newer research works [10], [11] reflect this trend.

B. Interactive Effects in NS

NS is a discipline that addresses and studies the importance of networked relationships, linkages and interdependence. Recent NS thinking has informed us of the many networked phenomena not well noticed in real-world scenarios, to the point that after twenty years of NS, it was acknowledged that NS has "...deep implications for our understanding of dynamic behaviour and phase transitions in real-world phenomena ranging from contagion processes to information diffusion..." [12]. The term and concept of "interactive effects" derives from NS to mean the influences of one node on the another based on a set of linkages or relationships. Some of the works in this field are related to study of interactive effects on metacognitive activities [13], formative assessment and instructional quality [14], and 3D virtual environment and VR learning [15]-[17]. What can be seen from these studies is a trend towards understanding the environment and the non-human agents contained therein. In our project, we underscore the importance of understanding the non-human study environment and entities that will eventually support the overall TNL processes. We term this as the social interactive effects on human agents of TNL.

C. SNA

Early SNA focused on simple networks and relationships. Examples of these studies include friendship, business, and disease networks. Moving up the SNA focus, is a perspective of NS. Today, NS has moved on from basic analysis of nodes, relationships and linkages towards newer fields such as data mining and analysis of feature-rich networks [18]. While newer research informs better approaches towards dealing with heterogeneous data sources, multiple levels and allow for greater mining of feature-rich information, the basis of modeling with SNA essentially remains as per early studies. Here, suitable formulation and mapping of nodes and node linkages are developed based on observed (collected survey) or generated hypothesis and experimental simulation and computations are conducted. The results are then displayed as suitable network configurations for further analysis.

D. Blended Learning (BL)

BL is not an easy concept to define. Over the last decade, we find various perspectives on the definition, all aimed at trying to unpack a complex process. For purposes of this paper, we adopt the central idea that BL is a process that integrates TNL approaches (formal, informal, face-to-face, online), directed path or self-discovery, digital and non-digital connections towards a set of individual or enterprise goals. BL seen from this perspective is intentionally broad and wide in scope to allow and to include the element of social influences of learning from human and non-human (technology) counterparts.

III. TNL Framework

The TNL framework adopted in this paper begins with some basic assumptions. First, this project focuses strictly on "planned learning". As we all are aware, learners can and will learn about many things in many different circumstances and situations. For purposes of this study, a planned learning framework is assumed. Planned learning implies the contents is delivered and taught in an educational setting. While it is true that even in such an environment, a learner can still learn about "unplanned-for" learnings, it is the planned learning that this paper is focused on. Secondly, an assumption is made about the basic information technology (IT) literacy of learners. Here, it is assumed that learners understand basic IT concepts and can use computers and laptops. Hence, this study is better suited for higher education scenario than learning by very young learners. Finally, we understand that TNL is a non-static process; however, for purposes of this project, we simplify the case to one of static cut in a continuous and dynamic TNL process, that is, we adopted a simplified perspective on the complex TNL process.

The basic simplified TNL framework comprises three components or pillars. The first pillar is content-based perspective, the second pillar is mode of delivery and the last pillar is an opportunity for learning reinforcement process. This cyclic framework is shown in Fig. 1. The learning environment is believed to be embedded in all the three pillars.

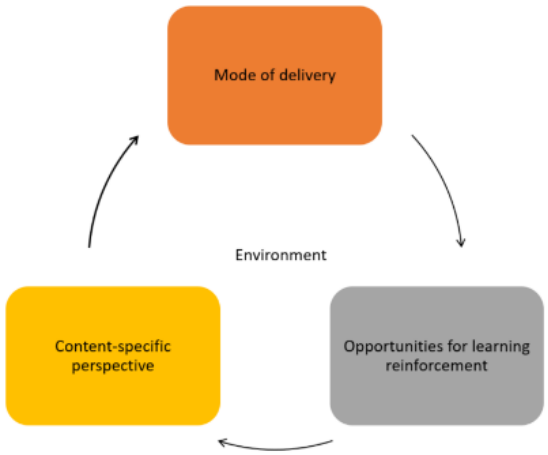

Fig. 1 Cyclic nature of TNL framwork that embedds the environment

IV. Project Methodology

Hybrid research methods were applied, for data collection, qualitative approach is used that involves interviews and focused groups and for experimental simulation and computational analysis, SNA techniques were applied.

Unlike other SNA that looks only at the human nodes (or social aspects), this project extends the work towards NS that allowed the inclusion of non-human nodes where non-human nodes are modelled as learning/study environment and required ICT infrastructures. As such, this project includes two sources: (1) a control data source that includes analytical qualitative data collection and analysis from a set of actual

learners, related study environment and computer science course delivered in a blended mode setting and (2) an experimental data source based on computational modelling, simulation, experimentation and visualization.

A. Qualitative Data Collection

A qualitative data collection design collects data on the perceptions of agents of TNL on the BL mode of delivery of computer science modules. The descriptive statistics of this phase is presented in the Fig 2. A total of 32 participants were interviews as well as two focus groups were conducted. From the interviews and focus groups, both 1-mode and 2-mode adjacency matrix were built. 1-mode adjacency matrix is a square matrix that addresses linkages of participants as network nodes while the 2-mode adjacency matrix addresses each TNL agent with the environment.

Fig. 2 Four teachers and 30 students were selected

However, only three teachers were available and only 29 students' responses were usable, giving a total of 32 responses.

B. Experimental Network Modelling

With the collected data, the second phase of the project is the building of the network. The following schema is used for the encoding:

1 = do not know the other (environment or agent);
2 = heard about but did not take notice
3 = have taken up the suggestion / advice on the environment
4 = advisor / friend

Agents of TNL and non-human nodes have links that are weighted. The values of these weights are simulated as part of the three simulated environment scenarios, namely, rich environment, average environment and poor environment. The networks are then generated and visualized to help improve the interview directions and discussions of the focused groups.

V. Results & Discussions

Based on observed and simulation runs, two core findings are of values: Firstly, the presence of possible range of environment that impacts TNL and secondly, the non-static nature of these networks. The networks' visualizations are shown in Fig. 3.

From the experimental computational simulation, we went back to the interviews and focused group discussions to refine the data collection effort. The second round of data collection allowed transcription of data and allow for thematic data analysis and synthesis. The categories of data that surfaced from the second and sequent rounds are shown in Table I.

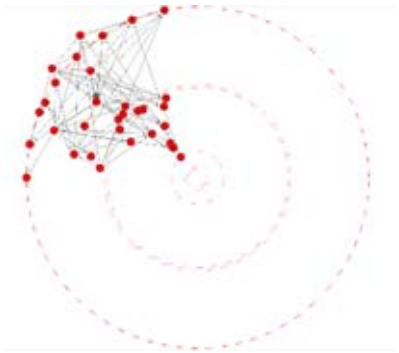

Fig. 3 (a) 2-mode (educator/learner-environment) network

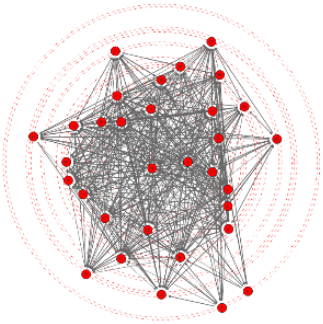

Fig. 3 (b) Normal 1-mode (educator / learners) network

TABLE I
Tabulated Data Categories and Selected Sample View

S/No	Environment Type(s)	Selected Sample Views
1	Distracted	"I sometimes can't concentrate in my study space" student 5
2	Dedicated	"I am most happy when I can find the space that I needed for my BL class" teacher 3
3	Disengaged	"After a while, I find that it is hard to remain focused" student 18
4	Disrupted	"Some things can be disruptive, for example, mum vacuuming the other room while I am online" student 3
5	Involved	"I am good, I like this time where I can cut off other things in my mind and concentrate on the task" teacher 1
6	Isolated	"I feel disconnected and alone" student 9
7	Reinforced	"The space is helpful to calm me down" student 21
8	Shared	"I like it when I can share and chat with friends when needed" student 17

The analysis of the categories of results suggests the following:

A. Positive and Negative Impacts

Environment itself can exhibits both positive and negative impacts. What is also interesting is that it can be non-static and can varies from agent to agent. We have just touched the tip of the environment pointer. This finding will pave the way for deeper search and understanding of both human and non-human interactive effects as well as other externalities.

Positive and negative impacts can be better viewed if we organized the results into data-pair as in:

Isolated/Dedicated: While dedicated space is a premium, not all agents of TNL may have the given required amount of space and environment. In addition, within a dedicated study space, some learners may start to drift and become isolated from the TNL process. We believe that there may be cultural elements involved in this data pair.

Distracted/Shared: Distraction or engagement can happen. This is true for both BL and for traditional f2f. Overcoming this environmental concern would help to improve the BL experience.

Disrupted/Reinforced: Will disruption be a non-recoverable process or are there options to introduced reinforced learning. The key to this could be a better way to handle environmental signals and cues.

Disengaged/Involved: This is the traditional concern of many TNL agents. The influenced of environment appears to increase disengagement for some and allow for more involvement for others.

B. Implications for BL

The second round of iterative data collection serves to introduce more questions than providing answers. What we can take away from this project are:

BL is situated. Unless and until a wholistic view of BL is put in place, trying to improve the contents or juggling the mode of delivery itself will not help much. There is a need to view the environment within each of the three simplified pillars of TNL framework.

BL process needs to be organized. Just as TNL agents specified the basic requirements of IT resources for each course, perhaps, there may be a need to address the spatial and environmental resources. We cannot continue to assume that agents of TNL have the space and environment needed. In most cases, educators will have the resources, but the same cannot be applied to learners. We should not assume that every learner has a quality learning space and environment.

In short, interactive effects can bring about other factors and externalities, for example, from good concentration for learning to periods of demotivation. Such interactive effects and externalities are non-trivial Ignoring these interactive environmental effects and externalities will impact BL process.

C. Iterative Support of Data Sources

The interactive phase of data collection, experimental computational simulation and data refinement helped to bring out richer data analysis and synthesis. As a result of such iterative support, the project is well suited for the investigation of complex process such as BL

D. Design of Dual Research Approaches

The use of SNA facilitates the application of a hybrid or dual design as research approach. While we recognized that not all project domains allow such dual design, where possible, dual design helps in strengthen the analysis stage. A clear limitation is the need for more allocation of project resources.

VI. Concluding Remarks and Future Works

Educators and learners, core agents of TNL, are linked by relationship and networks. For example, educators' network could include mentors, peers, quality assurance members and other administrative team-mates. Such a network contributes towards greater resource sharing and facilitates teaching and assessment activities' design and implementation. Learners' network similarly can be composed of peers, educators, external resources and other administrative agencies. NS and research show that interactive effects exist as well as influences of positive and negative externalities. The strength of these effects and influences, if suitably identified, could help to shed more light on effective TNL processes, activities and assessment design.

The scope and theoretical foundation of TNL is evolving and with new approaches and environment, it is necessary to update and improve on existing theoretical frameworks and foundations. This project, its contributions and findings add to a better understanding of BL process, allowing agents of TNL to be better prepared for the evolving transition. As well-noted by the field, BL is here, it is crucial for all to get it right for the current and the next generation to come. Future works of this project will move on towards finding out answers to help better understand the impacts and externalities of environment and how they can be used to help improve the social blended learning process.

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