18th Annual

KNOWLEDGE BUILDING SUMMER INSTITUTE

Building Knowledge in an Open Informational World

August 12-15, 2014

Laval University, Quebec City, Canada

Papers

18th Annual Knowledge Building Summer Institute
Building Knowledge in an Open Informational World

August 12-15, 2014
Laval University, Quebec City, Canada

Conference Co-Organizers:
Knowledge Building International (KBI) http://ikit.org/kbi/
Institute for Knowledge Innovation and Technology (IKIT) http://ikit.org/
Technology for Advanced Collaboration Among Teachers (TACT) http://tact.ulaval.ca
Remote Networked Schools (RNS) http://eer.qc.ca

Conference Chairs:
Thérèse Laferrière & Marlene Scardamalia

KBSI 2014 Committee
Carl Bereiter, Bodong Chen, Derya Kici, Susana La Rosa, Leanne Ma,
Yoshiaki Matsusawa, Monica Resendes,
Hongyan Son, Suresh Tharuma
-Toronto IKIT Team-

Kaçandre Bourdelais, Pier-Ann Boutin, Carolyn Buteau, Stéphanie Charest,
Julien Gobeil-Proulx, Christine Hamel, Madel Jean, Assetou Kouraogo,
Pascal Martineau, Jessica Métivier, Angela Perez-Duenas, Christian Perreault,
Nidia Sanchez, Esther Simard-St-Pierre, Chantal Trepanier
-Quebec CRIRES Team-

A special thanks to the colleagues who agreed to help us with the review process:

Stephane Allaire
Stefano Cacciamani
Rosa Chen
Maria Chuy
Gianvito D'Aprile
Frank de Jong
Bruce Forrester
Ella Fu
Nobuko Fujita
Calixto Gutierrez
Christine Hamel
Anne Hill
Huang-Yao Hong
Derya Kici
Leila Lax
Eddy Lee
Iris Feng Lin
Beatrice Ligorio
Sandy McAuley
Ritsuko Oshima
Don Philip
Fleur Prinsen
Richard Reeve
Monica Resendes
Giuseppe Ritella
Nadia Sansone
Pirita Seitamaa Hakkarainen
Steven Swan
Jan van Aalst
Johnny Yuen

18th Annual Knowledge Building Summer Institute
Building Knowledge in an
Open Informational World
August 12-15, 2014
Laval University, Quebec City, Canada

Increased openness of information resources is creating vast opportunities for people to take charge of their own learning, to become creators rather than merely acquirers of knowledge, and to tackle goals and problems previously accessible only to experts. At the same time, however, more of the task of processing the information into usable knowledge falls to the user-- posing a whole new level of difficulty for those disadvantaged in terms of academic knowledge and skills. The corresponding challenge is to enable classrooms and other educational settings to function as models of an inclusive knowledge society--a society that takes maximum advantage of the new openness of information while at the same time promoting ways for everyone to find a valued and rewarding role.

Table of Contents

Étude exploratoire de la communauté de pratique des enseignants de l'École en réseau (CoPÉER)

Pier-Ann Boutin, Christine Hamel
Université Laval
Email: Pier-Ann.Boutin@fse.ulaval.ca, Christine.Hamel@fse.ulaval.ca

Introduction

Le développement professionnel des enseignants à l'heure de la société des savoirs selon la perspective sociale sur l'apprentissage est une préoccupation au cœur de nombreuses initiatives depuis quelques années (Darling-Hammond, 1997; Daele & Charlier, 2006; Kmible & Hildreth, 2008; Laferrière & Allaire, 2010, Hamel, Allaire & Turcotte, 2012), et fait notamment l'objet d'un référentiel sur les compétences des enseignants publié en 2011 par l'UNESCO. C'est dans ce contexte que différentes innovations en terme d'accompagnement et de développement professionnel des enseignants émergent. Dans le cas qui nous occupe, l'initiative de l'École en réseau (ÉER) a innové en 2011 en proposant à des enseignants expérimentés de faire partie d'une équipe d'intervention agissant auprès d'autres enseignants voulant faire l'expérience d'une pédagogie de la coélaboration de connaissance dans le cadre d'une classe en réseau.

Afin d'accompagner les enseignants-ressources dans leur propre démarche de développement professionnelle et afin de les soutenir dans le renouvellement de leur pratique d'accompagnement, l'équipe de recherche et d'intervention de l'École éloignée en réseau s'est tournée vers la communauté de pratique (Lave & Wenger, 1991). En effet, le modèle de communauté de pratique de Lave & Wenger (1991) pourrait répondre à nombreux impératifs en terme de développement professionnel, notamment en ce qui concerne l'apprentissage par la participation (Sfard,1998), la négociation, l'étayage par les pairs (Pea, 2004), la coélaboration de connaissances (Scardamalia, 2002) et l'élaboration d'un discours cohérent sur des pratiques innovantes en classe par et pour les enseignants. L'engagement des enseignants dans la communauté de pratique est alors considéré comme le point de départ, essentiel, à la négociation de sens et à l'apprentissage. Dans le cadre de leur fonction comme enseignant-ressource pour la mise en œuvre de l'ÉÉR au Québec, comment les enseignants s'engagent-ils dans le processus de négociation de sens de leur communauté de pratique sur la pédagogie de la coélaboration de connaissances en réseau dans le cadre de l'ÉER (CoPÉER)?

Contexte

L'École en réseau. L'École en réseau (ÉER) a fait ses débuts il y a plus de 10 ans dans le cadre d'une initiative gouvernementale visant le maintien des petites écoles rurales sur tout le territoire québécois. Au départ, le modèle de l'École éloignée en réseau (ÉER) visait à enrichir l'environnement éducatif des petites écoles rurales. Depuis, le modèle a évolué et est maintenant ouvert à toutes les écoles du Québec. Résultat d'un partenariat entre plusieurs commissions scolaires et le ministère de l'Éducation dont l'action est informée et documentée par une équipe de recherche et d'intervention (ÉRI), l'École en réseau s'appuie sur les plus récentes recherches en sciences de l'apprentissage qui prennent en considération les compétences attendues au 21e siècle (Trilling & Fadel, 2009) et les compétences en matière de technologie de l'information, d'ailleurs ciblées par l'UNESCO, afin d'éclairer et soutenir les pratiques en réseau des enseignants et des élèves. Aujourd'hui, toutes les écoles du Québec peuvent profiter de l'expérience de l'École en réseau qui a par ailleurs perdu son qualificatif d'éloignée pour mieux correspondre à son identité.

L'Équipe multidisciplinaire intersite. Depuis les débuts de l'ÉÉR, une équipe de recherche-intervention (ÉRI) est disponible du lundi au vendredi par le biais visioconférence afin de soutenir et d'accompagner la mise en œuvre de l'innovation dans les différentes commissions scolaires, les écoles et les classes impliquées. Cette équipe était constituée au départ de chercheurs et d'étudiants aux cycles supérieurs. Ils ont développé une ethnographie virtuelle afin de faire un suivi des activités observées en ligne de même que des activités d'intervention auprès des intervenants impliqués (Hamel, Allaire, & Turcotte, 2012). Depuis 2011, afin de tenir compte de l'expertise exceptionnelle développée par les enseignants qui mettent en œuvre l'ÉER depuis 2002 (Laferrière et al., 2008), cette équipe compte des enseignants expérimentés. Ils sont dégagés de leur tâche d'enseignement une journée par semaine afin de soutenir les acteurs de l'ÉER, notamment les enseignants de leur milieu et d'autres commissions scolaires dans la mise en œuvre d'une pédagogie de la coélaboration de connaissance en réseau. La nouvelle équipe multidisciplinaire intersite (ÉMI) compte maintenant des chercheurs, des étudiants-chercheurs et des enseignants expérimentés de l'ÉER. L'ÉMI compta d'abord trois enseignants d'expérience amenés à se déplacer dans les différents milieux qui avaient besoin de soutien et d'accompagnement. En 2013, quatre nouveaux enseignants se sont joints à l'équipe afin de soutenir davantage les milieux où la mise en œuvre de l'ÉER était en émergence. Ainsi, les trois enseignants de départ demeureraient des accompagnateurs dans les différents milieux (ÉMI nationaux) et les quatre nouveaux enseignants seraient actifs dans leur propre commission scolaire afin d'intensifier l'accompagnement et le soutien à la mise en œuvre du modèle de l'ÉER. Ces enseignants ont été choisis en fonction de leur intérêt pour ce rôle, mais ils n'avaient pas l'expertise des trois autres étant donné leur peu d'années d'expérience dans l'ÉER, notamment en ce qui concerne la pédagogie de coélaboration de connaissances.

La CoPÉER. L'équipe de recherche de l'ÉER a démarré, en 2013-2014, une communauté de pratique (CoPÉER) qui devait permettre aux enseignants ÉMI expérimentés (ÉMI nationaux) de partager leurs expériences et de négocier leur pratique quant à l'accompagnement dans les milieux (écoles et classes). Plus encore, c'est le partage et la négociation entourant l'intégration du modèle de l'ÉER en classe par les nouveaux membres qui était prioritaire puisqu'ils avaient une expertise à développer pour avoir une légitimité d'intervention. De plus, la CoPÉER voulait soutenir l'élaboration d'un discours collectif (participation) pour en arriver à mieux nommer la pratique des enseignants de l'ÉMI (réification) et sur les liens théorie-pratique dans l'appropriation de la pédagogique de la coélaboration de connaissances dans une classe en réseau. Une professionnelle de recherche et trois chercheurs ont participé aux travaux dans la communauté à titre de facilitateurs afin de soutenir le discours progressif (Benoit, 1999). Le but avoué de la CoPÉER était donc d'aider les nouveaux venus à cheminer de la périphérie vers le centre des activités de la communauté pour rendre leur participation plus légitime (Lave & Wenger, 1991).

Les outils de télécollaboration de l'ÉER, un forum de coélaboration de connaissances (*Knowledge Forum* - KF) et un système de visioconférence, ont été mis à profit afin de faciliter la collaboration des membres de la CoPÉER qui sont dans plusieurs régions éloignées du Québec. Le choix des outils a été d'autant plus facile que la plupart des membres utilisaient déjà ces outils au quotidien dans leurs activités liées à l'ÉER.

Cadre théorique

La communauté de pratique (CoP) est, pour Lave et Wenger (1991), une communauté où les membres partagent une même pratique professionnelle ou une même expertise. Les membres d'une telle communauté se regroupent de façon spontanée ou non et peuvent effectuer des apprentissages non formels intégrés aux activités de la communauté qui ne sont pas, à proprement parler, des activités d'apprentissages planifiées. C'est à travers les mécanismes sociaux de cette communauté que les participants sont en mesure de repousser l'état de leurs connaissances et faire évoluer leur pratique par la négociation de sens, à travers les processus de participation et de réification. Les participants peuvent échanger, partager et discuter en face à face ou de façon virtuelle à l'aide d'outils de télécollaboration, c'est notamment le cas pour la communauté qui nous occupe.

Les dimensions de la pratique. Selon Wenger (1998), la communauté de pratique se définit selon trois dimensions : l'engagement mutuel, l'entreprise commune et le répertoire partagé. Ainsi, les membres d'une CoP s'engagent auprès des autres participants dans une entité sociale (engagement mutuel), entreprennent un processus de négociation de sens partagé quant à leur pratique professionnelle (entreprise commune) et partagent des ressources communes développées et/ou acceptées par les membres (répertoire partagé). À travers ces dimensions, les membres sont amenés à négocier leur pratique, leurs conceptions et leurs ressources à travers la pratique réflexive collective. La négociation de sens s'opère donc à travers les différentes actions et artéfacts de la communauté.

La négociation de sens, un double processus: participation & réification. Selon Wenger (1998), les communautés de pratique offrent un contexte privilégié de négociation de sens à travers les différentes dimensions de la pratique et des processus complémentaires de participation et de réification.

La participation aux activités d'une communauté réfère au fait de faire partie de quelque chose avec d'autres, de vivre des expériences sociales, de s'engager de façon dynamique. La réification fait quant à elle référence au processus par lequel la communauté élabore des objets, concepts, artéfacts qu'elle utilise et promeut. La réification cristallise les objets de la négociation de sens en un temps donné. Cela ne signifie pas que les objets réifiés ne peuvent être renégociés par la suite. Il est donc impossible de considérer séparément les processus de participation et de réification, ils sont complémentaires, essentiels l'un à l'autre. Le processus de négociation d'une pratique partagée, intégrant participation et réification, ne suppose pas d'emblée l'harmonie des conceptions des membres, ni leur collaboration. Ainsi, la négociation de sens fait appel à la diversité des idées et des expériences afin de faire évoluer la pratique. En ce sens, c'est à travers les processus de participation à la pratique et de réification de celle-ci que les participants négocient, perpétuent et/ou transforment leur pratique partagée.

La participation périphérique légitime (Lave & Wenger, 1991). Pour les nouveaux venus, dans le cas qui nous occupe les enseignants faisant nouvellement partie de l'ÉMI, il est essentiel que l'on reconnaisse la légitimité de leur participation périphérique à la communauté. Cette participation doit pouvoir s'exercer dans les trois dimensions de la pratique, soit l'engagement mutuel, l'entreprise commune et le répertoire partagé. De plus en plus, la participation des nouveaux venus sera de moins en moins périphérique et cheminera de la périphérie vers le centre des interactions de la communauté à travers les différentes actions posées à l'intérieur de leur pratique. La « périphéricité » et la légitimité leur offriront des expériences d'apprentissages qui forgeront leur identité professionnelle à travers l'atteinte de la maitrise de la pratique partagée (contenu et outils).

La coélaboration de connaissances et ses principes. Certains rapprochements peuvent être faits entre la négociation de sens à l'intérieur d'une CoP par le biais de la participation et de la réification et la coélaboration de connaissances. Ainsi, nous entendons par coélaboration de connaissances le plus haut niveau de construction collective de sens par un groupe, dans le but de se donner et d'approfondir des connaissances collectives sur un objet (question ou problème). Scardamalia et Bereiter (2003) décrivaient la coélaboration de connaissances en ces termes : « *Knowledge building may be defined as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts* » (Scardamalia & Bereiter, 2003, p.1370). De plus, la communauté est considérée comme étant inséparable de toute élaboration d'un discours collectif, ce discours par lequel les membres non seulement participent, mais aussi s'investissent de façon cognitive dans la coélaboration de connaissances (Bereiter & Scardamalia, 2003). La communauté de coélaboration de connaissances est un système d'interactions entre apprenants axé sur des buts collectifs de coconstruction/coélaboration/création par la voie d'un processus collectif d'amélioration des idées (Zhang, Chen, Sun, & Reid, 2004; Zhang & Sun 2005).

Scardamalia (2002), et plus tard, Scardamalia et Bereiter (2003) ont élaboré douze principes afin d'identifier et de décrire les différents processus inhérents à la coélaboration de connaissances.

- Idées réelles, problèmes authentiques
- Idées perfectibles
- Diversité des idées
- Élever le propos
- L'élève un agent épistémique
- Un savoir communautaire, une responsabilité collective
- La classe un lieu de démocratisation du savoir
- Enseigner et apprendre, deux rôles complémentaires
- Omniprésence de l'approche
- Utilisation constructive de sources d'autorités
- Évaluation simultanée, ancrée et transformative
- Le discours transformatif devenu routine Ainsi, nous croyons que l'amalgame de la communauté de pratique dont l'élaboration du discours progressif se fait selon les principes de coélaboration de connaissances peut soutenir le développement professionnel des enseignants qui ont moins d'expertise dans l'ÉER. Nos questions de recherche sont donc :
- Quelles sont les traces d'engagement des enseignants dans la CoPÉER en fonction des dimensions de la pratique de Wenger (1998)?
- Comment sont liées les dimensions de la pratique avec les principes de coélaboration de connaissances ?

Méthodologie

Les processus de participation et de réification sur lesquels nous nous sommes penchés lors de cette étude concernent davantage la négociation de sens entourant les aspects théoriques et pratiques de la pédagogie de la coélaboration de connaissances dans une classe en réseau.

L'expérimentation de devis. L'expérimentation de devis dans le cadre de cette étude tire ses bases des écrits de Brown (1992) et Collins (1992) sur le *Design Experiment* et du *Design Research* de Collins, Joseph & Bielaczyc (2004). L'expérimentation de devis vise le rapprochement entre les principes théoriques sur l'enseignement et l'apprentissage en aidant à comprendre les liens qui unissent les théories de l'apprentissage, les artéfacts et la pratique enseignante (The Design-Based Research Collective, 2003). C'est dans ce cadre que nous analyserons les actions posées par les enseignants participants et les traces d'engagement dans la CoPÉER, qui est alors considéré comme un lieu d'apprentissage, de développement professionnel et de formation continue.

La collecte de données. Nous avons utilisé l'observation participante (Jaccoud & Mayer, 1997) comme procédé de recherche qualitative afin d'observer les actions posées par les enseignants, durant les moments de rencontre en visioconférences et lors de l'élaboration du discours collectif écrit. En fait, une professionnelle de recherche a assisté, en tant que facilitatrice, aux différentes activités de la CoPÉER afin de comprendre de l'intérieur les processus de participation et de réifications s'opérant entre les enseignants impliqués. Nous avons colligé les observations faites pour repérer les actions posées par les enseignants selon les principes de la coélaboration de connaissances ainsi que selon les dimensions de la pratique de Wenger afin de les illustrer à travers les actions posées par les membres dans le contexte de la CoPÉER.

Analyse

Nous nous sommes tout d'abord penchés sur les actions posées par les enseignants afin de les mettre en lien avec les les différentes composantes selon Wenger (1998).

L'engagement mutuel dans la CoPÉER. Les enseignants de la CoPÉER se sont engagés de façon dynamique à travers la participation aux différentes activités de la communauté, tant à l'écrit que lors des rencontres en visioconférence. De plus, à travers ces activités, ils ont expérimenté la diversité et la partialité lors des partages de pratiques et dans négociation de sens entourant les principes de coélaboration de connaissances en classe. De plus, une relation mutuelle s'est installée entre les membres de la CoPÉER tout au long de leur participation aux activités de la communauté de pratique et lors de la coordination de ces activités. Les enseignants étaient donc engagés mutuellement dans la réalisation des activités de la CoPÉER ainsi que dans son design.

L'entreprise commune dans la CoPÉER. L'entreprise commune des membres de la CoPÉER réside dans la négociation entourant l'appropriation des principes de la coélaboration de connaissances en classe et leur mise en œuvre dans le milieu local de chacun des participants. De plus, l'accompagnement d'autres enseignants au niveau local de la part des enseignants participants à la CoPÉER fait également partie de leur entreprise locale négociée avec les autres membres de la communauté de pratique.

Le répertoire partagé dans la CoPÉER. Le répertoire partagé par les membres de la CoPÉER a pris différentes formes. Ainsi, il concerne à la fois les écrits scientifiques soutenant le modèle de l'ÉER ainsi que la pédagogie de la coélaboration de connaissances, un guide pédagogique coélaborer par un chercheur et des enseignants expérimentés, ainsi que les écrits des enseignants concernant leur pratique sur le forum de coélaboration de connaissances qui agissent aussi comme des artéfacts conceptuels élaborés et négociés par la communauté. Aussi, le régime de responsabilités collectives des participants s'illustre dans l'élaboration et dans l'avancement d'une compréhension commune quant à la pédagogie de la coélaboration de connaissances dans une classe en réseau. La négociation quant à elle s'exprime à la fois dans l'avancement de la compréhension commune et dans les principes de la coélaboration de connaissances qui agissent comme des ressources de l'engagement mutuel.

Les outils de participation et de réification dans la CoPÉER. Parmi les outils à travers lesquels les enseignants de la CoPÉER ont été amenés à négocier le sens de leur pratique, divers procédés les ont conduits à participer au discours collectif. Ainsi, les rencontres en visioconférence leur ont permis de participer à des échanges synchrones tandis que le forum de coélaboration de connaissances leur a quant à lui permis de collaborer de façon asynchrone. En plus de permettre le travail collaboratif de façon asynchrone, le forum a permis l'élaboration d'artéfacts conceptuels, de traces écrites de l'avancement de leur compréhension collective. Les objets réifiés par la communauté comptent par exemple l'horaire de rencontres en visioconférence proposé par la professionnelle de recherche afin de provoquer des moments d'échanges des pratiques et de réflexion sur les principes de la coélaboration de connaissances. De plus, un guide pédagogique, sur le modèle de l'École éloignée en réseau, a été élaboré en collaboration avec un chercheur associé à l'initiative de l'ÉER et les trois enseignants expérimentés faisant maintenant partie de l'ÉMI. Ce guide est devenu par la suite un artéfact réifié de la communauté et un document ressource pour les nouveaux membres. Le guide se veut un point de départ pour les participants de la CoPÉER d'où ils peuvent renégocier leur compréhension de la pédagogie de la coélaboration de connaissances dans une classe en réseau.

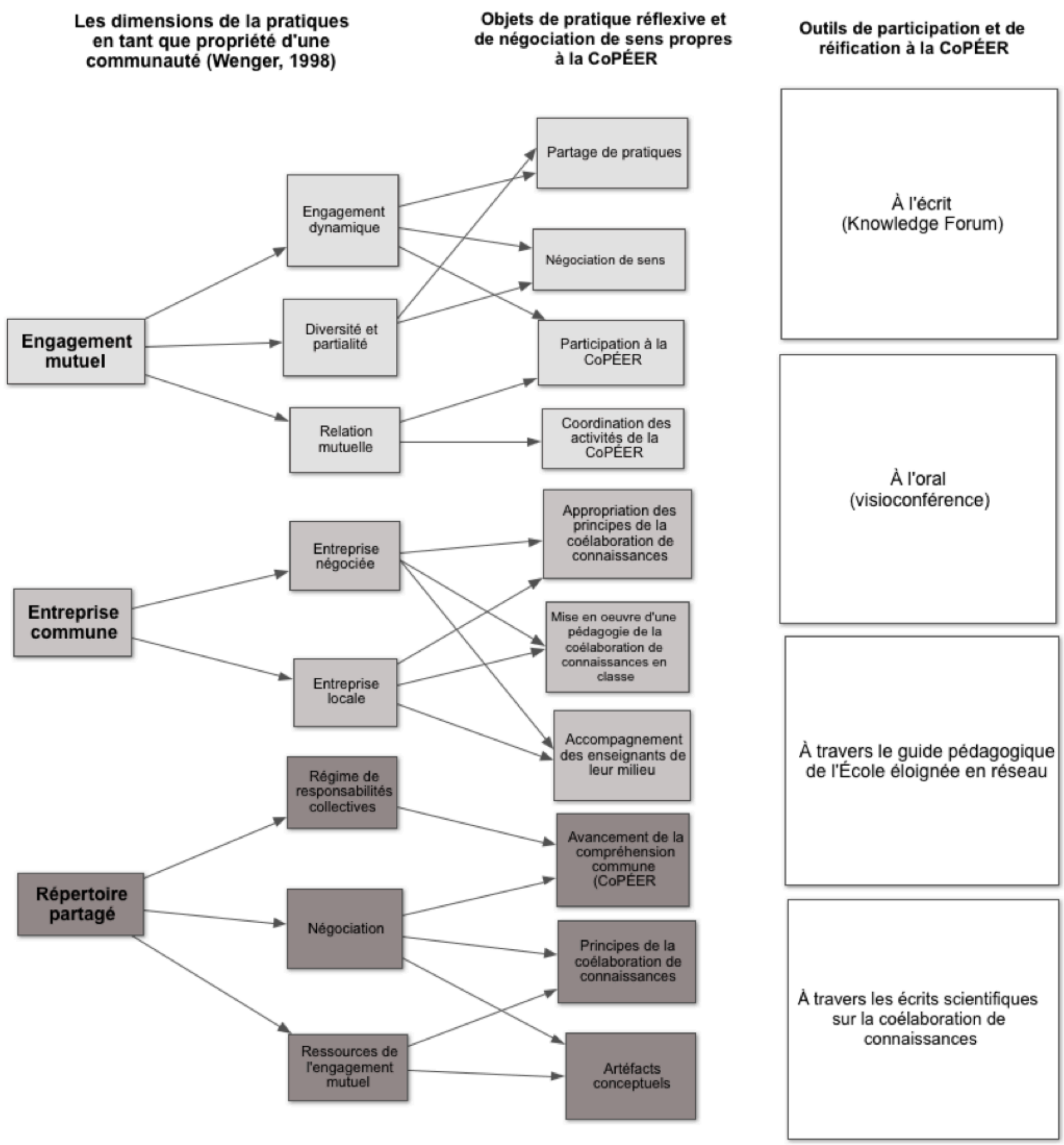


Figure 1. Les dimensions de la pratique de la CoPÉER

Les liens entre les dimensions de la pratique et les principes de coélaboration de connaissances

Comme nous l'avons déjà mentionné, nous croyons qu'un processus de négociation de sens sur la pratique professionnelle guidé par les principes de la coélaboration de connaissances dans le cadre de la CoPÉER peut soutenir le développement des enseignants qui ont moins d'expertise dans l'ÉER. Ainsi, les liens faits avec les principes de la coélaboration pourraient permettre aux enseignants engagés dans la CoPÉER d'avoir une meilleure compréhension de ceux-ci, en les expérimentant eux-mêmes, et de pouvoir ensuite transférer leur expertise dans le contexte de classe en réseau.

Les principes de la coélaboration de connaissances liés à l'engagement mutuel:

- Le savoir, une propriété communautaire et responsabilité collective
- Omniprésence de l'approche

Les principes de la coélaboration de connaissances liés à l'engagement mutuel et à l'entreprise commune:

- Idées réelles et problèmes authentiques
- Idées perfectibles

- Diversité des idées

Les principes de la coélaboration de connaissances liés à l'entreprise commune:

- Enseigner et apprendre, deux rôles complémentaires
- La classe un lieu de démocratisation du savoir

Les principes de la coélaboration de connaissances liés à l'entreprise commune et au répertoire partagé:

- Évaluation simultanée, ancrée et transformative

Les principes de la coélaboration de connaissances liés au répertoire partagé

- Utilisation constructive de source d'autorité

Les principes de la coélaboration de connaissances liés au répertoire partagé et à l'engagement mutuel:

- L'agentivité épistémique

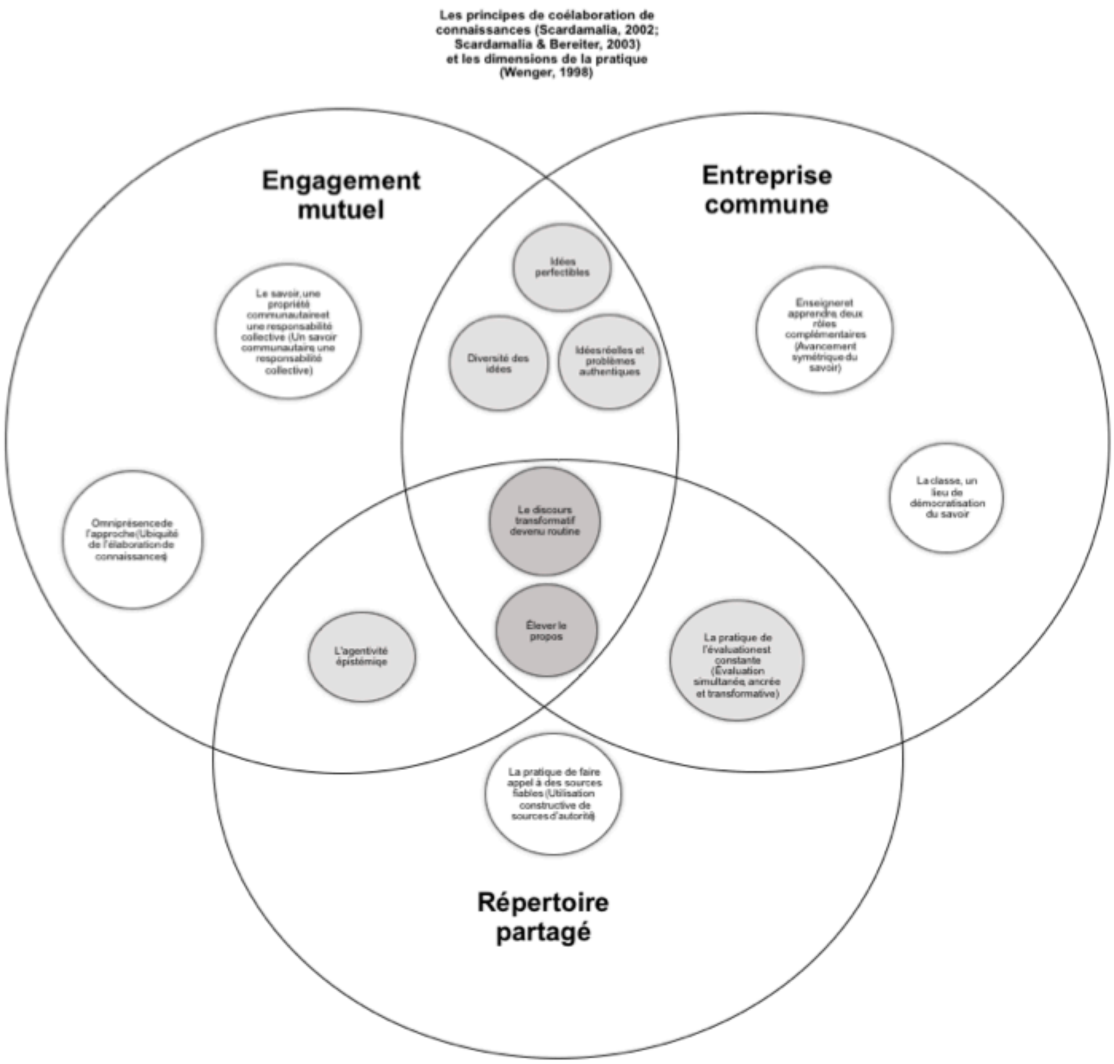


Figure 2. Principes de la coélaboration de connaissances (Scardamalia, 2002; Scardamalia & Bereiter, 2003) et dimensions de la pratique (Wenger, 1998)

Conclusion et suites

Nous planifions de poursuivre l'étude des activités de la CoPÉER quant à:

- l'analyse du discours écrit et verbal des enseignants pour la première année de mise en œuvre;
- l'analyse du discours des enseignants à propos de leur expérience dans la CoPÉER (bénéfices et limites);
- l'analyse de la pratique réflexive des enseignants sur les actions posées et les dimensions de la pratique ainsi que

les principes de coélaboration de connaissances;
- l'élaboration d'un design participatif lors de la deuxième année de mise en œuvre.

Références

Benoît, J. (1999). *De la communauté d'apprentissage à la communauté de pratique en ligne : une réflexion prospective et la construction d'un modèle de design polyvalent pour des fins d'apprentissage ou de travail (*mémoire de maitrise). Université Laval, Québec.

Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. Dans E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merriënboer (Eds.), *Powerful Learning Environments*: *Unravelling Basic Components and Dimensions* (pp. 73-78). Oxford, Angleterre: Elsevier Sciences.

Bourhis, A., et Tremblay, D.-G. (2004). *Les facteurs organisationnels de succès des communautés de pratique virtuelles*, Québec : CEFRIO.

Brown, A. L. (1992). Design experiments: Theoretical and methodological challenges in creating complex interventions. *Journal of the Learning Sciences*, *2*, 141-178.

Collins, A. (1992). Toward a design science of education. Dans E. Scanlon & T. O'Shea (Eds.), *New Directions in Educational Technology.* Berlin, Allemagne: Springer- Verlag.

Daele, A., & Charlier B. (2006). (Eds). *Comprendre les communautés virtuelles d'enseignants : pratiques et recherches*. Paris : L'Harmattan.

Dbrc. (2003). Design-Based Research: An Emerging Paradigm for Educational Inquiry. *Educational Researcher*, *32*(1), 5–8.

Hamel, C., Allaire, S., & Turcotte, S. (2012). Just-in time online professional development for an innovation in small rural schools. *Canadian Journal of Learning and Technology*, *38*(3), 1- 20.

Jaccoud, M., & Mayer, R. (1997). L'observation en situation et la recherche qualitative. Dans J. Poupart, L. H. Groulx, J-P. Deslauriers & A, Laperrière (Eds.). *La recherche qualitative : Enjeux épistémologiques et méthodologiques* (pp. 211-249). Montréal, Canada: Gaëtan Morin

Kimble, C., & Hildreth, P. (2008). *Communities of practice : Creating learning environments for educators*. Information Age Publishing.

Laferrière, T. & Allaire, S. (2010). *Développement professionnel d'enseignantes et d'enseignants : les passeurs de frontières qui façonnent l'École en réseau.* Éducation & formation, *e-293*, 101-120.

Laferrière, T., Allaire, S., Breuleux, A., Hamel, C., Turcotte, S., Gaudreault-Perron, J., Beaudoin, J., & Inschauspé, P. (2008). *L'École éloignée en réseau: l'apprentissage des élèves* (Rapport de synthèses 2006-2008, Phase 3). Québec, Canada : CEFRIO.

Lave, J., & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge, England: Cambridge University Press.

Pea, R. (2004). The social and technological dimensions of scaffolding and related theoretical concepts for learning, education, and human activity. *The Journal of the Learning Sciences*, *13*(3), 423–451.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. Dans B. Smith (Ed.), *Liberal Education in a Knowledge Society* (pp.67- 98). Peru, IL: Open Court.

Scardamalia, M., & Bereiter, C. (2003). Knowledge Building. Dans *Encyclopedia of education* (2nd ed., p. 1370-1373). New York: Macmillan Reference.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational researcher*, *27*(2), 4-13.

Trilling, B. & Fadel, C. (2009). *21 st century skills: Learning for life in our time*s. San Francisco, CA: Jossey-Bass.

UNESCO. (2011). *Référentiel de compétences en TIC pour les enseignants.* Récupéré de: http://www.unesco.org/new/fr/communication-and-information/resources/publications-and- communication-materials/publications/full-list/unesco-ict-competency-framework-for- teachers/

Wenger, E. (1998). *Communities of practice. Learning, meaning, and identity.* Cambridge, UK: Cambridge University Press.

Zhang, J., & Sun, Y. (2005). *Constructive learning.* Shanghai, CN: Shanghai Education Publishing House.

Zhang, J., Chen, Q., Sun, Y., & Reid, D. J. (2004). A triple scheme of learning support design for scientific discovery learning based on computer simulation: Experimental research. *Journal of Computer Assisted Learning*, *20*(4), 269-282.

Role taking and Knowledge Building: An examination of reading and writing activities in a blended higher education course

Donatella Cesareni, University of Rome Sapienza, Via Dei Marsi, 78, 00185 Roma, Italy, donatella.cesareni@uniroma1.it
Stefano Cacciamani, University of Valle d'Aosta, Strada Cappuccini 2/A, 11100 Aosta, Italy, s.cacciamani@univda.it
Nobuko Fujita, University of Windsor, Canada, nobuko.fujita@gmail.com

Abstract: Role taking is an established technique for promoting active learning. Taking a specific role within a group creates positive social interdependence in group interactions, which supports knowledge building. Students exercise agency over their own learning to engage in collective cognitive responsibility. The present study explored the effects of role taking on participation in knowledge building discourse in a blended university course. Of the 59 participants, students who assumed roles enacted four roles aimed at promoting group processes to support knowledge building in the second module of three consecutive, five-week modules. Students belonged to two conditions: students who took a role aimed at promoting group processes to support knowledge building in the second module and students who did not take a role, using the first and third modules as pre and post tests. Results show no differences in participation in the first module, higher levels of writing and reading for students with a role in second module, and this pattern sustained in the third module. Students with the Synthesizer role was the most active in terms of writing and the second most active for reading; students with the Social Tutor role were the most active for reading. Implications for role taking and Knowledge Building will be discussed.

Introduction

Various models of communities inspired by a socio-constructivist perspective have been developed for online course contexts. For instance, the Community of Inquiry (COI; Garrison, Anderson, & Archer, 2000) model asserts that to promote deep and meaningful learning, online course participants engage in collaborative inquiry through the development of three interdependent elements: "cognitive presence," "social presence," and "teaching presence." The Knowledge Building Community (KBC) model (Scardamalia & Bereiter, 1999; 2006) suggests that we re-conceptualize the classroom as a collaborative learning community involved in an inquiry activity where each member assumes "collective cognitive responsibility" for the community knowledge building process and makes a commitment to investigate and discuss real ideas and authentic problems. The goals for the KBC focus on progressive refinement of ideas and the creation of knowledge of value to the community.

Both COI and KBC models emphasize the idea that the main goal of the online learning community is to create new knowledge in and for the community through a deep collaboration between students and teachers. Therefore, more strongly than in the past or compared to face-to-face instructional practices, online courses guided by these models require the active participation of their students.

Many researchers support the idea that student participation is an important element in the design and successful implementation of university-level online education courses. As reported by Coldwell (2008), Beaudoin (2003) suggests that a high level of interaction and participation is desirable in online courses. Beaudoin's study found that performance cannot easily be correlated with participation. Although it found that highly participatory students achieved higher results, it also revealed that minimal online participation does not necessarily compromise student results. However a study undertaken by Alstete and Beutell (2004) found that the strongest indicator of student performance in online classes was discussion board usage. This finding was supported by the fact that the number of student sessions was positively and significantly related to overall course performance.

Lurking, the practice where students limit their action in to reading messages without posting any messages (Morris & Ogan, 1996), poses a risk to participation in an online course. Lurkers remain passive during much of the collaborative process. While lurkers often have a vested interest in staying abreast the group task—mostly for personal learning gain—their posting behavior is very minimal and consists more frequently of reflective comments than contributions of new knowledge (Strijbos & De Laat, 2010).

Recently, researchers have called attention to the need to expand the notion of student participation in online discussions to emphasize online listening behaviors as well as posting behaviors (Wyse, Speer, Marbouti, & Hsiao, 2013). According to Wyse et al. (2013), their notion of "listening" in online discussion is distinguished from the previous research on lurking by considering listening as: 1) a *behavior* that students engage in, rather than a fixed personal characteristic; 2) a behavior that is exhibited by the *same individuals* who speak or contribute posts; and 3) a behavior that can be useful not only in formal but also informal learning contexts, where users who access the most content are also the most active contributors. In online listening, especially as it pertains to knowledge building, the length of time students spend in online discussions reading others' messages to compose a reply should indicate deeper cognitive work with ideas. However, research suggests that students may select shorter posts to read and scan posts quickly instead of reading them for comprehension (Hewitt, Brett, & Peters, 2007). In large classes, students are more likely to experience information overload and become more selective in reading notes (Qiu, Hewitt, & Brett, 2012). Therefore, designers of online courses need strategies to encourage all students to participate in posting messages and reading messages to sustain the online knowledge-building community.

Role taking is an established technique for promoting active learning. A "role" can be defined in terms of a system of functions that people can assume in a group to guide individual behaviors and regulate group interactions among the group members (Hare, 1994). The cooperative learning approach advises the use of roles to create positive social interdependence among students at the K-12 level (Johnson, Johnson and Stanne, 2000) and at the university level (Johnson & Johnson, 2012). Role taking can promote individual responsibility and group cohesion. (Strijbos & Weinberger, 2010). Furthermore, taking a role can also facilitate a group member's awareness of peer contributions and the group's overall performance. (Strijbos, Martens, Jochem, & Broers, 2004).

Wise and Chiu (2011) claim that one hypothesis in CSCL research is that assigning roles to students can increase positive interdependence among students, help them to achieve more advanced phases of knowledge construction Two main perspectives characterize the study of role taking in CSCL: the *emerging roles* perspective, which focuses on the roles that participants develop spontaneously during their collaborative learning activity; and the *scripted roles perspective*, which focuses on how the collaborative learning process can be facilitated by structuring and prescribing roles and activities to learners (Strijbos & Weinberger, 2010). The first perspective emphasizes the structuring and self regulation of learners' online learning activity, where a learner develops a personal learning style and leads to assumption of a number of "emerging roles" that facilitates collaboration. The second perspective highlights the relevance of designed roles as instructional supports to improve both the processes and the outcomes of online collaborative learning.

Only a few empirical studies have analyzed the effect of role taking on students' participation in blended higher education courses. For instance, Brewer and Klein (2006) investigated the effects of roles based on different types of interdependence for collaborative learning. They found showed that university students in groups with roles-plus-rewards interacted with their peers significantly more than those who were given only the reward or those without the condition of interdependence. A significant correlation showed that participants with a high number of interactions also obtained higher scores in the post-test of the learning content. Similarly, Spadaro, Sansone, and Ligorio (2009) found that in-service teachers enrolled in a Master's-level blended course reached the highest level of participation, in terms of writing and reading, when they can play two roles in the course: *Tutor*, acting to promote forum discussion, and *Editor,* supervising collaborative writing tasks. These studies emphasize that role taking guides the activity of individual students, provides them with a script with which to act, and regulates their interactions within the group. Additionally, the possibility of playing a specific role within the group leads students to exercise greater responsibility for the community's own knowledge building activity. The purpose of the current study was to examine the effects of role taking on participation—writing and reading activities—in a knowledge-building activity in a blended higher education course. Our research questions asked: 1) Does taking on a role in a group in an online course lead to a higher level of participation in terms of writing and reading activity?; and 2) Among the roles designed, which specific types of role can foster a higher level of participation?

Method

Students in a first-year Psychology course were invited to participate in an online knowledge-building activity in addition to attending lectures. 143 students (22 males, 121 females), aged 18-30 years, voluntarily chose to participate in the online discussion activity, which was evaluated as part of their course grade. Students were organized into discussion groups of 10-12. They met both face-to-face and online, sharing their ideas and collaboratively constructing conceptual artifacts, for example a concept map of the group's shared understanding, to present during the larger lecture hall sessions. Online activities occurred were divided into three consecutive, five-week modules. In each module, students were asked to analyze, discuss, and reflect on various course themes, and to create a concept map at the end. The group composition remained the same during the three modules. In each module students who took on roles took turns enacting four specific roles: 1) "Social Tutor"; 2) "Synthesizer"; 3) "Map-Responsible"; and 4) "Skeptic." The Social Tutor supported participation of all the members of the group. The Synthesizer summarized the discussion each week, identifying the main questions and presenting them to the group. The Map-Responsible was responsible for creating a digital concept map and presenting it during the face-to-face group discussion and to other groups in the hall session. The Skeptic questioned the common ideas in the group to generate “prolific doubts.” This last role has to remain unknown to other students. These particular roles were designed in order to support group discussion and to engage in, through positive interdependence, collective cognitive responsibility (Scardamalia. 2002) toward knowledge advancement of the community. Roles were assigned by the teacher at the beginning of each module, giving students some instruction via email but leaving them freedom on how to enact the role. For example, students received an email like the following: “Dear... I propose you to take on the role of Social Tutor in your discussion group. Your task is to foster group participation, make sure that there are no debates between only two or three people and everyone is included in the activity. Let me know if you accept this role or not.” Students could accept or not accept the role by responding to teacher’s email. At the end of the module, students stopped enacting a particular role and other students were asked to take on that role. Some students did not take on any roles in the activity.

Students used Moodle for their knowledge-building activities. Moodle offers interactive tools like chat, forum, and wiki that are particularly interesting for promoting a constructivist educational approach. Moodle was chosen for its accessibility as free and open source software and for its usability in enabling students to access it from any browser. The instructor organized 14 different Moodle databases, one for each group, using interactive tools like a forum, the collaboratively built glossary, and the sharing of documents and artifacts collaboratively produced by students.

Procedure

This study examined if taking a role leads students to a higher level of participation and which specific role fosters a higher level of participation. To examine if role taking leads to higher levels of reading and writing activity, from the 143 participants, we selected two particular groups of students: participants who acted a role in Module 2 (31 students) and participants without a role over three different modules of the Moodle activity (Module 1, Module 2, and Module 3; 28 students) In Module 1 none of the students in the two groups had a role, in Module 2 students in the group “with role” enacted a role in their Moodle groups and in Module 3 again none of the students in these two groups had a role (see Table 1).

Table 1: Research design.

	Module 1	Module 2	Module 3
With role in Module 2 (n=31)	No role	With role	No role
Without role (n=28)	No role	No role	No role

To examine which specific role fosters a higher level of participation, we compared the writing and reading activity of the 31 students with a role in Module 2. Via email, the instructor assigned the roles to the students, who took turns enacting the “Social Tutor”, “Synthesizer”, “Map-Responsible,” and “Skeptic” roles.

Data Source and Analysis

Data consisted of student discourse in the Moodle. For the first research question, we compared the participation between students “With role in Module 2” and student “Without role” across two different modules, using Module 1 as a pre-test and Module 3 as post-test. We analyzed differences using the Student t-test because it was not possible to apply the ANOVA due to insufficient statistical conditions.

In order to answer to the second research question, which explores roles that foster a higher level of participation, we compared in a descriptive way the quantitative indicators of writing and reading activity among students with the different roles.

Results

Participation: Messages written and read

Comparing students “Without role” to students “With role in Module 2”, we can see that taking a role has a positive effect on writing activity (Table 2 and Figure 2).

Table 2: Messages written.

Module	Group	N	Mean	Standard Deviation
Module 1	Without role	28	4.92	7.16
	With role in Module 2	31	4.16	3.56
Module 3	Without role	28	3.75	6.63
	With role in Module 2	31	8.48	6.87

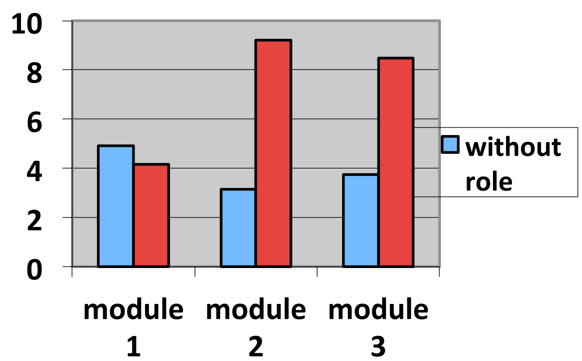


Figure 1. Writing activity in three course modules.

The two groups did not differ on writing activity in the pre-test or Module 1 (t (57)=-0.528, p>.05), before the introduction of the roles. Significant differences emerged in the post-test or Module 3 (t (57)=-2,68 , p=.01). The students "With role in Module 2" wrote a higher number of messages in the web-forum.

Table 3: Messages read.

A similar pattern is found in the reading activity (Table 3 and Figure 3).

Module	Group	N	Mean	Standard Deviation
Module 1	Without role	28	27.14	21.07
	With role in Module 2	31	34.90	36.14
Module 3	Without role	28	24.50	41.61
	With role in Module 2	31	60.03	66.37

Again, no differences are found between the two groups in the pre-test or Module 1 (t (57)= -0,772, p>.05), when students in the two groups did not take any role. In the post-test or Module 3, the students "With role in Module 2" read a higher number of messages compared to their counterparts (t (57)= -2,43, p=.018).

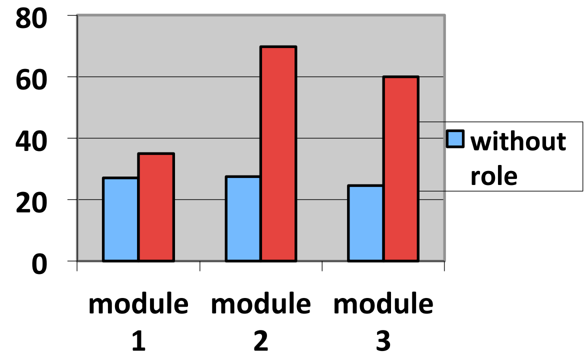


Figure 2. Reading activity in the three course modules.

Which type of role fosters a higher level of participation?
Participation of students in terms of roles that they assumed were analyzed (Table 4). The students who held the role of Synthesizer (of the group discussion) were most active in writing, followed by the students in the Social Tutor role. Students in the Map-responsible role were the least involved in the discussion.

Table 4: Messages written by students with different roles. [need to check formatting on Tables on template]

Role	Module 2 *M (SD)*
Synthesizer	10.24 (5.09)
Social Tutor	9.50 (2.71)
Skeptic	8.70 (4.85)
Map-responsible	7.00 (4.71)

As Table 5 below shows, the students who held the role of Social Tutor were the most active in the reading activities, followed by the Synthesizers. Similar to the findings for writing, the students in the Map-responsible role were the least involved in reading the messages.

Table 5: Messages read by students with different roles.

Role	Module 2 *M (SD)*
Synthesizer	73.94 (63.17)
Social Tutor	77.30 (42.69)
Skeptic	69.10 (44.58)
Map-responsible	51.46(34.97)

Discussion

Results for first research question, whether taking role in a group in an online course leads to a higher level of participation, indicate that students who assume roles in an online course are more active in both writing and reading activity in the knowledge-building online discussion activity. This result may be explained from the relationship, motivational, and metacognitive levels.

At the relationship level, the assigned roles structure interaction, making explicit the nature of the contributions expected from each role-taking participant in the online discussion. Along these lines, De Wever, Van Keer, Schellens, and Valke (2010) state that roles support the coordination and promotion of effective interaction patterns, as shown by the positive effects in improving task performance and satisfaction among participants, while also alleviating problems of non-participation and domination of the interaction by one group member.

At the motivational level, to understand why role-taking can activate a higher level of participation we can consider the different dimensions of the classroom learning environment proposed by Hakkarainen, Lipponen, Jarvela, & Niemivirta (1999). The “task dimension” concerns the design of learning activities that make learning interesting, and include both variety and personal challenge. It also helps students to establish realistic goals. The “authority dimension” stresses students’ opportunities to take leadership roles and develop a sense of personal control and autonomy in the learning process. The “evaluation and recognition dimension” concerns the formal and informal use of rewards, incentives, and praise in the classroom. This dimension contains guidelines such as recognizing individual student effort, accomplishment, and improvement, and giving all students opportunities to get rewards and recognition. The “grouping dimension” focuses on the students’ ability to work effectively with others on school tasks. This includes providing opportunities for social interaction and collaboration in varied group arrangements. Reframing this analysis, Strijbos and De Laat (2010) highlight that during a collaborative learning activity, a student is oriented toward individual and group goals, but not necessarily both kinds of goals and not at the same level of commitment. For instance, lurkers can be considered to be more oriented toward individual goals, because they invest a minimal amount of effort in the collaborative activity. It is plausible that taking a role can stimulate students to assume more responsibility in their own learning processes, take personal control of this learning, and change their prior orientation toward integrating personal and group goals. The interdependence created through other assigned roles can help to deepen students’ understanding of the importance of working together in a joint effort.

At the metacognitive level, scripted roles allow individual students to understand how to position themselves with regard to the group’s task, in this case the goal of knowledge building in asynchronous discussion. Students accept a specific cognitive responsibility to create a strategy of work consistent with the role attributed. This idea is consistent with Scardamalia’s (2002) notion of “collective cognitive responsibility” that emerges when students participate in a knowledge-building community. Scardamalia does not mention the assumption of roles by students, but the concept of an online activity orchestrated with interdependent roles seems useful for knowledge building, taking care to avoid “reduction to activities” – reducing the emergent, self-organizing nature of students’ knowledge-building discourse to role-taking activities (Bereiter, 2002). The notion of scripting and orchestration in this paper aims to scaffold the knowledge building process without “over-scripting” or inhibiting the student’s self-regulated application of higher-level internal collaboration processes (Dillenbourg, 2002; Fischer, Kollar, Stegmann, & Wecker, 2013). Scripted roles are functional in the sense that they specify the kinds of activities that are considered relevant for the collaborative learning and knowledge construction – the likes of which learners rarely engage in spontaneously, such as giving explanations, constructing arguments, and resolving conflicts productively (Strjibos & Weinberger, 2010).

Results for the second research question—among the roles designed which specific types of role can foster a higher level of participation—show that the role of “Synthesizer” is the most active, compared to the others roles, in terms of writing and the second most active for reading activity. As suggested by De Wever, Van Keer, Schellens, & Valke (2010), the role of “Synthesizer” requires a stronger focus on building upon others’ contributions, whereas other roles require less building on previous messages. Interestingly, the aforementioned authors report that this role has the largest positive effect on the level of knowledge construction (Schellens et al, 2005). Our findings are consistent with previous research. When a student works to synthesize an online discussion, this student takes on a responsibility to define the advancements in the community’s knowledge. Thus, the Synthesizer may stimulate the knowledge-building process in the community by more making frequent written contributions and analyzing the progress of knowledge creation through high levels of reading activity. Students that assumed the role of Social Tutor read more than the others roles. Students in this role are required to verify, through the content of the messages, the participation of the other members of the group. The Social Tutor may thus engage in active listening behavior in order to write messages (Wyse et al. 2013). To listen, this role must read messages carefully instead of scanning them quickly (Hewitt, Brett, & Peters, 2007).

Conclusions

Limitations of the present study include membership of the participants at one university, which limits the generalizability of the results and the limited number of male participants, which may have had an effect on role assumption, particularly with the relationship aspects. In a possible replication of this work, it could be useful to diversify the universities involved and balance the gender composition to increase rigor.

Future research is needed to explore the way in which students assume the role assigned. Interpretation of the scripts provided could be analyzed to identify different levels of interpretation of the task assigned. Another aspect to investigate is whether the positive effects on participation is sustained when the role-assignment period ends. Do students continue to self-organize in the collaborative activity, distributing the cognitive responsibility for the work and sustaining their previous roles? Or, which roles emerge spontaneously in their collaborative activity? Finally, as we designed three “cognitive” roles and one “social” role, it would be interesting to explore the contributions of the Social Tutor in supporting the knowledge building activity. This specific question could be addressed by combining quantitative analysis such as Social Network Analysis and qualitative content analysis of messages (Cucchiara, Ligorio, & Fujita, 2013).

References

Alstete, J. & Beutell, N. (2004). Performance indicators in on line distance learning courses: a study of management education. *Quality Assurance in Education, 12*(1), 6-14.

Bereiter, C. (2002). *Education and mind in the knowledge age.* Mahwah, NJ: Lawrence Erlbaum Associates.

Beaudoin, M. (2003). Learning or Lurking? Tracking the Invisible on line Student. *The Internet and Higher Education, 5,* 147-155.

Brewer, S., & Klein, J. (2006). Type of positive interdependence and affiliation motive in an asynchronous, collaborative learning environment. *Educational Technology Research & Development, 54*(4), 331-354.

Coldwell, J. Craig, A. Paterson, T. and Mustard, J. (2008) Online Students: Relationships between Participation, Demographics and Academic Performance. *The Electronic Journal of e-Learning,* 6(1), 19 - 30, available online at www.ejel.org, retrieved June 6, 2014.

Cucchiara, S., Ligorio, B., & Fujita, N. (2013). Understanding online discourse strategies for Knowledge Building through Social Network Analysis. H. L. Lim & F. Sudweeks (Eds.). *Innovative methods and technologies for electronic discourse analysis* (pp. 42-62). Hershey, PA: IGI Global.

De Wever, B., Van Keer , H., Schellens, T., & Valke, M. (2010). Role as a structuring tool in online discussion groups: The differential impact of different roles on social knowledge construction. *Computers in Human Behavior, 26*, 516-523.

Dillenbourg, P. (2002). Over-scripting in CSCL. In P. A. Kirschner (Ed.), *Three worlds of CSCL: Can we support CSCL* (pp. 61-91). Heerlen: Open University of the Netherlands.

Johnson, D. W., & Johnson, R. T. (2002). Social interdependence theory and university instruction: Theory into practice. *Swiss Journal of Psychology/Schweizerische Zeitschrift für Psychologie/Revue Suisse de Psychologie*, *61*(3), 119-129

Johnson, D. W., Johnson, R. T., & Stanne, M. B. (2000). *Cooperative learning methods: A meta-analysis.* Available at: http://www.ccsstl.com/sites/default/files/Cooperative%20Learning%20Research%20.pdf Retrieved July 10, 2014.

Hakkarainen, K., Lipponen, L., Järvelä, S. & Niemivirta, M. (1999). The interaction of motivational orientation and knowledge-seeking inquiry in computer-supported collaborative learning. *Journal of Educational Computing Research, 21*, 263-281.

Hewitt, J., Brett, C., & Peters, V. (2007). Scan rate: A new metric for the analysis of reading behaviors in asynchronous computer conferencing environments. *American Journal of Distance Education, 21*(4), 215-231.

Morris, M., & Ogan, C. (1996). The Internet as mass medium. *Journal of Computer-Mediated Communication, 1*(4). Retrieved from http://jcmc.indiana.edu/vol1/issue4/morris.html

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp.76-98). Chicago, IL: Open Court.

Scardamalia, M. & Bereiter, C. (1999). Schools as knowledge-building organizations. In D. Keating & C. Hertzman (Eds.), *Today's children, tomorrow's society: The developmental Health and Wealth of Nations* (pp. 274-289). New York, NY: Guilford.

Scardamalia, M. & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences*. New York: Cambridge University Press.

Schellens, T, Van Keer, H., &Valcke, M. (2005). The impact of role assignment on knowledge construction in asynchronous discussion groups: A multilevel analysis. *Small Group Research, 36,* 704-745.

Spadaro, P. F., Sansone, N., & Ligorio, M.B. (2009). Role-taking for knowledge building in a blended learning course. *Je-LKS, 5*(3), 11-21.

Strijbos, J. W. & De Laat, M. F. (2010). Developing the role concept for computer-supported collaborative learning: An explorative synthesis. *Computers in Human Behavior, 26,* 495-505.

Strijbos, J. W., Martens, R., Jochems, W. M. G., & Broers, N.J. (2004). The effect of functional roles on group efficiency: Using multilevel modeling and content analysis to investigate computer-supported collaboration in small groups. *Small Group Research, 35*(2), 195–229.

Strijbos, J. W. & Weinberger, A. (2010). Emerging and scripted roles in computer-supported collaborative learning. *Computers in Human Behavior, 26,* 491-494.

Qiu, M., Hewitt, J. & Brett, C. (2012). Online class size, note reading, note writing and collaborative discourse. *International Journal of Computer-Supported Collaborative Learning, 7*(3), 423-442.

Wise, A. F., & Chiu, M. M. (2011). Analyzing temporal patterns of knowledge construction in a role-based online discussion. *International Journal of Computer-Supported Collaborative Learning*, *6*(3), 445-470.

Wise, A. F., Speer, J., Marbouti, F. & Hsiao, Y.-T. (2013). Broadening the notion of participation in online discussions: Examining patterns in learners' online listening behaviors. *Instructional Science, 41*(2), 323-343.

La dimension émotive-motivationnelle des étudiants dans une *knowledge building community* à l'école

Idalissa Cingolani, University of Macerata, Italy,
cingolani.tirocinio@unimc.it

Abstract: Le modèle de la Knowledge Building Community valorise la collaboration entre étudiants dans l'activité de construction de connaissance, qui est réalisée par la lecture et l'écriture dans l'environment en ligne Knowledge Forum. Beaucoup d'études ont approfondi différents facteurs liés à cette activité dans le contexte scolaire, mais la dimension émotif-motivationnel des étudiants à été peu recherchée. Cette contribution entend rélever les relations entre cette dimension et la lecture et l'écriture des notes en ligne.
Une classe de 25 étudiants de deuxième année d'école inférieur secondaire a discuté en ligne pour réfléchir de façon critique sur quelques sujets historiques étudiés. Deux séries du Test Multidimensionnel de l'estime de soi liées à la réussite scolaire et les relations interpersonelles, et une série de la batterie AMOS 8-15 sur les émotions dans l'approche à l'étude ont été distribués. Les résultats soulignent corrélations positives entre les notes lues et l'estime de soi dans la dimension du succès scolaire; corrélations négatives entre la dimension émotive dans l'approche à l'étude soit avec les notes lues soit avec les notes écrites.

Introduction

Le modèle de la Knowledge Building Community (KBC) propose de repenser la classe dans la direction d'une communauté qui construit connaissance (Scardamalia, 2002; Scardamalia & Bereiter,2006): aux étudiants il est demandé de focaliser pas leur engagement sur l'apprentissage des concepts, mais sur la génération d'idées utiles au développement des connaissances de la communauté entière. Dans le modèle de la Knowledge Building Community dans la construction de connaissance est realisée par la lecture et l'écriture dans l'environment en ligne Knowledge Forum. Pour la participation active au processus d'apprentissage et de construction de connaissance dans un contexte collaboratif les dimensions motivationnelles et émotives de l'étudiant jouent un rôle de premier plan (Albanese, De Marco, Businaro, 2012).

Méthode

25 éleves (12 filles et 13 garçons), de la 2éme année de college appartenant établissement italien ont pris part à la recherché.

Le but de l'activité était une réflexion critique, à travers la discussion en ligne, de certains sujets étudiés dans les prgrammes d'histoire et citoyenneté.

Environment en ligne

L'environment en ligne utilisé dans cette étude est Knowledge Forum (http://www.knowledgeforum.com) dans la version 4.8. Il a été développé à l'intérieur du groupe de recherche de l'Université de Toronto, coordonné par Carl Bereiter et Marlene Scardamalia. Dans cet environment les étudiants peuvent créer des notes (textes écrits auxquels on peut ajouter des graphiques ou images), qui constituent les objets qui contiennent la connaissance graduellement construite par la communauté de la classe. Les notes peuvent être citées en autres notes où on peut les souligner avec des mots clé; elles peuvent être réunie les unes aussi aux autres avec des link. Dans ce cas, elles viennent définies avec le terme "élaboration", à indiquer qu'elles représentent des développements de l'activité de construction de connaissance. Les notes et les élaborations peuvent être groupé dans les «perspectives », qui permettent d'organiser pour zones thématiques l'activité de construction de connaissance dans son processus de développement. Pour faciliter la discussion, des structures linguistiques sont disponibles. Elles sont de soutien à l'écriture et elles s'appellent « Thinking Types » ou étiquettes de la pensée qui ont la fonction de échafaudages, dans le sens qui servent pour créer des catégories communes de construction du discours. Les échafaudages permettent de communiquer sur les buts des notes mêmes. Telles structures sont flexibles et adaptables.

Description de l'activité

L'activité avec la classe avait comme objectif la réflexion critique, à travers la discussion en présence et en ligne, sur quelques sujets étudiés à l'intérieur du programme d'études d'Histoire et Citoyenneté.

On a étudié en particulier la période napoléonienne en Italie et en Europe et les mouvements révolutionnaires de 1820 et de 1830 en Italie, suivi à la restauration de l'Anciem Régime après la défaite de Napoléon.

L'activité a été implémentée avec référence au modèle de la Knowledge Building Community dans les phases suivantes:
1. Le professeur a presenté une première partie du sujet d'étude à travers une leçon frontale et la lecture du livre: à la maison, chaque étudiant a individuellement étudié sur le livre le sujet expliqué par le professeur;
2. La classe a été subdivisée en deux groupes hétérogènes d'étudiants et à chaque groupe a été proposée une discussion sur la part de sujet étudié, à partir d'une question d'analyse critique: "Selon toi, est-ce que la période napoléonienne a eu plus d' aspects négatifs ou positifs? Pourquoi?". La discussion a été déroulée en présence, guidée par la chercheuse et enregistré par vidéo.
3. Le professeur, avec une leçon frontale suivante, il a conclu l'explication du sujet d'étude: à la maison, chaque étudiant a approfondi l'étude en forme individuelle.
4. En classe, les étudiants ont approfondi toute la période étudiée à travers un Jigsaw, (Aronson, 1978; Aronson, Blane, Stephan, Sikes et Snapp, 1978), articulé sur la base de question-guide, préparées par la chercheuse.
5. La chercheuse a présenté aux étudiants l'environment en ligne et il a proposé un familiarization avec l' environment par une perspective d'auto-présentation.
6. La chercheuse a successivement, a proposé une discussion en ligne pour la période historique étudiée, à partir de la même question de réflexion critique tournée aux étudiants dans la discussion en présence: "Selon toi, est-ce que la période napoléonienne a eu plus d'aspects négatifs ou positifs? Pourquoi?". Aussi dans ce cas, les étudiants ont été subdivisés dans les mêmes groupes de la phase 2.

Ce schéma de travail a été répété pour chaque sujet d'étude présenté par le professeur. Pour exigences d'organisation du professeur, l'activité de discussion en ligne sur la période napoléonienne a été déroulé après la discussion sur les mouvements révolutionnaires.

Variables observées

Objet d'étude de la recherche présente sont les variables observées suivantes:
- Les notes écrites
- Les notes lues
- L'estime de soi liées à la réussite scolaire et aux relations interpersonelles
- La dimension des émotions dans l'approche à l'étude

Instruments

Les variables notes écrites et notes lues ont été relevées à travers le logiciel Analytic Toolkit (ATK), qui fournit des statistiques inhérents les activités déroulées dans l'environment en ligne KF. Le logiciel détermine combien de notes sont présentes dans la base des données, combien de notes sont réunies, combien de notes ont été créées par chaque étudiant et combien de notes ont été lues. Pour chaque étudiant les notes écrites et les notes lues ont été calculées, à l'intérieur de chacun des perspectives . Pour le relevé de l'estime de soi chaque étudiant a rempli deux séries du Test Multidimensionnel de l'estime de soi (Bracken, 1992), relatives au succès scolaire et aux relations interpersonnelles avec les parents, les frères, les copains. Les deux séries du Test Multidimensionnel de l'estime de soi utilisées sont constituées de 25 items chacune. La réponse à chaque item se trouve sur l'échelle de Likert de 1 à 4, dans l'ordre croissant ou décroissant en fonction de la positivité ou la négativité de l'item. Le score pour chaque série peut varier de 25 à 100. Pour détecter la dimension émotionnelle dans l'approche a l'etude a été administrés une série de la batterie Amos 8-15 (Cornoldi, De Beni, Zamperlin & Meneghetti, 2005), qui détecte la la gestion de l'anxiété liée à l'activité d'étude. La série, qui a été crée pour les étudiants à partir de 8 à 15 ans, est composée de sept items, dans laquelle le sujet doit répondre sur une série Likert à trois niveaux. Le score peut varier de 21 à 49.

Pour chaque élève ont été calculées d'abord les notes écrites et les notes lues; après, des corrélations ont été observées entre les notes écrites et respectivement la réussite scolaire, les relations interpersonnelles et la dimension émotionnelle. La même procédure a été utilisée pour les corrélations avec les notes lues.

Analyse des données

Les données ont été analysées avec le logiciel SPSS, pour détecter les corrélations, à l'aide du coefficient Rho de Spearman (compte tenu du nombre d'élèves), entre les notes écrites, les notes lues, l'estime de soi et la dimension émotionnelle dans l'approche de l'étude.

Résultats

Les résultats pour la corrélation entre les variables sont présentés dans le tableau suivant.

Tab.1 Les corrélations entre les variables.

	ESTIME DE SOI success scolaire	**ESTIME DE SOI relations interpersonnelles**	**DIMENSION EMOTIONNELLE Approche à l'étude**
NOTES ECRITES	.07	-.14	-.46**
NOTES LUES	.57**	-.12	-.59**

La série de la réussite scolaire est corrélée de façon significative avec les notes lues (Rho = 0,57, p <0,01), mais pas avec les notes écrites (Rho = 0,07, p> 0,05).
Il n'y a pas de corrélation significative de la série de l'estime de soi aux relations interpersonnelles, soit avec les notes lues (Rho = - 0,12, p> 0,05), ni avec les notes écrites (Rho= - 0,14, p> 0,05).
La série de la dimension émotionnelle dans l'approche à l'étude a une corrélation négative avec les notes lues (Rho= - 0,59, p <0,01) et avec les notes écrites (Rho= - 0,46, p <0,01).

Conclusions

Les résultats montrent des corrélations positives entre l'estime de soi et les notes lues dans la dimension de la réussite scolaire et des corrélations négatives entre la dimension émotionnelle dans l'approche de l'étude et les notes lues et écrites.
L'estime de soi de la réussite scolaire est associée à l'activité de lecture en ligne. Dans l'activité d'enseignement en ligne les étudiants le plus actifs dans la lecture des notes sont ceux qui attribuent à eux-mêmes un niveau élevé de compétence de la gestion de la réussite scolaire; l'estime de soi liée aux relations interpersonnelles ne semble pas être une dimension pertinente.
Les étudiants qui présentent une dimension majeure de l'anxiété sont plus actifs dans la tâche de construction du savoir: ce qui confirme le fait que un contrôle efficace de l'anxiété à l'école, révèle un mécanisme d'activation psycho-physiologique positif, plutôt qu'un obstacle, à confrontés à des tâches qui nécessitent plus d'effort et de concentration.

Evaluation of a Knowledge Building Classroom in Aspect of Transactional Distance Theory

Derya Kici, University of Toronto/OISE, Institute for Knowledge Innovation and Technology, Canada
derya.kici@mail.utoronto.ca
Hamdi Erkunt, Bogazici University, Turkey
erkunt@boun.edu.tr

Abstract: This study aims to explore a Knowledge Building classroom as a blended learning environment in respect to transactional distance theory. Knowledge Building environments that are particular form of online learning environment, differs from other online environments, which are designed more specifically for course delivery, computer mediated projects and distance learning (Bereiter & Scardamalia, 2003). Because of these differences, we aimed to develop a new understanding for transactional distance from knowledge building perspective. In order to do that we explore the elements of transactional distance (dialogue, structure, and learner autonomy) in students' impressions in a knowledge-building classroom and search for the interplay of these variables and how one variable affects the others.

Introduction

Most of the contemporary educational approaches pursue two main goals: One of them is to enhance students to grasp significant ideas and the other one is to support students' development as autonomous learners and thinkers (Scardamalia and Bereiter, in press). Moore (1993)'s transactional distance theory, that refers to "independent study and highlights the shared responsibility of the teaching/learning enterprise with learner independence as the most important and desired outcome " coincides with these twin goals.

Transactional distance is a theory, which represents an exchange of intellectual ideas and interaction between people in an educational setting (Moore, 1980). It provides a framework for psychological and communication gap that is a function of the interplay among structure, dialogue, and learner autonomy. Shearer (2009) defines transactional distance in learning environments as "an educational exchange that happens at a distance. The effectiveness and efficiency of the exchange depends on dialogue, structure, and autonomy, and is affected by a psychological dimension of connectedness" (2009). Zhang (2003) also defines transactional distance as cognitive, emotional, social, cultural, and/or physical distances between learners and other components that prevent active student engagement with learning in the learning environments.

One of the three elements of transactional distance, *dialog* is an exchange between learners in an educational environment where knowledge growth is the desired outcome. (Shearer,2009, cited in Moore,1980,1993). According to Gokool-Ramdoo (2009) this outcome is the result of shared negotiation through dialog and structure between multiple permutations and combinations of relationships among the elements of learning environment such as instructor, learner, course materials, teaching subject, culture, and so on to decrease possible misunderstandings and miscommunications.

Structure refers to learning objectives, activities, assignments, planned interaction, evaluation and other components in the course design. *Autonomy* is individual learners' characteristic, to monitor, control, and manage their own learning in a self-directed way. Bereiter and Scardamalia (2003) claim that in KBEs, although it is possible to get from distance learning to knowledge building, designs have not advanced in that direction. KBEs aim to knowledge creation and continual and sustained idea improvement. On the other hand, a learning management system or a courseware as distance learning technology, provides an administrative system, which facilitate course lists, presentation of course outlines, delivery of course materials, declaration of deadlines and announcements, and reporting of grades. Despite KBEs can be used for these purposes, it is not the primary aim. Knowledge Forum (the second generation of CSILE) is the technology provides a KBE that supports the learning of individual learner by sustaining the kinds of inquiry, providing tools for tracking learner activities, and sustaining an online environment for learners to actively and collaboratively define research problems, and creatively work with ideas (Scardamalia, 2004; Pea, 1993).

Moreover, knowledge building pedagogy is inherently implemented as blended learning. In general cases, the instructor/teacher and students meet once or twice in a week in face-to-face class hours to collaboratively work on ideas. At the same time, the students can access Knowledge Forum whenever they want during the semester. The theory of transactional distance in education context refers the separation between learners, and between teacher and learners. However, this distance refers to psychological distance rather than geographical (Moore & Kearsley, 2004).

Moore (1993) explains psychological and communications spaces between leaners and teacher/instructor are continuous rather than a discrete variable. He points that there is a transactional distance in any educational program, even in face-to-face education. This definition of distance makes convenient to apply transactional distance theory to knowledge building classrooms.

In transactional distance theory, the teaching procedure fall into two categories (dialogue and structure), and the third cluster of variables includes the behaviours of learners (autonomy) (Moore, 1997). The interplay of these three clusters of variables determines the low or high levels of transactional distance. Transactional distance is low when dialogue is high and structure is low, whereas transactional distance is high when dialogue is low and structure is high. On the other hand, regarding autonomous/dialogue plane, if autonomy is high but dialogue is low, transactional distance is still low. In other words "high levels of dialogue may not be required by the autonomous learner" (Saba & Shearer, 1994 cited in Moore,1980, 1993; Saba & Shearer, 1994).

Method

In this study, it was hypothesized that in knowledge-building classrooms, transactional distance is low, and therefore learning outcomes are maximized.

Participants and data collection

In order to explore transactional distance variables in a knowledge-building classroom, an exploratory research applied in an undergraduate course that is taught by knowledge building pedagogy in tandem with Knowledge Forum. The main objective of the course is to gain an insight of education and technology to prospective teachers. The participants are the students who took this course in Spring 2013 as one of the compulsory courses in their curriculum. The course was taught by the second author who teaches in the department of Computer Education and Educational Technology in Bogazici University /Turkey.

The data came from the students' impressions about the knowledge-building course that they introduced first time. The students are asked to write their overall impressions about the course, technology, and pedagogy in Knowledge Forum through the end of the term. The participants are pre-service teachers who enrolled their at least 5th term in a program in Faculty of Education. To hear their sense about knowledge building are especially important for us because they are prospective teachers.

Analysis

In order to explore the perception of transactional distance of the students in this knowledge-building course, qualitative methods were applied. First, open coding was applied on the written impressions of the learners. Following this, themes were created on the basis of the three elements of transactional distance (dialogue, structure, and learner autonomy). Then the emerged themes for each element were examined. Table 1 shows the elements and themes as the results of coding.

Elements of Transactional Distance	Themes
Dialogue	Expressing thoughts/ideas/opinions
	Collectivity
	Poor quality of discussion
Structure	Course objectives
	Course design
	Difficulties
Autonomy	Positive perception
	Negative perception

Table 1: Emerged themes from open coding

Regarding *dialogue*, this study focuses on not only dialogue in face-to-face classroom discussions but also asynchronous text-based electronic exchanges. The evaluation of course designs in aspect of objectives, activities, assignments, and examinations refer to *structure* of the course. Autonomy is considered as learners' independent behaviours in order to manage and monitor knowledge-building process.

Findings

Most of the pre-service teachers reflected their satisfaction about expressing themselves in comfort. Some of them explained they talked in this course as much as they never did in other courses, thus they felt more active and engaged. They also expressed their pleasure about sharing ideas, working in collaboration with others, and hearing from different perspectives. Their impressions are based on considering others' thoughts to develop a common understanding and learning from each other.

Nevertheless, a significant number of the pre-service teachers stated that they did not like when the discussion is poor. They indicated the repetition as one of the reasons of poor discussion. They complained that repetition of same ideas/thoughts/opinions for several times inhibits the development of ideas. The other reason, which reduces the quality of discussion, is being out of topic. Some pre-service teachers stated that it is getting boring when some one is talking or writing much about irrelevant subjects. Also, if they start to discussion before understanding the problems well, discussion might easily go in different ways. A pre-service teacher mentioned this situation with the following quote:

> *"When we started to comment without well understanding of the problem, it went in different ways, but if we had a good understanding of the problems, we had good outcomes."*

One of the participants reported his inconvenience when they cannot make any consensus at the end of the discussion. Participants pointed that shallow discussions and dialogues demotivate them to contribute both classroom discussion and online discussion. One of the participants mentioned that he prefers to be silent in such cases.

Another student expresses her emotional condition in this course as 'confused':

> *"One of the question in this course was 'How do you feel?' My answer for this question was 'I am confused!' Because, sometimes I was looking for the answers for very interesting questions."*

Pre-service teachers define this knowledge-building course "different" because of its particular objectives and unfamiliar course design. Example quotes from the participants' impressions are below:

> *"This course is different from other course. It aims to teach us understanding the problems and questioning."*
>
> *"The best part of this course is to enhance us to think deep and gave a chance to use our knowledge."*

The pre-service teachers mentioned that the components of this course which distinguish it from other usual courses are the technology they use (Knowledge Forum), suggested readings, final examination aka "finale", written portfolios as assignment, and sitting configuration as circle at face-to-face meetings. One of the pre-service teachers description of "finale" is below:

> *"The final exam of this course is completely different form classical exams. For instance, we call it as "finale". (...) You have to talk in the finale rather than keep silence, and you don't need a pencil and eraser, of course if you can keep the ideas in your mind. "*

Following quote belongs to the same pre-service teacher about the portfolio assignment:

> *"There is also a portfolio assignment for assessment. We reference the other notes in KF while writing this portfolio. This is very different from the assignment we are familiar with."*

While some of the participants showed willingness to take similar courses again because this course enriches thinking and expands students' horizons, some of them mentioned about the challenges they had about the course. Some quotes below exemplify what kind of challenges they had:

> *"I don't like this course when I need to create a concrete production and when it makes my thoughts very busy."*
>
> *"We had difficulties in this course because we are not familiar with the assignments and exams of this course."*
>
> *"At the beginning the course I had no idea about what I am supposed to do because its format was different from other courses which I was familiar with. Because of this, I found it was a bit weird. But in time I got accustomed to its structure."*

Most of the participants defined the course as "student-centered" and they mentioned that students are completely active in this course. They expressed their pleasure to have autonomy on their learning. One of the students explained the main difference of this course is changing traditional roles of the students and teacher:

> *"This course is different from the other courses I took before in the way that teacher and students generally exchange their roles."*

On the other hand, one of the students explained his negative perceptions as:

> *"I think the only negative part of this course is that progression is very slow because the instructor stands behind."*

Discussion

The three variables of transactional distance are interpenetrated and one variable affects the others. The discussion is going around the statements of the pre-service teachers, which usually refer to more than one variable.

Moore's theory indicates that transactional distance and dialogue are inversely correlated. Shearer (2009) refers the theory that the maximum level of communication or dialogue means more effective the exchange or transaction. As a result of the analysis of pre-service teachers' impressions, most of the students express their pleasure about the dialogue in the course. Moore (1993) claims, that "dialogue is determined by the educational philosophy of the individual or group responsible for the design of the course, by the personalities of teacher and learner, by the subject-matter of the course, and by environmental factors." As one of the environmental factors, medium of communication is a quite important determinant. In knowledge building classrooms, the centrality of discourse, particularly dialogue is handled more causally and opportunistically, with significant support from Knowledge Forum with its graphical views to organize works on problems, as a computer based knowledge building environment (Scardamalia and Bereiter, in press). Knowledge Forum provides an environment for sustained discourse, which students are engaged in, to share with each other, and to improve the knowledge advancement.

As with dialogue, structure is mostly determined both the nature of the communications media being employed and by the teaching philosophy employed in the course and teacher's and learners' emotional characteristics, personalities, and other individual characteristics (Moore, 1997). One of the participants expressed his positive perceptions about the sitting configuration as "knowledge building circle" in face-to- face time that constitutes the dialogue. The knowledge-building circle is an intentional physical configuration to engage students in knowledge building discourse. In the book which is a resource for knowledge building teachers, namely "Natural Curiosity", the importance of this physical configuration explained as: *"Circles promote attentive listening __and communication. The physical shape facilitates face- to-face dialogue amongst students. Eye contact and 'attentive' body language – physical signs of respect and active listening – are more visibly apparent. Circles eliminate hierarchy. All students enjoy an equal place in a circle. No one student takes precedence over another. The teacher takes his or her place within the circle as a co-learner. As members of this egalitarian knowledge building community, students both learn from, and contribute to, each other's understanding. They take turns speaking and wait patiently for their turn."* (p.12).

Participants generally evaluated this course as different and unfamiliar because of its objectives, activities, assignments, interaction, and evaluation. The distinguished structure of the course is based on 12 principles (Scardamalia, 2002), which a knowledge building course design should pursue. The final exam has also its special design and the instructor calls it as "finale" to break traditional exam conception of the students. As one pre-service teacher expressed about finale and written portfolios, the assessment tools of knowledge building course, which aim to formative assessment, are unusual. The 12^{th} principle of knowledge building is 'concurrent, embedded, and transformative assessment.' Assessment is an integrated part of Knowledge Building, which helps to advance knowledge through identifying advances, problems, and gaps as work proceeds. This principle proposes that students should take a global view of their understanding, and then decide how to approach their assessments. The students are expected to create and engage in assessments in a variety of ways (Lee, Chan, & van Aalst, 2005; van Aalst & Chan, 2007).

Autonomy is individual learners' characteristic, to monitor, control, and manage their own learning in a self-directed way. In the cases, students are highly autonomous, high structure or a high level of communication with the instructor may not be required for success. Thus transactions, in other words the intellectual exchanges among the students may go to minimal. Shearer (2009) states, "A student who is not self-directed may need a large amount of structure and dialogue to succeed." Most of the pre-service teachers had positive statements about the learner-centered structure of the course, active participation and engagement of the learners. The readings are not required but suggested in this course. Although some of the students are reluctant to read the articles at the beginning, they noticed the profit of the readings to the quality of discussion, and they showed more willing to read them. A participant mentioned that the benefits of that readings not only this course but also for their professional career.

As Shearer (2009) cited, Moore describes learner autonomy as "the extent to which in the learning-teaching relationship, it is the learner rather than the teacher who determines the goals, the learning procedures and resources, and the evaluation decisions of the learning program" (1984). One of the main principles of knowledge building, which is related to learner autonomy, is cognitive collective responsibility and the other one is monitoring own understanding. "Students' contributions to __improving their collective knowledge is the primary purpose of the knowledge building classroom" (Scardamalia, 2002). Although the teacher is also a part of this community, her/his role is a more knowledgeable person or a co-worker rather than a transmitter. A pre-service teacher interprets these new role definitions as exchanging roles between teacher and students.

Monitoring own learning is one of the five criteria in the evaluation of written portfolios of the students. Students are expected “to explain what they did not know and what they have learned; to recognize discrepancies, misconceptions and new insights; to trace their own paths of understanding; and to show their new ways of looking at questions, ideas, and issues after examining other Knowledge __Forum notes__” (Lee, Chan, & Aalst, 2005). This is one of the ways of to give responsibilities to the learners on their learning path in a knowledge-building course.

Some of the pre-service teachers also have negative feelings about the knowledge building process. The need of consensus and concrete products, unfamiliarity, and slow progression are some of the reasons of negative perceptions reported by the pre-service teachers. Some of them are not satisfied with dialogue because of the low quality of discussion, repetitions, and irrelevant arguments. In addition, one of them expressed his displeasure when the problems in the course make his thoughts much busy. Moreover, one participant claims that because the instructor stands behind, they have slow progression. This results show that even a small number of the learners are unsatisfied with flexible structure of the course and high leaner autonomy. They may feel more comfortable by the teacher is more dominant in the course. However, not taking over cognitive responsibility is exactly what a knowledge building teacher is expected (Chuy, Resendes, and Scardamalia, YEAR). Regarding Scardamalia and Bereiter (in press)’s three kinds of teacher definitions, in a knowledge-building classroom, teacher “assumes responsibility for helping students take on as much cognitive responsibility, individually and collectively, as is consistent with overall learning and knowledge building objectives”, rather than the teacher as “expert or arbiter knowledge, who transmits the information to the students through a prescribed, but well-organized series of lessons that cover each curriculum expectations” (Natural Curiosity, p.17).

Conclusion

In conclusion, it is possible to say that knowledge-building classrooms have low transactional distance as its natural design. Some of the knowledge-building principles and the evaluation criteria for portfolios can be shown as evidence of low transactional distance. Pre-service teachers impressions as knowledge- builders also support these evidences. However, all participants’ active contribution cannot always be guaranteed. As a follow–up study a survey design is suggested to collect extensive quantitative data to understand the transactional distance perceptions in knowledge building classroom. A broaden data would show the facilitators and obstacles in that classrooms to create more sustained communities.

Note

The excerpts from pre-service written impressions about the course were translated from Turkish with an effort to keep the original tonality.

References

Bereiter, C., & Scardamalia, M. (2003). Learning to work creatively with knowledge. *Powerful learning environments: Unravelling basic components and dimensions*, 55-68.Gokool-Ramdoo (2009).

Chuy, M., Resendes., M., & Scardamalia, M. (2010, August). Ways of contributing to knowledge building dialogue in science. Paper presented at the *Knowledge Building Summer Institute (KBSI)*, Toronto, Canada.

Lee, E. Y., Chan, C. K., & van Aalst, J. (2005, May). Students assessing their own knowledge advances in a knowledge building environment. In *Proceedings of th 2005 conference on Computer support for collaborative learning: learning 2005: the next 10 years!* (pp. 378-387). International Society of the Learning Sciences.

Moore, M. G. (1993). Theory of transactional distance. In D. Keegan (Ed.), *Theoretical Principles of Distance Education* (Vol. 1, pp. 22-38). New York: Routledge.

Moore, M. G. (1980). Independent study. In R. Boyd & J. Apps (Eds.), Redefining the Discipline of Adult Education. San Francisco: Jossey-Bass, pp. 16–31.

Moore, M. G., & Kearsley, G. (2004) Distance education: A Systems View. Belmont, CA: Wadsworth Publishing Company July 2004

Natural Curiosity: A Resource for Teachers. 2011

Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (ed.), Distributed cognitions: Psychological and educational considerations (pp.). Cambridge, UK: Cambridge Univ Pr. 47–87.

Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. *Liberal education in a knowledge society*, 67-98.

Scardamalia, M. (2004). CSILE/Knowledge forum®. *Education and technology: An encyclopedia*, 183- 192.

Scardamalia and Bereiter, (in press). Education for Innovation Saba, F., & Shearer, R. L. (1994). Verifying Key Theoretical Concepts in a Dynamic Model of Distance

Education. *The American Journal of Distance Education, 8*(1), 36-59. Shearer, R. L. (2009). *Transactional distance* *and dialogue: An exploratory study to refine the theoretical construct of dialogue in online learning* (Doctoral dissertation, The Pennsylvania State University).

Zhang, A. (2003). *Transactional Distance in Web-based College Learning Environments: Toward Measurement and Theory Construction.* Unpublished Dissertation, Virginia Commonwealth University, Richmond.

van Aalst, J., & Chan, C. K. (2007). Student-directed assessment of knowledge building using electronic portfolios. *The Journal of the Learning Sciences*, *16*(2), 175-220.

Sociocultural Analysis of a Knowledge Building Classroom in Teacher Education

Derya Kici, University of Toronto/OISE, Institute for Knowledge Innovation and Technology, Canada, derya.kici@mail.utoronto.ca
Hamdi Erkunt, Bogazici University, Turkey, erkunt@boun.edu.tr

Abstract: In this study, a sociocultural analyze of a knowledge-building classroom in teacher education will be presented. The purpose is to identify online behaviors and interactions of the members based on sociocultural structures through four planes namely personal, interpersonal, community, and technology. In order to do this, a particular sociocultural approach is adopted from Gray and Tatar (2004) in order to understand the sociocultural dynamics of a pre-service teachers community in knowledge building process. The study was conducted on a knowledge-building classroom with 21 pre-service teachers who were at least fifth term of their study in various departments of the Faculty of Education, in Bogazici Univesity/Turkey. The results supported the importance of engaging pre-service teachers in actual knowledge building practices within a community of people from diverse interests with the aim of preparing to teach in 21st century.

Introduction

In this study, I describe and analyze the sociocultural structure of a knowledge-building classroom in teacher education. The purpose is to identify online behaviors and interactions of the members based on sociocultural structures throug four planes namely personal, interpersonal, community, and technology (Gray & Tatar, 2004). In this paper, a particular sociocultural approach is adopted from Gray and Tatar (2004) in order to understand the sociocultural dynamics of a pre-service teachers community in knowledge building process.

Through a pre-service teachers community, following research questions are investigated: How do community members interact with a particular problem space? (personal), how do community members interact with other members? (interpersonal), how does community grow and how do community members interact with different problem spaces? (community), and what are the community members' opinions about Knowledge Forum as an educational technology? (technology).

In this paper, I start with a theory-based explanation of knowledge building communities and sociocultural approach based on online communities. Following this, I explain the method to analyze data come from Knowledge Forum to explore our research problems. Finally, I discuss the implications of the study to extend the results for the design of professional development in knowledge building communities.

Knowledge Building Communities

Knowledge building community (KBC) is a community in which, the main goal is problem redefinition at increasingly high levels and knowledge creation. Scardamalia and Bereiter (1994) emphasize the importance of restructuring the schools as communities where the knowledge construction is naturalized as a collective goal. In a knowledge building community, community members engage in collecting information, supporting discourse and information exchanges. Learners are empowered to work constructively and creatively with ideas as knowledge creators (Bereiter, 2002). Hewitt (2004) defines the knowledge building community as a type of community of practice (CoP) based on the description of a CoP by Barab , MaKinster, and Scheckler (2004). A CoP is characterized by "(1) shared knowledge, values, and beliefs; (2) overlapping histories among members; (3) mutual interdependence; (4) mechanism for reproduction; (5) a common practice and/or mutual enterprise; (6) opportunities for interactions and participation; (7) meaningful relationships; and (8) respect for diverse perspectives and minority views". However, knowledge-building communities could be distinguished from usual CoP because the primary goal in a knowledge building community is to create knowledge rather than constructing a product or completing a task (Riel and Polin, 2004). There are several analogies in order to describe collective cognitive responsibility in a knowledge building community, for example expert surgical team in which the members "ideally share responsibility not only for carrying out the surgical procedure; they also take collective responsibility for understanding what is happening, for staying cognitively on top of events as they unfold (Scardamalia, 2002)."

Knowledge building pedagogy is supported by the Knowledge Forum technology which is a second generation Computer Supported Collaborative Learning (CSCL) environment that supports the learning of individual students by sustaining the kinds of inquiry, providing tools for tracking learner activities, and by sustaining an online environment for learners to actively and collaboratively define research problems, and creatively work with ideas

(Scardamalia, 2004; Pea, 1993). Knowledge Forum aims to engage learners in the same sorts of intellectual and cultural process that sustain real world scientists in efforts to knowledge advancement" (Scardamalia & Bereiter, 1993).

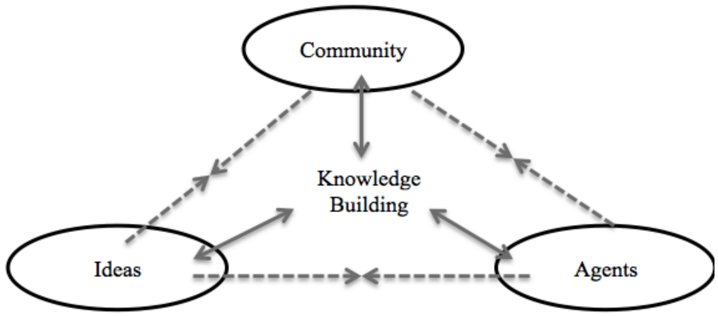


Figure 1. Relationships between three critical knowledge building entities; ideas, community, and agent (Hong, Chen, and Chai, 2010).

Scardamalia (2002) identifies twelve principles of knowledge building, which facilitate the knowledge building process. These principles are; real ideas and authentic problems; improvable ideas; idea diversity; rise above; epistemic agency; community knowledge, collective responsibility; democratizing knowledge; symmetric knowledge advancement; pervasive knowledge building; constructive uses of authoritative sources; knowledge building discourse; and concurrent, embedded, and transformative assessment. Hong, Chen, and Chai (2010), claims that these twelve principles are basically describe the behaviors of and relationships between three critical knowledge building entities; ideas, community, and agent, which are shown by Figure 1 (for details, see Hong, Chen, and Chai, 2010).

These three essential knowledge-building entities give an opinion about the sociocultural structure of KBC. They are shown in the Table 1 that explains how some of the principles conceptualize these three components.

Table 1: Three examples that explain how some of the knowledge building principles conceptualizes three components (Hong, Chen, and Chai, 2010).

Real Ideas, Authentic Problems	Epistemic Agency	Community Knowledge, Collective Responsibility
Real Ideas, Authentic Problems high-lights the importance of viewing students' ideas as conceptual artifacts (Bereiter, 2002) that are as real as things touched and felt, and that knowledge problems arise from efforts to understand the world and the ideas of other collaborators in the community, leading to problems of understanding that are quite different from textbook problems and puzzles.	The principle of Epistemic Agency underscores that participants deal with the full range of knowledge problems (goals, motivation, evaluation, long-range planning, etc.), including knowledge problems normally left to teachers or managers.	The principle of Community Knowledge, Collective Responsibility emphasizes that contributions to shared, top-level goals of the community are prized and rewarded as much as individual achievements; team members produce ideas of value to others and share responsibility for the overall advancement of knowledge in the community.

Because the sociocultural dynamics of KBC is differentiate from a conventional classrooms', there should be a significant shift in conventional classroom's norms and student and teacher practice such as defined work by pre-specified procedures, clear scripts and rules, or any highly-structured, ritualistic learning activities that represent fixed rather than improvable classroom procedures (Hong and Sullivan 2009; cited by Hong, Chen, and Chai, 2010) in order to be transformed into a KBC where students actively and collaboratively define problem of understandings, develop research plans, identify intellectual impasses, synthesize ideas, and work with others as a community, to make sense of their area inquiry (Hewitt, 2004).

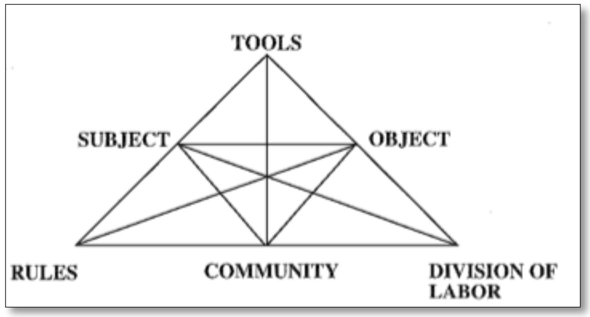


Figure 2. Triangular diagram of Activity System

In order to clarify the relationships between three essential knowledge-building entities (ideas, community, and agent), I use the Activity Theory framework. Activity Theory framework helps us to understand the sociocultural relationships among the knowledge building entities. Activity Theory framework is represented with a triangular diagram (see Figure 2) which depict the relationship among the individual (subject), tools, problem space (object), the community of people who are working on the same problem space, the division of labor, and the rules. According to Schlager and Fusco (2004)'s Activity Theory framework definition, the focus is on the activities in which individuals and groups engage (*subjects*). *Subjects* engage in to accomplish the *object/objective* of the activity, which leads to some *outcome(s)*. *Tools* mediated activities, which take place in the context of, and are influenced by, a surrounding *community* of people who are similarly concerned with the problem. The community work on the activity through the mediation of established *rules* which includes values, norms of behavior, dispositions toward inquiry, trust, and commitment, *tools* that have been institutionalized in the community, and *division of labo*r that means the allocation of roles and responsibilities through the community members.

This framework is viewed as useful for understanding the dynamics of the relationships among the community of individuals, community of ideas, and Knowledge Forum as an online learning environment. In the light of activity system (see Figure 3), a KBC can be demonstrated as an activity system as following (Hewitt, 2004): KBC is a group of learners whose orientation to the object of their collective effort (knowledge creation/ knowledge building) is mediated by a division of labor (pre-service teachers from different subject fields/ pre-service teachers work collaboratively on different problems), rules (guidelines for work on Knowledge Forum/sustained knowledge building discourse) and cultural artifacts (Knowledge Forum/classroom resources). Hewitt (2004) cited that in comparison with a typical classroom, in a Knowledge building classroom, there is not any tangible product in contrast to the products (a report, a presentation, or a project) of activity of a usual classroom and the product, in a manner, is the same with process of inquiry, which is based on the intentional stance of the students on their own learning (Bereiter & Scardamalia, 1989).

The Sociocultural Perspective

The work of sociocultural theory is to explain how learning is perceived in social, cultural, institutional, and historical contexts, and what the best understanding is as a form of participation in those contexts. The sociocultural perspective focuses on the simultaneous transformation of social practices, culturally organized activities and individual's roles, who participate in them (Boreham & Morgan, 2007). In sociocultural perspective, the "activity" as a part of the analysis is never considered individual activities isolated from the active and dynamic contributions, and separate from social partners and historical traditions and materials (Rogoff, 1995).

This study is designed on the basis of Gray and Tatars (2004)'s Four "Planes" or Foci of analysis, which is developed by following Rogoff (1995)'s studies. In addition to personal, interpersonal, and community planes, Gray and Tatars (2004) added technology as a fourth plane, to analytical framework. I borrowed this "Four Plane" analysis in order to investigate the research questions, which are looking for the interrelation aspects among the individuals, community, and technology. Table 2 shows the adaptation of Four Planes into this study.

Table 2: Four Planes, which is adapted from Gray and Tatars (2004)

Plane	Analytical Focus	Example
Personal	How community members interact with a particular problem space.	Notes worked on, notes created, note read, and notes revised
Interpersonal	How community members interact with other members.	Notes that are linked, social networks among the participants
Community	How community grows and how community members interact with different problem spaces.	Growth of database, build-on trees, work across views.
Technology	What are the community members' opinions about the Knowledge Forum as an educational technology?	Opinions of community members about KF as an educational technology.

As summarized in Table 2, the focus of the personal plane of analysis is the way of interaction of community members with a particular problem space. It could be in the way of adding notes, reading others' notes and making revisions on their own notes. Interpersonal plane of analysis focuses on the interaction of the community members with others through the ideas, which they are working on collaboratively. This happens by building on others' notes, posting annotation, referencing from others, and so on. As a result of their collective work, a social network of the interaction among the community members is formed. Community plane of analysis examines how community grows and how community members interact with different problem spaces. Knowledge Forum encouraged the members to work across the different views. The indicators of this plane of analysis are the growth of the community of ideas; build on trees, and the number of different views, in which a particular member interacts with at the same time. Last but not least, in technology aspects, we seek for the opinions of the community members about the Knowledge Forum as an educational technology. For this study we asked pre-service teachers to discuss in a particular view about the Knowledge Forum technology in aspect of learning. In order to search about pre-service teachers' opinions, the open coding is applied on their notes in that view.

Method

Participants and Data Collection

The data were collected over "Technology Tools for Teaching for Pre-service Teachers" course in which 23 students with 14 female and 9 male were enrolled in Spring 2013 school term in Bogazici Univesity/Turkey. The participants are pre-service teachers who were at least fifth term in their study in various departments of the Faculty of Education. This educational technology course is one of the compulsory courses in their curriculum. The participants of this study were of similar age and education and only evident of demographic characteristic was gender. Participant 9 and participant 23 were not included into analysis because they dropped the course later. Thus, the final number of participants is 21.

The course taught by the instructor who has almost ten years experience with Knowledge Building pedagogy. The main objective of the course is to understand education and technology, "as it was explicitly clear that educational technology makes sense if and when it addresses educational needs; and an educator cannot appreciate the value of technology in education without a substantial understanding of education" (Erkunt, 2007). During the term, pre-service teachers worked collaboratively on four different problems of understandings highly related to teaching, education, and technology in both face-to-face meetings and through Knowledge Forum.

In order to understand the sociocultural structure based on behaviors and interactions of the members through Knowledge Forum, mixed method research designed is employed. Analytical Toolkit for Knowledge Forum (ATK) (Burtis, 1998) is used to analyze the quantitative data and the open coding employed to analyze qualitative data. Both quantitative and qualitative data came from Knowledge Forum. In this study, both qualitative and quantitative design methods are used for investigation of different research questions in order to extend the focus of the study (Caracelli & Green, 1997). Both types of data are collected concurrently and blended with complementarity purposes to evaluate different facets of the study. Qualitative and quantitative analysis results are merged during interpretation.

Analysis and Results

Prior to explaining the data analysis and results, we like to give an overview of the database. Pre-service teachers worked on four different problems of understandings related to teaching, education, and technology. Table 3 shows the overview of the contributions of the participants on the basis of these four problems of understandings.

Table 3: The overview of the contributions of two groups.

Total number of notes contributed	558
Number of notes contributed per author	24.26
Percentage of notes that have been read per author	66%
Percentage of authors' notes that are linked	78%
Percentage of authors' notes with keywords	4%
Number of build-on trees participated in by this group	53

Regarding the sociocultural perspective, the results of the Four Plane analysis are explained below:

Personal Plane: RQ - How do community members interact with particular problem spaces?

In order to explore this research question, basic knowledge building measures are used. The following explanations of the parameters, which measure the custom behaviors in Knowledge Forum, are made by ATK. Basic knowledge building measures are; *the number of notes worked on* during the semester in fours problem spaces; the percentage of notes in the selected section of the database that read by the user; the number of notes created by the users, and *the number of revisions of notes.* The table in Appendix A shows the results.

Interpersonal Plane: RQ - How do community members interact with other members?

In order to seek for interpersonal phase, I examine the *percentage of notes that are linked.* This is explained in ATK documentation as "the percentage of notes authored by each user that the author has "linked" to at least one other note in the database, averaged over all authors in the selected group (see Appendix B). A note is considered to be linked to some other note if it is a build-on, it references another note, or it is a rise-above note." The social networking ties are also depicted in Appendix B to provide a visual understanding about the interpersonal relations among the pre-service teachers in the KBC.

Community Plane: RQ - How does community grow, and how do community members interact with different problem spaces?

In knowledge building communities, the focus is on the ideas more than people. The community means more comprehensive than sharing ideas, news, announcement, and resources. Scardamalia (1995) argues "the key is *symmetric knowledge advancement,* which occurs when the participants in a network are able to advance their own knowledge-building agendas by helping other participants advance theirs." Considering this groundwork, I examined for the parameters such as growth of the database, build-on trees, and work across views show us the community building and collaborative work of the pre-service teachers. The numbers of added notes day by day and the growth of the database are shown in the graphs below.

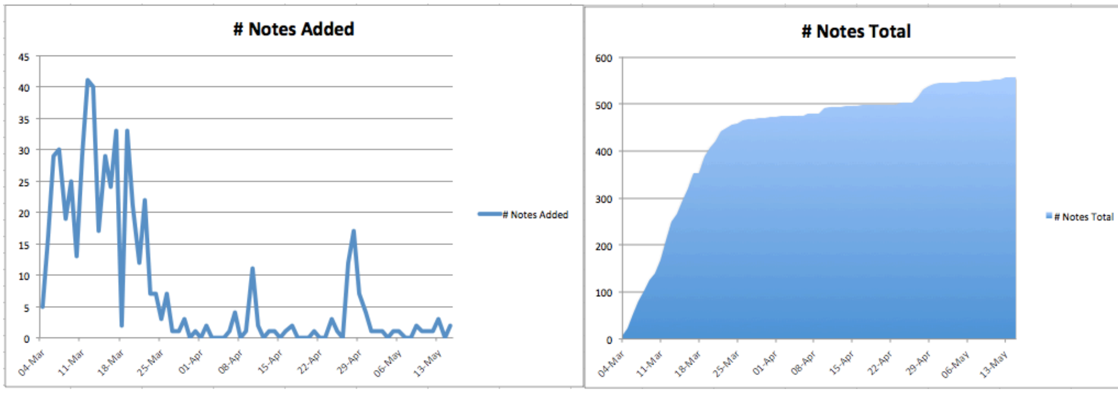


Figure 3. The growth of the first section's database

Second indicator for this research question is build-on trees. The number of build-on trees in the view with the specified number of notes in them for each view and the total number of notes contained in build-on trees of the specified size for each view are shown in the tables below.

Table 4: The number of build-on trees for the first section

View Name	Total # of Trees	2-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	over 40
PoU 1	16	7	3	1	2	0	0	1	2	0
PoU 2	14	6	5	0	2	0	0	0	0	1
PoU 3	8	3	2	1	2	0	0	0	0	0
PoU 4	15	7	5	1	1	1	0	0	0	0
totals over all views	53	23	15	3	7	1	0	1	2	1

Table 5: Total number of notes contained in build-on trees for the first section

View Name	Total Notes	Notes in Build-ons	Single Notes	2-5	6-10	11-15	16-20	21-25	26-30	31-35	36-40	over 40
PoU 1	215	208	7	22	27	13	35	0	0	35	76	0
PoU 2	156	153	3	21	37	0	35	0	0	0	0	60
PoU 3	81	77	4	12	19	14	32	0	0	0	0	0
PoU 4	112	107	5	17	36	12	20	22	0	0	0	0
totals over all views	564	545	19	72	119	39	122	22	0	35	76	60

In order to search how community members interact with different problem spaces, we also look for the number of notes worked across views, which are shown in Table 6.

Table 6: The number of notes worked across views

	# notes created	# notes in multiple views	# times a note from another view was referenced
MEAN	24.3	2.4	0
SD	27.78	3.28	0
MEDIAN	17	2	0

Technology Plane: RQ - What are the community members' opinions about the Knowledge Forum as an educational technology?

For the search of this research question, qualitative analysis was applied. The data came from asynchronous online discussions through the third PoU, that pre-service teachers worked on during the semester. The PoU was about the evaluation of KF in space and time; and the relation between KF and Transactional Distance. Transactional distance (TD) is a theory, which represents an exchange of intellectual ideas and interaction between people in an educational setting (Moore, 1980). This theory has three essential components; dialogue, structure, and learner autonomy. It searches how these components "interact to either increase TD the feeling of connectedness and a measure of efficiency in diminishing miscommunication, or to decrease TD" (Shearer, 2010). According to TD theory, while dialogue increases and structure decreases, TD. On the other hand, while structure increases and dialogue decreases, TD increases. (Shearer, 2010). It is a powerful theory in order to understand the agency of the KF on the knowledge-building pedagogy in aspects of discourse, teacher's role, and collective responsibility.

Pre-service teachers were asked to worked on this view to develop a common understanding where KF is located in space-time quadrant and whether KF decreases TD so that increases learning. Space-time quadrant have four sections; (1) time-dependent, place-dependent;(2) time-independent, place-dependent; (3) time-dependent, place-independent; (4) time-independent, place-independent. The works of pre-service teachers pursued the following path in their discussion: The pre-service teachers first started to discuss about space-time quadrant to develop a common understanding for "time" and "space" concepts. Then they questioned the KF as a virtual/online-learning environment while working to place it in this quadrant. Next, they switched their discussion to TD and its three elements. They evaluated the KF in aspect of these three elements and finally sought to the relations among the Knowledge Forum, TD, and learning.

In order to analyze data, open coding was conducted on with the aim of identifying, naming, categorizing and describing phenomena found in the notes. In this view, the text-based discussion through 8 build-on trees is examined. Each note was read in search of the answer to the repeated question "What is this about? What is being referenced here? (Borgatti, 2005)" Following the open coding, 4 themes emerged: (1) understanding space-time quadrant, (2) virtual environments, (3) parameters of transactional distance, and (4) indicators of transactional distance in KF. The first three themes included various discussions that served to reach the arguments in fourth theme, which is about the discussion of transactional distance in KF. Appendix C shows a build-on tree with 5 notes by 3 different pre-service teachers as evidence of their opinions about the relations among Knowledge Forum, TD, and learning.

Discussion

The overview of the database showed that the contributions of the participants are medial (66% read and 78% linked). Although the percentages are more than 50, the practice of collaboration of the group in the form of read, contributes, and link-to would be developed better.

Personal plane: The results of analysis conducted for personal plane indicate that almost all per-service teachers contributed in knowledge building process for all PoUs in different levels by reading each other's note, creating new notes, and making revisions in their notes throughout the semester. While some pre-service teachers have well-developed knowledge building process through these activities, some of them need to develop better participation. In any case, on the basis of these results it is possible to say that Knowledge Forum makes all participants engaged more or less in personal level.

Interpersonal plane: From interpersonal perspective, while participants showed strong interactions through reading, build-ons, references, and annotations, they have weak ties through rise-above notes and co-authored notes. The lowest mean of linked notes percentage is 63,80 % for the fourth PofU and 75,30% for the first one. This numbers show us the interconnectedness of the participants in aspect of their contributions is sufficient but for strong connectedness it should be higher. Social network diagrams also support these findings. In comparison of the four social network diagrams that are shown in Appendix B, while reading ties are very strong, and interpenetrated, the annotation ties are intermittent.

Although the strong connections among the reading, build-ons, references, and annotations, what causes the lack of rise-aboves and co-authored notes? Time restriction could be one of the reasons of these weak ties. The group worked on the PoUs only for one semester (approximately 3 month) and this technology and pedagogy were new for all of the participants. It takes time to comprehend and internalized the pedagogy and get familiar to the technology and tools. Moreover, rise above notes require the growth of the ideas in knowledge building process. While some participants have 100% linked in one PoU, they have lower percentage in another one. Another reason of the weak ties might be that they could prefer to focus one or two PoUs and did not engage in some of them.

Community plane: What do we learn from three different analyses (The numbers of added notes day by day and the growth of the database, number of build-on trees, and work across views) with respect to community plane? The results showed that the database was grown efficiently in the first month, and it continued slowly the rest of the time. The number of single notes versus the number of the notes in build-on trees indicated that the ideas are mostly connected each other. Also the closed number of build-on trees in different views showed that participants worked almost equally for each problem of understandings. Only PofU 3, which has the smaller number of build-on trees, could be an exception in this case. On the other hand, although the participants worked on all of the four views, the amount of the work across views is very low. Any participant never referenced a note from another view, and they created only a few notes in multiple views. This shows that participants could not make any connections among the ideas across views. As a result, it is possible to say that even they have an active community practice; they need more time, experience, and interaction to build a community of ideas in cognitive manner.

Technology plane: In technology plane, the qualitative analysis' results informed us that pre-service teachers were not much familiar with online learning environments and had some confusion with virtual concepts. However, after spending a collaborative effort to understand these environments in time and space context, and evaluating Knowledge Forum technology in aspect of transactional distance, they agreed on the effectiveness of Knowledge Forum as an educational technology.

The results of the examination of the knowledge building communities through four planes showed us the intertwined structure of all planes. It is not possible to make a distinct analysis among all these complementary planes.

Limitations of the study

This study examined a KBC from the sociocultural perspectives. However, for the first three planes the results are only based on quantitative data. For further studies, it is suggested to use qualitative methods in order to investigate what societal factors affect the evolution of a KBC. Interviews with the participants who showed outstanding performance could be helpful to have a deeper understanding about the personal, interpersonal, and community planes.

Also, this research was conducted on only one KBC. However, each community has its own particular dynamics. Another suggestion is to examine different KBCs in societal aspects and compare and contrast the results to find out the various kinds of networks models in KBCs.

Conclusion

KBCs are built into various dynamics by which participants communicate and pursue organizational goals (Scardamalia, 2003). KBCs have slightly different sociocultural dynamics from typical discussion groups. In its special sociocultural dynamics, KBCs create self-maintaining social system by the combination of talents within and between the people who are from different fields. However a KBC is not simply a collection of people from diverse interests. Instead of this, that people "share their knowledge, support one another in knowledge construction, and thus develop a kind of collective expertise that is distinguishable from that of the individual members in a commitment to the collective goal of engaging all participants in productive knowledge work." (Scardamalia, 2003). In the light of these sociocultural dynamics, we recommend that it would be useful to engage pre-service teachers in actual knowledge building practices with the aim of preparing them to teach in 21st century.

References

Barab, S., MaKinster, J. G., & Scheckler, R. (2004). Designing system dualities. *Designing for virtual communities in the service of learning*, 3-15.

Bereiter, Carl. 2002. *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bereiter, C., & Scardamalia, M. (1989). Intentional learning as a goal of instruction. *Knowing, learning, and instruction: Essays in honor of Robert Glaser*, 361-392.

Boreham, N., & Morgan, C. (2004). A sociocultural analysis of organisational learning. *Oxford Review of Education*, *30*(3), 307-325.

Borgatti, S. (2005). Introduction to grounded theory. *Retrieved May*, *15*, 2010.

Burtis, J. (1998). *Analytic Toolkit for Knowledge Forum*. Centre for Applied Cognitive Science: The Ontario Institute for Studies in Education/University of Toronto.

Caracelli, V. J., & Greene, J. C. (1997). Crafting mixed-method evaluation designs. *New directions for evaluation*, *1997*(74), 19-32.

Erkunt, H. (2007). Of joy and responsibility of coming to understand: Transforming schoolwork into Learning. 07-10 August 2007, OISE/University of Toronto Institute of Knowledge, Innovation and Technology (IKIT), IKIT Knowledge Building Summer Institute, Toronto, Canada.

Gray, J. H., & Tatar, D. (2004). Sociocultural analysis of online professional development. *Designing for virtual communities in the service of learning*, 404-435.

Hargreaves, D. H. (1999). The knowledge-creating school. *British journal of educational studies*, *47*(2), 122-144.

Hewitt, J. (2004). An exploration of community in a knowledge forum classroom. *Designing for virtual communities in the service of learning*, 210-238.

Hong, H. Y., Chen, F. C., Chai, C. S., & Chan, W. C. (2011). Teacher-education students' views about knowledge

building theory and practice. *Instructional Science*, *39*(4), 467-482.
Hong, H. Y., & Sullivan, F. R. (2009). Towards an idea-centered, principle-based design approach to support learning as knowledge creation. *Educational Technology Research and Development*, *57*(5), 613-627.
Moore, M. G. (1980). Independent study. In R. Boyd & J. Apps (Eds.), Redefining the Discipline of Adult Education. San Francisco: Jossey-Bass, pp. 16–31.
Pea, R. D. (1993). Practices of distributed intelligence and designs for education. In G. Salomon (ed.), Distributed cognitions: Psychological and educational considerations (pp.). Cambridge, UK: Cambridge Univ Pr. 47–87.
Riel, M. & Polin, L. (2004) Learning Communities: Common Ground and Critical Differences in Designing Technical Support. In Barab, S. A., Kling, R., & Gray, J. (Eds.). Designing for Virtual Communities in the Service of Learning. Cambridge, MA: Cambridge University Press.
Rogoff, B. (1995). Observing sociocultural activities on three planes: participatory appropriation, guided appropriation and apprenticeship. In J. V. Wertsch, P. Del Rio & A. Alverez (Eds.), Socioculturul studies of the mind (pp. 139-164). Cambridge: Cambridge University Press.
Sawyer, R. K. (2004). Creative teaching: Collaborative discussion as disciplined improvisation. *Educational researcher*, *33*(2), 12-20.
Sawyer, R. K. (Ed.). (2006). *The Cambridge handbook of the learning sciences* (Vol. 2, No. 5). Cambridge: Cambridge University Press.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. *Liberal education in a knowledge society*, 67-98.
Scardamalia, M. (2003). Knowledge Society Network (KSN): Toward an expert society for democratizing knowledge. *Journal of Distance Education*, *17* (Suppl. 3, Learning Technology Innovation in Canada), 63-66.
Scardamalia, M. (2004). CSILE/Knowledge forum®. *Education and technology: An encyclopedia*, 183-192.
Scardamalia, M., & Bereiter, C. (1993). Technologies for knowledge-building discourse. *Communications of the ACM*, *36*(5), 37-41.
Scardamalia, M., & Bereiter, C. (1994). Computer support for knowledge-building communities. The Journal of the Learning Sciences, 3(3), 265-283.
Schlager, M. S., & Fusco, J. (2003). Teacher professional development, technology, and communities of practice: Are we putting the cart before the horse?. *The Information Society*, *19*(3), 203-220..
Shearer, R. L. (2010). Transactional distance and dialogue in Online Learning. 26th Annual Conference on Distance Teaching & Learning

Internet References

Analytic Toolkit for Knowledge Forum (ATK) http://analysis.ikit.org/atk/atkdoc.html

APPENDIX A. The Indicators of Personal Engagement

	#Notes Worked On				#NotesCreated				# revisions				Percentage of Notes Read			
Author Name	PoU 1	PoU 2	PoU 3	PoU 4	PoU 1	PoU 2	PoU 3	PoU 4	PoU 1	PoU 2	PoU 3	PoU 4	PoU 1	PoU 2	PoU 3	PoU 4
P1	1	0	2	3	1	0	2	3	0	0	0	0	68%	69%	70%	0
P2	4	6	1	1	4	6	1	1	0	2	0	0	26%	47%	82%	0
P3	3	5	4	5	3	5	4	5	3	0	0	1	100%	100%	100%	1
P4	1	1	4	0	1	1	4	0	0	0	6	0	71%	100%	100%	0
P5	0	0	3	4	0	0	3	4	0	0	0	0	21%	32%	44%	0
P6	2	13	4	14	2	13	4	14	0	15	3	5	34%	97%	94%	5
P7	19	7	3	3	19	7	3	3	3	1	1	1	100%	100%	100%	1
P8	4	0	0	0	4	0	0	0	3	0	0	0	3%	3%	0%	0
P10	4	8	5	4	4	8	5	4	0	0	0	0	96%	99%	99%	0
P11	15	19	5	9	15	19	5	9	7	4	0	1	100%	100%	100%	1
P12	8	13	6	10	8	13	6	10	4	14	5	6	70%	88%	85%	6
P13	9	6	2	0	9	6	2	0	2	6	1	0	91%	94%	94%	0
P14	**40**	**16**	**4**	**3**	**40**	**16**	**4**	**3**	**12**	**5**	**0**	**0**	**94%**	**95%**	**96%**	**0**
P15	1	0	2	4	1	0	2	4	3	0	3	3	35%	45%	56%	3
P16	17	6	3	2	17	6	3	2	4	0	0	0	98%	86%	87%	0
P17	12	4	0	10	12	4	0	10	15	3	0	12	96%	84%	99%	12
P18	1	5	0	10	1	5	0	10	0	2	0	11	14%	41%	0%	11
P19	10	3	0	4	10	3	0	4	1	0	0	2	100%	97%	87%	2
P20	1	1	11	2	1	1	11	2	1	0	11	0	46%	29%	97%	0
P21	**57**	**37**	**17**	**21**	**57**	**37**	**17**	**21**	**1**	**2**	**0**	**2**	**100%**	**100%**	**100%**	**2**
P22	1	4	3	2	1	4	3	2	1	0	0	0	17%	23%	48%	0
MEAN	9.1	6.7	3.4	4.8	9.1	6.7	3.4	4.8	2.6	2.3	1.3	1.9	60.00%	66.40%	71.20%	1.9
SD	13.61	8.36	3.83	5.16	13.61	8.36	3.83	5.16	3.83	4.13	2.66	3.37	37.82%	36.15%	36.47%	3.37
MEDIAN	4	5	3	3	4	5	3	3	1	0	0	0	70%	86%	87%	0

APPENDIX B. The Indicators of Interpersonal Plane

	Percentage of Notes Linked			
Author Name	PoU 1	PoU 2	PoU 3	PoU 4
P1	100%	0%	100%	100%
P2	75%	100%	100%	0%
P3	100%	80%	100%	100%
P4	100%	100%	100%	0%
P5	0%	0%	100%	75%
P6	100%	100%	100%	93%
P7	100%	100%	67%	100%
P8	25%	0%	0%	0%
P10	100%	100%	100%	100%
P11	100%	89%	60%	78%
P12	89%	85%	83%	90%
P13	90%	100%	100%	0%
P14	98%	94%	100%	100%
P15	100%	0%	100%	75%
P16	94%	83%	67%	100%
P17	75%	50%	0%	100%
P18	100%	100%	0%	70%
P19	90%	33%	0%	100%
P20	100%	100%	100%	100%
P21	97%	95%	88%	86%
P22	0%	75%	33%	0%
MEAN	75.30 %	64.50 %	65.10 %	63.80 %
SD	38.02 %	41.56 %	42.08 %	43.13 %
MEDIAN	97%	85%	88%	86%

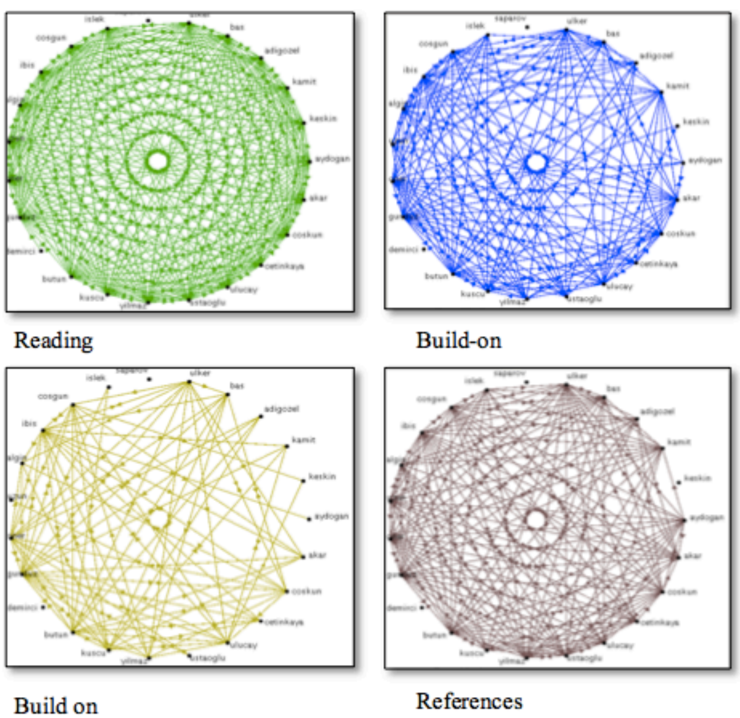


Figure 4. The social networking ties

APPENDIX C. The notes of the students from the view about Knowledge Forum and Transactional Distance

The notes of the students were translated faithfully from Turkish to English by the researcher.

Student A: *“I think that transactional distance theory is based on philosophy more than science. Socrates used dialogue as a teaching method in order to let his students to find truth. But, when we think in educational settings, can we say that if transactional distance is low, learning is high? If the dialogue is high in a low-structured course, does learning increase? Does this theory have any answer for this question?”*

> Student B: *“I think in the case of transactional distance and structure are low, it is possible to adjust the subject into the learners' cognitive level. As I said in one of my previous notes [students gave a link to note here], because each individual are unique, the low structure will direct the attention to the individual learners and so that, the individual student can interpret the subject on the basis of her/his own interests. Thus, learning will be increased.”*
>
> > Student A: *“I think Knowledge Forum decreases transactional distance. The problems are discussed and the dialogues among the learners give responsibility to them on their own learning. As distinct from traditional methods, learners reach the knowledge by discussing about the problems instead of taking it from the teacher. The individual interests and thoughts are critical in knowledge building. We can say that, knowledge is more permanent in this way.”*
> >
> > > Student C: *“This requires extra time and effort. It should be considered that, even though it improves research and development, it might digress from the subject. The discussions bring new arguments and new inquiries. As a result, don't you think that we need more time in such a learning environment?”*
> > >
> > > > Student A: *“I agree that it requires more time and effort. We also use Knowledge Forum. It is sometimes tiring that reading notes, think deeper, and make contribution. Sometimes the discussion can be digressed from the problem. But, Scardamalia states about Knowledge Forum that "a comprehensive knowledge building environment would provide a means of initiating students into a knowledge-creating culture—to make them feel a part of humankind’s long-term effort to understand their world and gain some control over their destiny".”*

From theory to practice: Implementing knowledge building communities in secondary schools using the PROCESS model

Kwok-Wing Lai, University of Otago College of Education, wing.lai@otago.ac.nz

Abstract: In this paper a practice model called PROCESS is discussed. This model was developed from a two-year project undertaken in New Zealand with 16 on-site and distance senior secondary classes in 2012-2013 to guide teachers in implementing the knowledge building communities model (Scardamalia & Bereiter, 2006) in their classes. Designed as a professional learning and development tool, the PROCESS model has included the key elements that teachers would consider when using the knowledge building communities model in teaching and learning.

Introduction

A two-year project investigating how the knowledge building communities (KBC) model (Scardamalia & Bereiter, 2006) could be effective implemented in New Zealand senior secondary classes was undertaken in 2012-2013. 220 students and 8 teachers from 16 on-site and distance classes participated in this project (refer Table 1). A practice model called PROGRESS was developed from this project as a professional learning and development tool to guide New Zealand teachers to implement the KBC model in their classes (Note 1). In this paper the PROCESS model is discussed, illustrated by examples from three 2013 Year 11 (Economics Year 11, English, and Biology) and three Year 13 (Art History, Classical Studies, and Physics) classes.

Table 1: Summary of participating classes and students in 2012 & 2013

Class	2012	Number of students	2013	Number of students
Accounting	Y12 (V)	16		
Art History	Y13 (V)	10	Y13 (V)	12
Biology	Y11 (V)	9	Y11 (V)	5
Classics	Y13 (V)	25	Y13 (V)	20
Economics	Y12 (V)	7		
Economics	Y12 (C)	9	Y12 (C)	11
Economics	Y13 (C)	13	Y11 (C)	17
English	Y11 (C)	23	Y11 (C)	20
Physics	Y13 (C)	13	Y13 (C)	11
Total		124		96

*** (V) stands for videoconferencing class and (C) stands for on-site class.**

The PROCESS practice model

Multiple data collection methods including questionnaire survey, interview, content analysis and participation data analysis were employed in this project (Lai, 2014b). Based on the findings of this project, a practice model called the PROCESS model (refer Table 2) is developed to guide teachers to implement the KBC model in their classes. The key elements of this model will be discussed in the following sections.

Table 2: The PROCESS practice model

	Element	Explanation
P	**Principles** of knowledge building	Teacher and students understand and committed to knowledge building principles.
R	**Roles and Responsibilities**	Community focused. Teacher to develop trust, collective responsibility, and a collaborative culture. Teacher as thinking coach, facilitator, and knowledge creator. Students as epistemic agents.
O	**Open-**ended inquiry	Teacher identifies topics that allow open-ended inquiry of authentic questions/problems. Teacher or student provides starter question. Students ask explanation-driven questions (why and how). Focus on promising ideas – develop, test, critique. Teacher may provide content and direct teaching.
C	**Conversant with** *Knowledge Forum*	Teachers and students conversant with *Knowledge Forum* (scaffolding tools). School provides infrastructural and technical support.
E	**Evaluate** progress	Teacher encourages and monitors participation, supports investigation of promising ideas, and holds debriefing and milestone meetings to evaluate progress of idea creation. Formative assessment.
S	**Structure**	When to do what? Participation structure (small group/whole class). Activity structure (consult authoritative sources, online/offline dialogues, conduct experiments/field trips).
S	**Show** evidence of knowledge building	Summative assessment. Students produce epistemic products (e.g., a portfolio) to show what new ideas have been developed by, and for the community.

Principles of knowledge building

Before implementing the KBC model in their classes, teachers need to understand and committed to the knowledge building principles (Scardamalia, 2002). In our project we found that it had taken teachers a long time to translate these principles into practice. Since inquiry learning has been widely popularised in New Zealand, many of our teachers confused knowledge building with inquiry learning. It is only through readings, discussions and in particular, through practice in two consecutive years that teachers came to understand their subtle differences and the strengths of the KBC model. As commented by the Classical Studies teacher at the end of the second year:

> The first year I thought it was sort of really a community inquiry thing…it's about a research team working together, sharing ideas. This year I've realised that it's about improving ideas…that you're continually sort of digging and try and improve each others and that it's an ongoing process…I think it really challenges you to think outside the box…I value an inquiry approach to learning…but [knowledge building] really takes it to another level.

To help teachers understand the KBC model, the differences between knowledge creation and learning should be discussed first (refer Table 3), then followed by a discussion of the differences between the KBC model and inquiry learning (refer Table 4).

Table 3: Distinctions between learning and knowledge creation

	Often conceptualised as	**Pedagogical goal**
Learning	An individual, internal cognitive process of knowledge representation and understanding	To improve what is in the student's mind
Knowledge creation	An external process of producing ideas, explanations, and theories by the whole community, for the benefits of the community	Students working collectively to create and improve ideas being treated as external, public cognitive artefacts

Source: Scardamalia & Bereiter (2010)

Table 4: Distinctions between knowledge building and inquiry learning

Knowledge building	**Inquiry learning**
Creating community knowledge as the goal. Personal understanding will also be deepened as a result.	Deepening personal understanding as the goal. New ideas and knowledge may be generated as a result.
Epistemic agency.	Learner agency.
On-going idea development.	Project- or task-based.
Investigating authentic questions/problems.	Investigating authentic questions/problems.
Students working collaboratively.	Students working collaboratively.

Teachers also need to make sure that their students have a good understanding of the knowledge building process from the outset, as this would affect how they participate in the knowledge building discourse. In our project, students in the three most successful classes (in terms of how the knowledge building principles were used and the amount of ideas contributed and developed) were keen to build-on ideas, which was partly due to their deeper understanding of the knowledge building principles, as compared to students in other classes. The following examples showed their understanding of knowledge building:

> We sort of collated a few of our own different ideas and we ended up coming up with something that was, completely different than any of us had ever initially thought when we looked at [the Artist's] work. (S27, Art History)

> We all sort of used and developed…extended each other's ideas…I drew stuff from the students as a whole…if I used an idea, it might be one person's idea. It might have been an idea that was developed by multiple people. (S48, Classical Studies)

> Some of the students were getting fairly creative with their ideas and as a group, we work quite well in developing those ideas and then we're making them more realistic. (S12, Physics)

Roles and responsibilities

The roles of the teachers and students in a knowledge building class should be clarified from the outset, as they are different from a conventional class. For example, the Art History teacher considered her role as a thinking coach, not a knowledge provider.

> My role was [a] thinking coach and the students' role was, I labelled them co-curators, being art history, to try and shift our thinking about what we're actually doing and just break up that idea of the traditional teacher/student type roles.

In her class students were responsible for generating content collectively. Students were encouraged to ask questions, conduct research, provide answers, and generate new ideas. They were considered epistemic agents capable of taking control of their own learning. The Art History teacher further commented:

> Putting students in charge of content is not about abandoning them. It's about supporting them to engage and learn, just a different way…they engaged more quickly at a much deeper level with the content than when I deliver it…

The Physics teacher discussed three key knowledge building concepts with his class in the first day of the project, that is, "all ideas are valid. All ideas are improvable and all ideas belong to all of us, the community". He highlighted the importance of the community concept, pointing out the reason "why we can do this and that we're all in it together, working together for our own ultimately personal gain in terms of a qualification but there's absolutely no competition for the mark at the end so everyone can conceivably get excellence".

If students are to exercise collective responsibility in creating and improving new ideas, it is essential that a strong sense of community be developed from the outset. As pointed out by the Art History teacher:

> …developing that sense of community and trust…was pivotal because it did take a bit of coaxing to get people started and it still takes coaxing…and remaining really positive. So there's this constant kindness and coaxing going on. The more I do it, the more they engage…I realise they do have a real sense of responsibility to each other and they feel pressure and stress of needing to contribute. They definitely feel that and that tells me that they have a sense of responsibility to the community.

The failure to develop a collaborative culture was a key factor why the Economics teacher reverted to conventional teaching in his Year 12 class in 2013. The Biology teacher also found it difficult to develop a collaborative culture in his small class (five students), which may account for the lack of idea development in this class.

In this project teachers had to tackle the problem of uneven participation, as a small number of students in every class contributed proportionally a much larger share of notes and annotations. As can be seen from Table 5, Classical Studies and Economics classes had the most uneven contribution and in contrast, Biology had the most even contribution of notes, which was followed by Art History (refer Table 5). While we know that participation is often quite uneven in online discussions, we had hoped that students in a well-designed knowledge building community would behave differently.

Table 5: Contributions of notes and annotations

Class	# of students	Average contribution per student (%)	Contribution by the top contributor (%)	Contribution by the three top contributors (%)	Contribution by half of the class (%)
Art History	12	8	17	44	68
Biology	5	20	28	80	55*
Classical Studies	20	5	22	56	85
Economics	17	6	18	49	80**
English	20	5	15	37	73
Physics	11	9	23	58	75***

*contributed by 40% of the class
**contributed by 47% of the class
***contributed by 45% of the class

One way to encourage participation is to discuss with students the benefits of developing confidence and dispositions in creating knowledge. This includes a discussion of the nature of the knowledge society, the important of agency, and the skills that students will develop in a knowledge building community. Students also need to understand that the KBC approach will support them to excel in both internal and external assessments. The following comments showed some of the benefits of knowledge building:

> I've thoroughly enjoyed the method that we've used, it's so much focused on us learning…we have to find it out ourselves rather than just being told the answers…I feel a lot more confident going to university now. (S27, Art History)

> We've kind of had to sort of do it ourselves…[the teacher] giving us an idea of what we need to do but we've had to go and do it ourselves which I suppose is good for like next year when we have university. (S54, Classical Studies)

Open-ended inquiry

Teachers in this project viewed knowledge building as a process, which began with asking a question, then sharing of individual ideas and information, and finally with ideas being built-on collectively by the community. However, the reality is that not every topic of study in the school curriculum is suitable for open-ended inquiry. As pointed out by the teachers, in some content heavy areas, direct teaching would be required. While our goal was for teachers to use the KBC model for the whole school year, some of them only used it interspersed with traditional teaching. One way to tackle this is to set up some "what" views to deal with content, while open-ended topics are discussed in other views.

We observed that whether the topic of study was open-ended and whether explanation-driven questions were asked during discussions were key factors affecting development of ideas. As pointed out by the Physics teacher, in order "for some knowledge building to happen", it is vitally important to ask a good start-up question which is open-ended.

> To use an extremely extreme case, if you were to ask something…like what's the capital of Papua New Guinea, they will find the answer, full stop, that's it. No knowledge building. You've just got a bit of information...It's just regurgitation…what I was doing last year with my kids was, there was a large element of regurgitation, a large element…but this year, I've got a better idea of how to get it in terms of the sorts of things I need to present to the kids…it's really important that you're asking something that allows for some knowledge building to happen.

Asking explanation-driven questions, i.e., "how" and "why" questions would encourage students to generate theories, while asking "what" questions would usually facilitate information sharing. As an example, the view with the highest proportion of communal idea development notes in each class was analysed to understand what types of questions were being asked. (A coding scheme adapted from Damsa, Kirschner, Andriessen, Erkens, & Sins (2010) was used to code *Knowledge Forum* notes into (a) questions; (b) sharing of ideas and information; and (c) development of communal ideas). As can be seen from Figure 1, students in the Physics and Classical Studies classes, two of the three most successful classes, asked many more questions than students in the other classes, and many of these questions were explanation-driven. In contrast, in the Biology class, the teacher asked all the questions and he contributed 44% (16 out of 36 notes) of the notes in this view. However, in the Art History class (the other successful class), students had asked no questions, but they did engage in an in-depth and substantial communal idea development process. The reason was that the teacher had asked a good open-ended starter question.

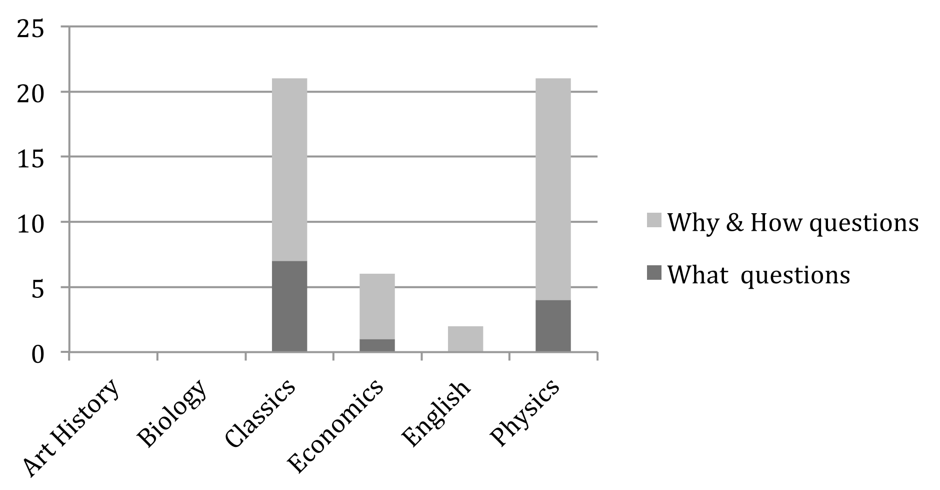


Figure 1: Types of questions asked by students

Conversant with *Knowledge Forum*

In the project, there were two technology-related issues that teachers were interested to explore. The first one was whether it was more difficult to implement the KBC approach in distance classes, and the second one was whether *Knowledge Forum* was an essential tool to support the knowledge building process (Lai, 2014a). With regard to the first question, it seems not to be the case, as two of the most successful classes in the project were distance classes (Art History and Classical Studies). In fact, distance students in these two classes were more familiar with online text-based discussions than the on-site students. However, as distance students came from different schools, it was important that their home schools were aware that a new pedagogy was used and they should provide technical support. According to the Classical Studies teacher, "that's something that an e-teacher has to take a lot of responsibility to try and set that up". For the Biology teacher, distance teaching using the knowledge building approach was not a problem however, the lack of control of the technical environments of the home schools posted barriers.

As for the second question, we found that while in theory it was possible to undertake knowledge building without having to use any collaborative technologies or *Knowledge Forum*, in practice it was difficult to scaffold knowledge building (e.g., facilitating distributed expertise and tracking idea developments) without using *Knowledge Forum* (Lai, 2014a). We had used and reviewed several software packages (e.g., Muarl.ly, Padlet) and found *Knowledge Forum* the most effective software to support knowledge building because it was designed based on the twelve knowledge building principles (Scardamalia, 2002). For example, the English teacher felt that her students could have done knowledge building on a piece of paper but *Knowledge Forum* helped support the knowledge building process.

> They can do it on paper…I've had the big A3 sheets of paper out and…keeping a record of it…but you don't have to have [*Knowledge Forum*] in order to have development of ideas. What you're doing is capturing it [but] when [*Knowledge Forum*] becomes easier to use, and more intuitive and there's more of a flow to it, then I think the development of the ideas will come faster and it will seamlessly integrate into the classroom.

Before introducing *Knowledge Forum* to his class, the Physics teacher took a butcher's paper and some post-it notes to the class (refer Figure 2). He started off by asking a simple question, and then asked his students to write down their ideas on a post-it note, and stick it onto the butcher's paper. He also wrote some thinking prompts (e.g., "my theory", "I need to understand") on the whiteboard and asked students to use at least two of them to help frame their thinking. This example shows that it is possible to simulate the knowledge building discourse without having to use *Knowledge Forum*. However, as pointed out by the Physics teacher, it was essential for him to use *Knowledge Forum* with his class in subsequent sessions, as it was too difficult to record and develop complex ideas on papers (Lai, 2014b).

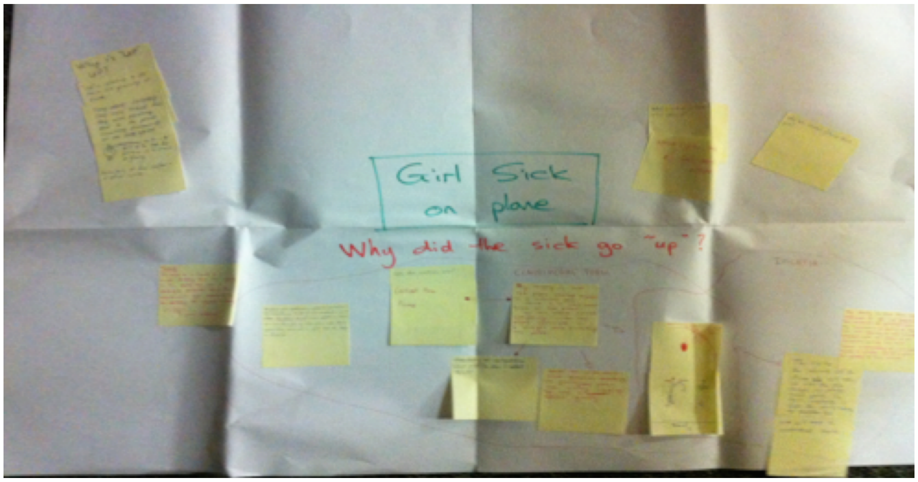


Figure 2: The butcher's paper

Evaluate progress

Ongoing monitoring is essential to encourage student participation in the knowledge building community and to assess the extent to which new ideas had been developed. We found that annotations could be used as a tool to affirm students' work and encourage them to develop ideas further (see Figure 3). Also, views could be set up to help students monitor their progress. For example, in the beginning of the year a view called "Sharing learning problems" was set up in the Art History class. A view was also set up during each assessment period for students to review other students' work. To help students understand the knowledge building principles, a view was set up at the end of each term (e.g. Term 1 review) for them to discuss and deepen their understanding of knowledge building (Refer Figure 4).

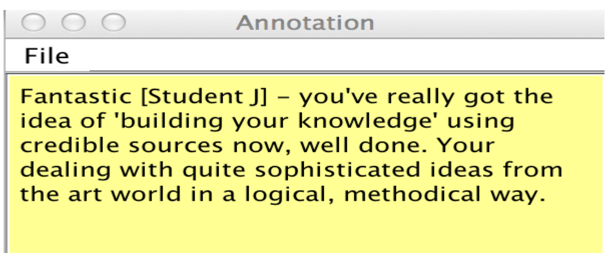


Figure 3: Example of an annotation

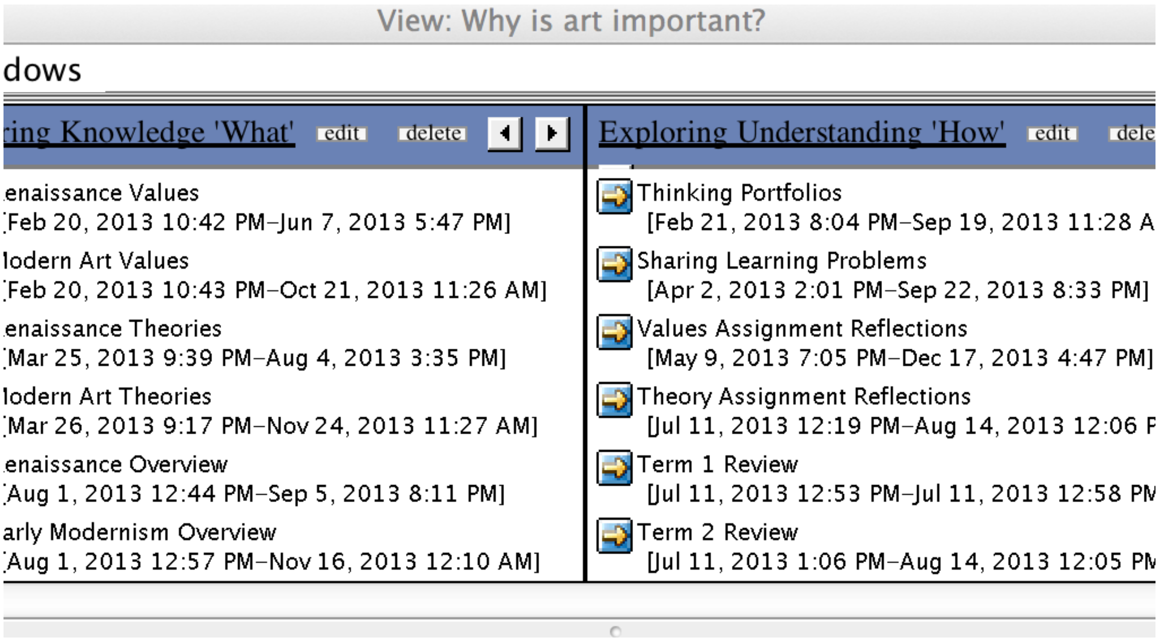
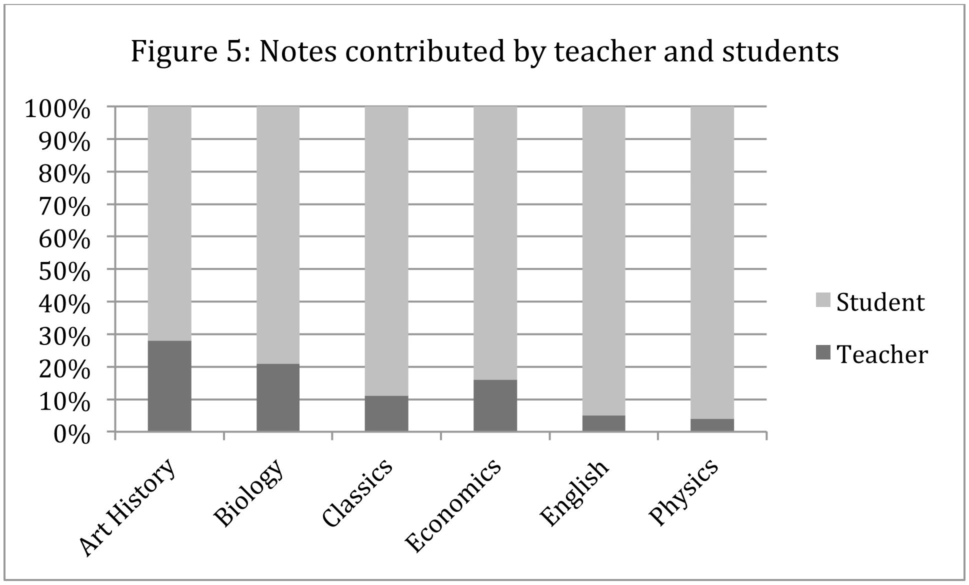


Figure 4: Views for monitoring progress

Structure

While we observed that an activity structure should be put in place, as students could be easily “side-tracked”, “got-off topic”, and “didn’t focus much on the task at hand” in an open-ended inquiry process, as pointed out by some Physics students, flexibility was also needed. It seems that year levels had little to do with how much structure should be put in place. In the project all Year 13 classes had a more flexible structure where students had freedom to explore and direct their own investigations than the Year 11 classes, which had a tighter structure. For example, in the English Year 11 class, the topic of discussion and start-up questions were all pre-determined by the teacher for each *Knowledge Forum* discussion.

How often should teachers project their presence by contributing notes to *Knowledge Forum* is an open question. As can be seen from Figure 5, the Biology teacher had the highest percentage of contribution (21%). In fact, in one of the views, the teacher provided all the discussion questions. The Economics teacher also had a strong teaching presence, contributing 16% of the total number of notes and annotations in the online discussions. These notes included questions for discussion, resources on the topics of study, and comments on ideas and information provided by students. He considered himself a “knowledge transmitter” and quite “teacher centric” in the beginning of the project and this might have accounted for his high teaching presence. However, while the Art History teacher encouraged her students to take control of their learning, she also had a high teaching presence due to the large number of annotations she had contributed, which was used primarily to affirm and encourage students’ participation.



Show evidence of knowledge building

In the New Zealand education system, students are assessed both internally and externally in the last three years of secondary school (Years 11-13). The New Zealand's National Certificates of Educational Achievement (NCEA) are national qualifications for senior secondary school students introduced in 2002. There are three levels in NCEA, and each has its achievement standards (AS), assessed through internal and external assessments.

In this project all but one class (English) integrated NCEA internal assessment standards into their knowledge building classes in 2013. For example, in Art History and Classical Studies, students were asked to synthesise ideas they had developed in *Knowledge Forum* to produce an evidence portfolio for summative assessment. The Art History teacher asked her students to produce a thinking portfolio (refer Figure 6). As explained by the teacher:

> I changed from writing an essay [for internal assessment] to writing a synthesis statement [using a] portfolio in *Knowledge Forum*. So in effect [students] were gathering written evidence of their thinking and that evidence can be applied to assessment…What I also got the students to do was…there's view…where the students read each others' synthesis statements and made comments…So I would basically copy and paste synthesis statements into a note so it would be anonymous and then I encouraged students to read at least three or to make at least three comments and I kind of framed it up saying what I want you to focus on is how this, how the student has structured their writing.

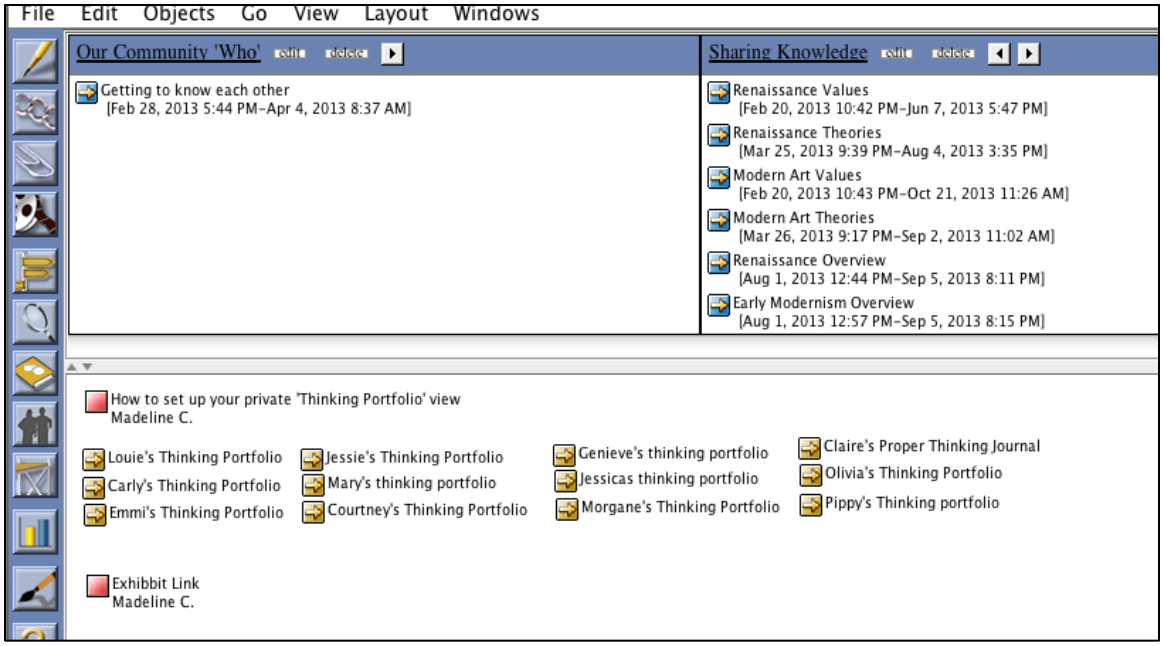


Figure 6: Thinking portfolios

She was very impressed with the quality of her students' work.

> In the last internal that most of them did, I was quite blown away. There were quite big shifts…I had a couple of students who had jumped merit into low excellence and I just didn't think that would happen.

While we found portfolios a good tool for assessing students, it is hard to separate individual ideas from communal ideas presented by students in the portfolios. We were unable to find ways to assess communal ideas, as pointed out by the Biology teacher:

> I think the biggest obstacle is that when we think [about] assessment, we are thinking of the evaluation of individual learning and [in] knowledge building, you're really wanting to assess the collective product and there is a bit of a disjoint there of what culturally we're trying to do, which is assess the individual rather than assess the community's building on understanding.

Conclusion

In this paper a practice model developed as a professional learning and development tool to support teachers to implement the KBC model in their classes was discussed. We feel that it will be helpful for knowledge building teachers to consider the elements included in the model. It should be noted that implementing knowledge building in senior secondary classes is not an easy task. Using the KBC model involves a change of pedagogical beliefs and teachers have to be willing to commit to change. Developing and integrating the KBC model into the school curriculum involves many complex issues, for example, the question of how much structure should be provided in a knowledge building class has not been adequately investigated. In the study we also focused on developing new individual assessment methods but how to assess communal knowledge has not been dealt with. Sustained professional learning and development supported by the school leadership is required to encourage teachers to use the KBC model in teaching and learning.

Note

1. The PROCESS model was initially called the PROGRESS model (Lai, 2014a).

References

Damsa, C., Kirschner, P., Andriessen, J., Erkens, G., & Sins, P. (2010). Shared epistemic agency: An empirical study of an emergent construct. *The Journal of Learning Sciences, 19,* 143-186.

Lai, K.W. (2014a). Transforming New Zealand schools as knowledge building communities: From theory to practice. *Set: Research Information for Teachers*, number 1, 33-41.

Lai, K.W. (2014b). *Designing knowledge building communities in secondary schools: Final report*. Wellington:

New Zealand Council of Educational Research.
Scardamalia, M. & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97-118). New York: Cambridge University Press.
Scardamalia, M., & Bereiter, C. (2010). A brief history of knowledge building. *Canadian Journal of Learning and Technology*, *37*(1).

Acknowledgements
This project was funded by a Teaching and Learning Research Initiative (TLRI) grant from the New Zealand Ministry of Education. The author would like to acknowledge the support of the teachers and students participated in this project, in particular, Ken Pullar, Ann Trewern, and Fiona Stuart. The author is also grateful for the editorial assistance provided by Dr Lee Smith.

Innovative Practice in Modern Languages – a Flavour of Knowledge Building

Niall MacKinnon Head teacher, Plockton Primary School, Highland, Scotland, UK,
nlmackinnon@avernish.co.uk

Abstract: This paper gives an account of a single lesson. It articulates the author's nascent introduction to Knowledge Building. The lesson articulates values which predate the author's own awareness of the Knowledge Building concept. The purpose of this paper is to demonstrate a congruence of approach leading in to the core conceptual realm of Knowledge Building itself – the notion of idea improvement. The discussion of the lesson forming the case study is used to juxtapose different notions of curriculum and how they have come to be articulated in school education change, both at national system level and at school level. Based in Scotland, itself going through major reforms articulating a major shift of approach to its curriculum, the paper points to similarities of changes across education systems. The author concludes by arguing that concepts come to have a readiness for application through congruence of similar processes. As a practitioner he explains why he is attracted to the Knowledge Building concept and how he will utilise it as part of a learning journey he found he was already on.

Introduction

During the last few years some big changes have come sweeping over schools. This is due to a technological revolution, which has spawned major social changes. Children themselves are changing because how they and their families interact with the world is changing. As technology has opened up new operational possibilities across so many human domains school educators have had to rethink their relationship to pedagogy. This has then gone further – rethinking the basis of pedagogy itself as modes of thought in society shift.

At the ICSEI 2014 congress in Java, Indonesia I presented an account of a journey of practice change, and thinking about practice change, pertaining to my own job role and function as a primary school teacher and school principal (MacKinnon 2014). I outlined how my own job as a teacher has fundamentally transformed since the millennium and out of all recognition since I started teaching over thirty years ago. This has embraced far more than technological change, for children now use new media in new ways, ones that transform the basis of knowledge itself – what is known and more importantly how it is known. In particular new interactive and collaborative learning modes have moved away from a transmissivist (Priestley 2012) approach to pedagogy which is essentially individualist. This has been operationalised in corporate terms by what Biesta (2009) has turned 'learnification'. An obsession with individual targetised approaches arose which came to be subsumed under an overall ethic of performativity (Ball 2003). But current social changes and technological forms operating in tandem are disposing to interactive and collaborative learning activity. New literacies are causing information to be stored and processed in new ways via new media. Accessibility is changing the nature of human memory and information processing. This causes shifts in the nature of knowledge itself. What is known and how it comes to be known transcend the individual. But social change, technological change, and pedagogic change have been recently so rapid that the ways and means of organising school education practice could not keep up – that is management, evaluation, assessment and the conceptual tools which bind these altogether.

My own practice has been innovative, embracing new media, new technologies and new approaches, working with partners near and far. Yet in now attending my first conference on Knowledge Building my first introduction to the term and the school of thinking that gave rise to it was at the start of 2013 at the ICSEI Congress in Santiago, Chile on hearing Marlene Scardamalia's keynote there (Scardamalia 2013). However whilst the Knowledge Building concept was new to me, in terms of its specific conceptualisation and method, many of its components were not, in terms of a changing problematic of school education practice (MacKinnon 2012; 2013).

My purpose here is to draw my first practice link specifically to the Knowledge Building school of thinking established by Bereiter and Scardamalia (1993). I present an account of a single lesson. The lesson fits in with a change of approach to curriculum and its organisation which had arisen as my response to a changing pedagogy, here in Scotland but more broadly. As my own introduction into Knowledge Building the particular mental patterning of the concept is new to me – as a conceptual and operational formulation – yet so many of its components are not. They pertain to the very issues I had been grappling with, along with colleagues and members of this school community, including most particularly the pupils. For whilst younger primary age children may not formulate or draw on theories of pedagogy their personal and social development is intimately bound into their own means of making sense of reality, including, or rather especially, social reality.

The lesson

For a few weeks of one recent school session I took the French class whilst the usual teacher was absent. For a while now I had wanted children to ‘get the point’ of learning a modern language and thus to give Modern Languages in the Primary School (MLPS) a new focus. I was considering some approaches and methods. I felt a greater need for them to feel the need for a real purpose in learning another language, and to get some exposure to ‘real’ French. I tried two approaches which I then linked together.

We have an exchange school partner in France and were already in process of writing and exchanging letters. I decided to give these letters more of a focus. In both schools the knowledge of the other language is limited. However both languages are on the curriculum of the other school respectively. Our letters were written in English and French bilingually. We decorated them and put in pictures. They were well received. We received some back likewise. The native language used in each case was naturalistic and with honesty the children said they could not understand them very well.

However I found when I read the letters to the children in French they enjoyed listening and were then really interested to find out what they meant. This was a real letter to them from a real child. I’m not making too much of this, it was only a few minutes, but I noted real interest from a real human connection. It did not matter that the language was ‘above them’. Having got to know our correspondents via this indirect route we then said we could exchange some films. Both schools had been exploring video in different ways. The French school had recently acquired a camcorder and we were conducting some work in animating stories we had written.

This gave me an idea. We had been writing some stories. I realised that there would not be much point in sending these to them given the language level. They would not understand them. However as part of utilising Information Communications Technology (ICT) in the curriculum we had been experimenting with a film-making package called ‘Revelation, Sight and Sound’ by Logotron. This piece of software allows children to animate a story from still frames, add a voice track and various sounds and effects. It is a good piece of software for use with primary age children because it combines the element of simplicity and ease of use with an attractive and effective interface yet with a professional look and feel. This makes it easy to accomplish the final product. It has a professional styled visual display for the various film tracks – video, sound, effects etc, but it is specifically designed for a primary child to use. It also has libraries of sounds and effects. I found it very easy to use and could start using it for a productive purpose almost from the word go. We decided to use it for our stories and to write some specifically to be made into animated film-stories.

At the time of taking over these lessons in French we had already made some film stories and the animated film software had been inspiring the children’s writing. This is where I had the idea of using it for MLPS. I did this in two ways. In my view a lot of teaching comes from serendipity. I had a good friend staying with me from France and was playing around with the films at home, refining the sound and image tracks. He was interested too and we thought, how about a French version and an English version? I thought of this as a route to enhancing the link between the two schools, for them to receive one of our stories written by the children, but in French. Hey presto, we had it. Well hey presto and an evening’s work. However another idea then occurred to me.

Back at school the next day I played a trick on the children. I said I had a story for them to listen to and then I played them the sound file we had just recorded. I said, “listen to this” and let the tape roll (well I clicked the MP3 file actually, but that doesn’t sound so poetic). They soon groaned and moaned. They can be like that, modern kids that is. We might be in the remote North-Western Highlands of Scotland but these are modern kids.
“We don’t understand. We can’t speak French”. So I said, “listen” and they did, still looking non- plussed. I said, “What was that about?” They looked even more puzzled, some adding “dunno”. This was something they were clearly not used to.

I said, “Yes, you do know”. “No we don’t” “Yes you do. Listen again”. They listened again but now I added a clue: “See if you can hear about any animals.” They then listened a bit more intently. A couple of minutes further in and they were all enthusiastic, calling out “zebres”, “gazelles”. And then they got it in a oner (pron. ‘wunner’). Having just written these stories and made film stories a couple of weeks before, they recognised this as the sound track to Claire’s film story, though now in colloquial, idiomatic French.

Then we watched it. And they watched and listened to it transfixed. I could see a sort of amazement on their faces. This was one of their stories now as an animated film, but here it was coming back in French. It didn’t seem to matter that the language was flowing over their heads. They didn’t seem to mind. But perhaps that is because it wasn’t now simply washing over them. They didn’t ‘understand’ it, but they were engaging with it. My interpretation was that they were enjoying the sounds, that the sounds had real meaning, which they were following with the pictures, and in any case it was a story they knew anyway. That was because it was their story. They now looked pleased, and there were no groans. I told them I’d had the story translated and had a friend over from France staying with me just now who’d translated the story. They liked that, and also that I was thinking about them out of school. I could see Claire looked interested. Something was happening to her story.

Then I asked them something else. I said, "How much of that did you understand in French?" Back to the frowns, groans and grimaces. "Right," I said, and I gave them a task whilst listening. I said, "I want you to listen to this again. And here's a question. What's the French for a towel? I'm not giving you any clues. Also listen for any words you already know and here's a hint – listen out for any parts of the body and anything about the weather. Oh and what's the French for a swimming pool?" I also said, "Don't shout out. You can raise your hand when you hear a word you know or can understand".

They seemed quite interested now and eager to listen to the film again. From the off hands were shooting up all the time. At the end I asked them what they recognised. So then I quizzed them. The words flowed out, starting with 'gazelles', 'zebres', which they had already spotted and then many others which were exactly or nearly the same in English: 'feroce', 'lion'. But my clues were working and a couple of the children were listening for the body words and identified 'yeux', 'pied', 'bras'. 'Chaud' for 'hot' was spotted. 'Serviette' was identified as the French for towel and we had a really interesting discussion about how words can flow between languages and shift to a different meaning which is similar, holding on to something in the switch over, but also changing. Another child identified 'jaune'. She had been listening out for colour words. Of course I also knew that she knew the story and that she knew the word 'yellow' was in it. But that was not the point, she was now decoding French, but not just artificial sentences of known vocabulary, but real French spoken in real time, not simplified, but idiomatic. But still she located the word. Another child identified 'topaze'. And another child answered my question to give me 'piscine' for 'pool'.

During the film I was quite surprised at the frequency with which the hands went up and thought "Surely they haven't learned that much from this?" I said to them that their hands had been going up a lot more frequently than just the words they had given me. I asked them, "You seem to have some other words," genuinely puzzled. Out they poured: "le', "la", "avec", "elle", "mais". I had not expected that. But they were now listening intently and saw it as a game. They didn't have to understand the sentences, just decode words and locate ones they knew. That is what they had done, just as requested. So was it that they were not then switched on to the 'real' meaning? Quite the contrary, by doing this I felt that they indeed were understanding. They were trying to extract meaning. They were treating it as a game and a challenge and adopting different strategies: listening for words they knew because they might be the same or nearly the same in English, identifying words from their admittedly limited French vocabulary, then all the common link words, even if they just stood on their own, and then my two target words which did not really fit any of the above, 'serviette' and 'piscine'. Both were identified. Another child said "Rhiannon" the subject of the story. "Excellent", I said.

We did not take overly long to do this. But the children became switched on to problem-solving, now for a modern languages lesson. Hitherto they had learned French words and then used them in language constructions almost entirely set in language contexts containing only known words. That was what they were familiar with and was why I got the groans when I asked them to listen to the story in idiomatic French with no clue. In discussion they agreed that this was what usually happened. We looked into what it was that they were now doing differently.

What had been happening was that they had started to cue into words they knew without worrying about those they didn't. They now had a more limited aim to 'identify words' rather than the overwhelming 'understand this'. Of course the words they knew were completely surrounded by words they didn't, but the P6/P7 pupils picked up on "jaune" – yellow, "fille" – girl and others like this from their existing French vocabulary. They also got unknown words from their context: 'serviette', 'piscine'. But this was a different listening experience, identifying an unknown word from its context. Hitherto sentences in second language lessons in primary school were always of the known.

We then had an interesting discussion about learning languages when young. I asked them: "How did you learn English? Did you only stick to words you knew? Did people only speak to you with words you are already familiar with? Did they teach you vocabulary?" Some looked surprised, but several of them smiled and looked knowingly. They agreed that this was not what happened.

So what new French language had they learned? By the end of the lesson, in content terms, perhaps no more than 'serviette' (towel) and 'piscine' (swimming pool). But I felt they had learned much more. The experience had taken their learning somewhere else. They had gained confidence in tackling a modern language, through access to tools to decode it. They had also found out for themselves that they could understand a lot without worrying about whether the whole piece was intelligible. And also that this didn't matter.

I then also said that of course this was easy once they realised this was Claire's film story. They knew this story already. In discussion they agreed this made it a lot easier. But then I instigated some further discussion. I asked them, "Isn't this true of most speech?" We discussed the fact that most of the time you have a pretty good idea of what is being talked about because you are there, and can see what is going on and already know what is being talked about. This helps you learn new words because you can guess what they are. The children were interested by this.

In watching this film they could also see a real purpose. I hadn't had this translated to play a trick on them, but to enable the children in our French partner school to understand one of our stories. This lesson was a by-product. I felt this was a successful lesson. Only one, and one undertaken fairly spontaneously from using other contexts which had all arisen at the same time: me taking over the French class for a short while, making film stories in writing lessons, having a French partner school, vaguely thinking of ways of livening up the French school link, having a friend to stay from France, exploring the potential of ICT, my views on second language learning and thoughts of how to make it more engaging.

It now occurs to me that this approach also has something to say about the nature of learning, particularly as we are changing national curricula just now in Scotland. In a primary school 'the curriculum' and 'courses' are not necessarily the way forward. I am suspicious of overly pre-written structured learning, which is then audited to death: 'Does the course contain breadth and balance over all the elements? 'In what way does structured progression occur?' and so on. For me I had been exploring the potentiality of the incoming Scottish 'Curriculum for Excellence' (Scottish Executive 2004) in a new way, following Pasi Sahlberg's (2007) notion of the 'Curriculum as Process', which I have written on elsewhere (MacKinnon 2011). In the approach adopted here the primary planning focus is the learning process which leads to the assemblage of content and activity, not the other way round. Hitherto much curriculum planning and design has been the opposite: constructing courses to fit desired outcomes, with outcomes 'emerging' from coverage. Hence the all-pervading topic grids in 'environmental studies'. I remain suspicious of this in the primary stages, and note a more experiential, community-focused, and enterprising approach emerging, now specifically asking us to free up and look for real contexts for learning.

I would also add a cautionary note concerning assessment, and in particular matching learning goals to assessment. In this school we have been trying out many strategies in 'Assessment for Learning', and have recently conducted a two-school project with funding from Learning and Teaching Scotland (the then national curriculum development agency). But here too I see a counter element. Let's suppose this lesson was part of a lesson 'observation'. What were the learning intentions? Were these shared with the pupils beforehand? Early in the lesson, or even at mid-point, what answer would the children have given to being asked what they were learning and why. Imagine if when listening to the sound file they had been asked, "Did you understand that?" Answer: "No". Or, "Why are you listening to this?" Answer: "Dunno". Or "What are you learning here?" Answer: "Not sure". Or even very late on, "What have you learned?" Answer: "Er......"

Think how would this might have fared on an inspection audit of 'meeting children's needs', or 'matching lesson content to children's prior knowledge', or any other criteria from the audit-indicator mindset, ticking off audit gradings against lists of indicators? How would this lesson have fared if scrutinised in such an overly mechanistic and observational mindset with follow-on 'feedback'? Yet through qualitative and collegiate dialogue based on other pedagogic principles a very different story emerges, the one I am telling here. So on the one hand it might seem that the children had not 'learned' much, adding 'pace: poor' to the woe, and overall 'impact: none'. I could very much potentially see this as 'feedback', in a grading, observation-orientated ethos of school quality 'monitoring' from the performativity mindset. But in fact the children here were aged six to eleven and all successfully identified and located French words in a colloquial and idiomatic context, including some with virtually no French knowledge whatsoever.

So for me this is a cautionary tale. The idea came to me to 'take' the children's learning somewhere else. I wanted to puncture a few presuppositions, and give them an insight into how language 'worked'. There can be times when it is important not to be explicit about where a piece of learning is heading precisely because 'giving the game away' early on would take away the whole point of the experience. For me this particularly applies when the learning outcomes concern developing informed attitudes and insight into learning modes as here. I was not focussing on coverage or pace or impact, which are central evaluation tools throughout the UK. The dynamics of this lesson did not fit a looping sequence of 'intention – activity – recap – assessment – outcome – next steps'. It is just as important to understand processes of learning qualitatively in terms of intention, process, realisation and insight gained. Narrow audit-indication, pre-specified structuring of learning, mechanistic processes of acquisition-activity- assessment, and attempting to quantify processes of learning through scalar measurement as grades to fixed precepts might not necessarily be best means of trying to ascertain and understand 'what is going on' in assembling meaning, the essence of learning. We need to give far more weight to interpretative and collegiate understanding through joint dialogue and formative methods in the development of learning strategies by pupils and teachers in schools and the synergy between them.

After this lesson I felt that some of the children had some new insight into how languages worked: that unfamiliar language needs to be decoded, and that they can apply this skill as much to a foreign language as to their own. So what had they learned? For me the principal outcome was attitudinal. Not to be intimidated by a foreign language. It is only speech after all. You can decode it. A couple of weeks later our French partner school sent us some camcorder film of our correspondents talking and showing us their school and some of their activities. They spoke in fluid fluent French. We watched and listened. Everyone in the class watched and listened intently and not one of them said anything about not understanding it all, nor did they make any comment about unfamiliar words and expressions used. These were just kids talking to kids.

Conclusion

This lesson occurred before I had ever heard of Knowledge Building in the formal sense of that concept as articulated by Carl Bereiter and Marlene Scardamalia (1993). Yet my own journey as an educator had taken me into an arena of practice change and conceptual development very much within the territory of those who formulated and then utilised and developed the Knowledge Building concept. Thereby I have made the effort to come to this conference and prepare this paper. I have done it to develop my own practice as an educator, whilst communicating with others in that role. I have done it by entering into its conceptual space, thereby as an exemplification of 'design mode' (Bereiter and Scardamalia 2003). I see my own practice as an improvable process but not moving to 'best practice'. That is why I have turned away from the discourse of 'excellence', which has become central in Scotland (MacKinnon 2008; 2011; 2012). This is not easy in a national curriculum change programme which has labelled itself as an absolute, around this term – Curriculum for Excellence, founded in 2004 (Scottish Executive 2004).
I have moved towards adaptivity, not in an ad hoc manner but systemised to purpose. That is by definition malleable, for even within overall frameworks and commonalities of principle, which I commend, micro-purpose shifts – this student, that situation, this context, that event etc. But Knowledge Building transcends the individual – educator and student. Ideas and processes become mental constructs to be worked on. Thereby malleability becomes built into the core, not as an add-on to meet changing circumstance. But the appeal of the Knowledge Building concept, and its application, is because it transcends system or practitioner adaptation, and places idea improvement as a core goal of school education itself – not just what educators do, or what students do, but what students and educators do together. Thereby in a class setting educator and students may set about improving how they function, for their purposes, which they will work on formulating (albeit within grander overarching frameworks). Thereby Knowledge Building transcends the hackneyed term of 'teaching and learning', which disposes to transmissivist modes of thinking, leading to hypertargetization and individualization – Biesta's (2009) 'learnification', Reeves (2013) 'assessowork', Fullan's (Ross 2008) 'administrivia', Sahlberg's (2007) 'product model' of curriculum and on to Seldon's (2010) 'factory schools'. Conjoined these turn into a surveillance monolith as per Corbett's (2008) 'edumometer' and Ball and Olmedo's (2013) 'neo-liberal governmentalities' in school education. All learning activity then becomes grade assessed, against 'best practice' absolutes even if the criteria pertaining to purpose has long moved on, or does not apply as a generality for all students in all contexts and institutions. Yet certain school practice grading schemas such as Scotland's How Good Is Our School? (HMIE 2007) purport to do just that, yet they cannot. This is the world I have been forced into. Yet it is not my world, in the sense of what it is that I really do, as per Seddon's (2003) 'value work', which as he and colleagues have analysed from case studies right across the UK public sector belie all attempts at fixed centralised graded audit indication. The reason lies in failing to 'get knowledge' of 'how the work works', and to 'absorb variety' grasping the nature of 'the work which makes the work work', which, if not grasped, drowns public service practitioners in 'waste work' (ibid). How do the actions and mental processes of the participants of a primary classroom gel? What is the nature of their 'variety'? What provides the coherence of form and function? I see the direct link to Knowledge Building through the notion of idea improvement, but not best practice. This drills down into such basic entities as 'curriculum' itself, which the performativity mindset thereby enshrines in terms of Sahlberg's (2007) 'product model'. I do not see curriculum as a corpus of content, nor skills, but as a set of principles to be articulated and realised through interaction with real children for real purposes, ones articulated with them via their dispositions, realisations and world views. Through those they garner skills, and knowledge and on to the sensibilities which form them as a person and as a community. It is anything but a 'product model' of curriculum.

So am I arguing for a 'do what you like when you like as you like' curriculum? Would a class, school, local authority, school chain or school system function well on such a model? I don't think it would and I am not arguing for such. The lesson gives an appearance of being ad hoc but yet it was not. It did not simply 'happen'. There was a huge amount of predisposed structuring. Just because the usual teacher was not available for a few weeks did not mean I sent the children home. We had an overall curriculum structure which had placed French on the curriculum. I continued that. So I did not abandon 'the curriculum' either. Seeking to administer other teacher's plans does not work easily. I knew these children since I taught them regularly. I knew their capabilities and dispositions and what other tasks and goals they were immersed in. I was operating within higher order outcomes. I was opposed to a disconnected knowledge based curriculum, which has a long pedigree. I was attracted to Gardner's (1991) notion of the 'unschooled mind' forming a professional disposition that true learning only occurs once there is ownership of purpose. Of course children may become culturally disposed to the notion of 'lessons' and be habituated to levels of compliance in their modes of operation. They could turn up to a lesson called French, partake in activities devised by the teacher – ones prefigured with 'learning intentions' – yet not really place any intentionality on their actions. Some memory pertaining to the content may remain – "Je m'appelle Claire". Through cajoling they may even be paced through content. Through bribes, threats or rewards, as per the rationales of Kohn (1999; 2011) and Bower (2013) they may even place some meaning on teacher devised exhortation to 'perform', placing value on test scores and such like, coming to see them as intrinsic goals instead of what they really are – carrots on sticks masquerading as goals. None of this for me constitutes learning, certainly not on to the higher order development of a person, yet for which language is so central.

So much came together at once. The children were making film stories and using computer programming via Logotron's Revelation Sight and Sound software to animate them themselves. The final product had given a structure and purpose to their writing which is where the old fashioned stuff came in – the 'basics' so beloved by the traditionalists. But I am not knocking that. There are a swathe of basic skills to be acquired. But it is how they do that which really matters, in what context, moving on to acquiring the dispositions to do that. All those children could, in the right milieu, if they so wished, become fluent speakers of French. There was so much more that I was trying to foster. Firstly that real people speak French for real purposes; that real children speak French and do so fluently. They may come here – move home, holiday, school trip etc, and the children here may do likewise there. There were so many curricular scaffolds – writing and language, presentation, drama, information technology, behaviour, conduct, social skills such that once the school is functioning in a dynamic sense with broader goals in place and being operationalized around purpose, context and situation, connections make themselves. They can be disposed to happen. This was one such. It could just be a passing moment, or if it worked particularly well then it could be incorporated it into another opportunity, perhaps for another group of children. In a sense then this is not ad hoc development but curriculum development. Everything that we do in school has been thought up by someone at some time. Even if novel and seemingly 'first time' it builds on patterns of expectation which are configured by prior learning and habituated modes of behaviour, for educators and pupils. What emerges is a metacurriculum. I knew where those children 'were' so to speak. This then becomes a plea for professionalization, or rather reprofessionalization, away from the over-mandated, pre-scripted, mis-audited surveillance modes of assessment and evaluation which have come to dominate so many school education systems, and as they certainly have throughout the UK. If a curriculum can operate on the basis of principles, purpose, threads and a loose coherence of framework then the detail can be filled in, not as 'anything goes' but as an adaptation to circumstance in context within a framework to a purpose. What arises can be sophisticated and detailed, but not necessarily prescripted from the outset. Thereby such a mode of operation depends on what Hargreaves and Fullan (2012) have termed 'Professional Capital'. Surveillance modes of deprofessionalizaiton prevent Professional Capital, but even worse prevent the modes of practice they inculcate. Without it school practice is different. This is why 'theory' and conceptualizations matter. This leads into improvability of ideas and the principles of Knowledge Building as articulated by Scardamalia and Bereiter (1993). For such components are sophisticated indeed but require there to be a space to function, with boundaries, but essentially fluid within their core realm. I will not overly force contrivance to this lesson example for I have stated that it occurred before my familiarity with the precise conceptualisation of Knowledge Building. But the link was there nonetheless. The normative, communicational and technological shifts disposing to the creation of Knowledge Building also disposed to the learning journey which enabled me to conceive this lesson. I will single out three component elements which have attracted me to the Knowledge Building concept and wish me to take it and apply it to my own practice as an 'improvable idea' – this school's articulation of it as a practical conceptual tool for our purposes.

The first was an authentic problem. I wanted children to 'get' the idea of learning another language and to do so using modes of learning which were part of their natural repertoire, yet which did not readily fit a 'lesson' approach. They were also already making animated stories from start to finish. It was their job to 'make it happen'. Secondly it pertained to the component of 'democratizing knowledge'. Language is about communication which is about connecting purpose. It is inherently social, so I wished the process of acquiring language competencies – here another language – to be centrally a social endeavour. This was fitting into Symmetric Knowledge Advancement. Firstly I was sensitive to the children's own capabilities and dispositions. I didn't just want them to 'learn French' but to 'learn how to learn French' and to 'learn why they may wish to learn French', which fits into my wider goal of how to learn about anything and learn about how to learn anything, or more importantly, how to learn about why you may wish to learn anything. That is about purpose. Which then comes back to my own learning.

I sought to be ready to make connections, to seek to foster motivation and to acquire insight into my own thinking as I placed those higher learning goals of myself – the essence of Professional Capital. That goes all the way to coming to this conference, and to do so with the mental preparation of preparing a paper even as a first time attendee. In there lies the notion of Symmetric Knowledge Advance for me too as my own thinking bounces off others – from the pupils in this school to local colleagues and to wider international colleagues. I then form my own specific dispositions, codifications of 'what works' to the purposes I have set myself and the wider purposes, principles and frameworks within which I operate as a practitioner – the wider goals of those who have employed me and the wider constituencies who establish schools and school systems and fund them. I have come to see how knowledge changes, and its components – concepts, ideas and so on – and to formulate an evidenced opinion to concepts, ideas, modes of operation and broader operational frameworks to which I am less attracted, or, truth be to tell, to which I am repelled. Much of the performativity, deliverology, transmissivity, excellence discourse does not work for me, as those notions have come to be applied. But I do wish students to excel, perform, transmit – even on occasion to deliver – along with a host of other dispositions and capabilities, most of which I would give much higher precedence. Here I see Knowledge Building as a key concept and why I am attracted to it. Learning becomes collaborative and thereby transcends learning. Building knowledge is beyond learning but that does not make it remote or distant.

In the example of the single lesson presented here the material used as the basis of the lesson had already been produced by the pupils. I added the twist of French translation. Thus the content was 'theirs'. I could use the familiar to take them somewhere unfamiliar, but bring them back to the familiar. I wished to demonstrate that language learning was ordinary. Yet it was also not, as the processes of learning acquisition in oral language mastery bear little resemblance to traditional instructional techniques in schools. I was trying to give a hint to their native language knowledge learning processes and thus to give an insight into processes of learning and how children could come to 'own' them by becoming aware of them in themselves – the essence of the Knowledge Building component concept of Epistemic Agency. That is to open up a chasm, which is both of individual and collective potential, and yet is the only means by which real learning occurs.

Appendix: The text of the film story

Rhiannon A film-story by Claire

Rhiannon walked happily along the dusty track on her way to the big outside swimming pool. The ground was boiling hot. All the mud had cracked and from above must have looked like fish scales. Her glossy black hair was too hot to touch and her tanned skin was frazzling.

There was a sudden rustle in the parched grass and a small group of gazelle and zebra approached her.

"That's odd" she thought, "usually they keep a distance from me, but today they're coming up to me! There must be something strange going on!!"

Then she saw the eyes. Mustard yellow eyes, glinting like topaz marbles. There was a lion in the grass, probably out for the hunt. Most girls would have turned tail and ran or screamed or done some other silly thing that would attract the beast's attention, but not Rhiannon. She whipped her red towel out of her rucksack and held it in front of her. Then she put it round her back and, spread her arms out wide. She knew that that would make her seem big and ferocious.

The lion whined like a little puppy, then ran off into the grass. The towel trick also scared the zebra and the gazelles. So now she was all alone again and she carried on walking towards the pool. She had a lovely time at the pool. But every time she went to the pool after that she always made sure she had a large red towel.

Rhiannon

Rhiannon marchait tranquillement le long du chemin poussiéreux qui menait à la grande piscine. La terre brûlait sous ses pieds. Toute la boue était fissurée; vu d'en haut ça devait ressembler aux écailles d'un poisson. Ses cheveux noirs brillaient – on ne pouvait pas les toucher – tellement ils étaient chauds – et sa peau bronzée brûlait.

Soudain un ruissellement se faisait entendre dans les herbes à moitie morte de soif et un petit groupe de gazelles et de zèbres s'approchait d'elle.

« Bizarre », pensait Rhiannon, « D'habitude ils gardent leurs distances, mais aujourd'hui ils s'approchent de moi! Ce n'est pas normal. »

C'est à ce moment la qu'elle a vu les yeux. Des yeux jaunes comme de la moutarde, avec des éclats comme des billes de topaze. Il y avait un lion dans l'herbe, et probablement il chassait. La plupart des filles aurait fait feu des deux fuseaux ou hurlé ou bien aurait fait qui sait quelle bêtise qui aurait attirée l'attention de la bête. Rhiannon n'a rien fait de la sorte. D'un geste vif elle a retirée sa serviette rouge de son sac à dos et elle l'a étendu devant elle. Ensuite elle l'a mise derrière elle et elle a écarte ses bras. Elle savait que comme ça, elle paraîtrait grande et féroce.

Le lion a couiné comme un petit chiot et a filé en courant dans l'herbe. Le coup de la serviette a également fait peur aux zèbres et aux gazelles. Comme ça elle se trouvait de nouveau toute seule et elle a continué son chemin jusqu'à la piscine. Elle s'est très bien amusée à la piscine. Mais, par la suite, chaque fois qu'elle s'y rendait, elle n'oubliait jamais d'emporter une grande serviette rouge.

References

Ball, S. (2003). The teacher's soul and the terrors of performativity. Journal of Education Policy, Vol. 18, No. 2, 215-228.

Ball, S. & Olmedo, A. (2013). Care of the self, resistance and subjectivity under neoliberal governmentalities, Critical Studies in Education, 54:1, 85-96

Biesta, G. (2009). Good education in an age of measurement: on the need to reconnect with the question of purpose in education. Educational Assessment, Evaluation and Accountability (2009) 21:33-46.

Bereiter, C., and Scardamalia, M. (1993). Surpassing Ourselves – an inquiry into the nature and implications of expertise, Open Court: Chicago and La Salle, Illinois

Bereiter, C., and Scardamalia, M. (2003). 'Learning to Work Creatively With Knowledge' in E. De Corte, L. Verschaffel, N. Entwistle, & J. van Merriënboer (Eds.), Unravelling basic components and dimensions of powerful learning environments. EARLI Advances in Learning and Instruction Series.

Bower, J., (2013). 'Reduced to numbers: from concealing to revealing learning', in Bower J. and Thomas P. L. , (eds) (2013) De-testing and de-grading schools: authentic alternatives to accountability and standardization, New York: Peter Lang

Corbett, M. (2008). The Edumometer: The commodification of learning from Galton to the PISA, Journal for Critical Education Policy Studies, Volume 6, Number 1 http://www.jceps.com/print.php?articleID=125 and http://firgoa.usc.es/drupal/node/39878

Fullan, M., and Hargreaves, A. (2012), Professional Capital – transforming teaching in every school. London & New York: Routledge.

Gardener, H. (1991). The unschooled mind: how children think and how schools should teach. New York: Basic Books.

HMIE (2007). How Good is Our School?. Livingston, Scotland: HM Inspectorate of Education. Kohn, A. (1999). The schools our children deserve – moving beyond traditional classrooms and "tougher standards", Houghton Mifflin Company, Boston & New York. Kohn, A. (2011). Feel-bad education and other contrarian essays on children and schooling, Beacon Press, Boston.

Logotron (2007). Revelation, Sight and Sound, (Software), Rickitt Educational Media Ltd. Bridgwater,

Somerset, UK. MacKinnon, N. (2008). The Perils of Permanent Perfection, Times Educational Supplement for Scotland, 21 March. http://www.tes.co.uk/article.aspx?storycode=2596504

MacKinnon, N. (2011). The urgent need for new approaches in school evaluation to enable Scotland's Curriculum for Excellence, Educational Assessment, Evaluation and Accountability, Volume 23, Number 1. February http://link.springer.com/article/10.1007/s11092-011-9116-4 http://link.springer.com/journal/11092/23/1/page/1

MacKinnon, N. (2012). A Scottish Headteacher's View of the Effectiveness Challenge, ICSEI Express and Digest, The International Congress of School effectiveness and Improvement, May http://www.icsei.net/index.php?id=1592 (p10)

MacKinnon, N. (2013). A systems thinking approach for school enhancement, 26th International Congress of School effectiveness and Improvement, Santiago, Chile http://pasg.cl/icsei/download.php?file=envios/ab29b9905935e05341b0b5c61d7f7466.pdf http://pasg.cl/icsei/download.php?file=envios/ef2a05a5db035c1a40dfe6ce9e0a082b.pdf

MacKinnon, N. (2014). The Local–National–Global Nexus of Education Change – Action Research Perspectives from a Scottish Rural Primary School, 27th International Congress of School Effectiveness and Improvement, Yogyakarta, Java, Indonesia https://secure.icsei.net/membership/papers/141_34kwj_141.pdf

Priestley, M. (2012). Progressive pedagogy: lessons from the Eight Year Study, http://mrpriestley.wordpress.com/2012/05/25/progressive-pedagogy-lessons-from-the-eight-year-study/

Reeves, J. (2013). 'The Successful Learner', chapter in Priestley, Mark. and Biesta, Gert (eds) (2013), Reinventing the Curriculum – New Trends in Curriculum Policy and Practice, Bloomsbury: London

Ross, J. (2008). Love your employees, Times Educational Supplement for Scotland, 21 November http://www.youblisher.com/p/768817-Times-Educational-Supplement-Scotland-Love-Your- Employees-21-November-2008/

Sahlberg, P. (2007). Common Futures, Different Pasts: Global Solutions to Curriculum Challenge. Keynote speech, Scottish Learning Festival.

Sahlberg, P. (2008), Rethinking accountability in a knowledge society, Journal of education change, 11:45-61

http://pasisahlberg.com/wp-content/uploads/2013/01/Rethinking-accountability-JEC- 2010.pdf
Sahlberg, P. (2011). Finnish Lessons – What can the world learn from educational change in Finland? Teachers' College Press. (2011), http://www.finnishlessons.com/
Scardamalia, M. (2002). 'Collective Cognitive Responsibility for the Advancement of Knowledge', in: Smith, B., (ed.), Liberal Education in a Knowledge Society. Chicago: Open Court, pp. 67–98
Scardamalia, M. (2013). 21st Century Competencies environments and Assessments, keynote speech, 26th International Congress of School Effectiveness, Santiago, Chile http://www.icsei.net/fileadmin/ICSEI/icsei_2013/css/video_scardamalia.html
Scottish Executive (2004). A Curriculum for Excellence. Report of the Curriculum Review Group.
Seddon, J. (2008). Systems Thinking in the Public Sector: the failure of the reform regime and a manifesto for a better way, Axminster: Triarchy Press. Seldon, A. (2010). An end to factory schools – an education manifesto, Centre for Policy Studies http://www.anthonyseldon.co.uk/pictures/CPS%20booklet.pdf

Connecting to the curriculum: A case study exploring the online and offline discourse of a Grade 2 knowledge building class

Monica Resendes, Derya Kici
University of Toronto/OISE, Institute for Knowledge Innovation and Technology, Canada,
monicaresendes@gmail.com, derya.kici@mail.utoronto.ca

Abstract: A common concern among educators today is how to engage students in authentic knowledge work while ensuring they are covering the broad array of curriculum expectations they are mandated to teach (Ontario Ministry of Education, "Building Capacity, 2013). Knowledge Building (Scardamalia & Bereiter, 2003) is a pedagogical approach that provides a solution with its emphasis on immersing students in sustained creative work with ideas. This research describes an exploratory case study of Grade 2 students doing knowledge building in science. Qualitative and quantitative analysis of students' online and offline discourse is conducted to explore the extent to which young children can meet and exceed curriculum benchmarks and standards of achievement through engagement with idea improvement and pervasive knowledge building discourse. Content-based analysis is used to map the extent to which students' discourse engages specific curriculum expectations as an indicator of content knowledge and understanding. Lexical analysis is performed to help evaluate students' competencies in communication in both written and oral forms. Results show that students' offline and online discourse demonstrates consistent use of key vocabulary, and meaningful engagement with big ideas in ways that both consistently meet and exceed the curriculum expectations for Grade 2.

Introduction

A statement in an Ontario Ministry of Education monograph defines the main challenge for education in the 21st century as the imperative "to provide opportunities for students to move beyond being passive recipients of knowledge to become knowledge builders, capable of creative and innovative solutions to problems" ("Building Capacity," 2013, p. 1). Building opportunities for creative knowledge work in the classroom is critical to meaningful educational reform. However, from a practitioner perspective, an increasingly common and pressing concern is how to meaningfully engage students in authentic knowledge creation, ensure deep disciplinary learning, and still cover the broad array of curriculum expectations they are mandated to teach ("Building Capacity," Ontario Ministry of Education, 2013). Indeed, the problem of the overcrowded or "mile-wide, inch-deep" (Bransford, Brown, & Cocking, 1999, p.125) curriculum characterizes numerous education systems around the world (National Council for Curriculum and Assessment, 2010; Parsons & Beauchamp, 2012), and has been criticized as fostering teaching and learning scenarios that rely too heavily on rote memorization and recall rather than deep understanding (Bransford, Brown & Pellegrino, 2000). Helping students to become competent knowledge creators, on the other hand, requires they are supported in deep and sustained engagement with complex problems of understanding.

Knowledge building

So, how can educators engage students in deep disciplinary learning in ways that help them concurrently to develop competencies for working creatively with knowledge? Knowledge Building (Scardamalia & Bereiter, 2003) is a pedagogical approach that most directly addresses this issue by immersing students in sustained idea improvement from the earliest grade levels. Knowledge building can be described as "the production and continual improvement of ideas of value to a community" (Scardamalia & Bereiter, 2003, p. 1370). Two central principles of knowledge building pedagogy are *idea improvement*—the premise that ideas are real objects that can be continually improved (Scardamalia & Bereiter, 2006), and engagement in *pervasive knowledge building* or "progressive discourse" (Bereiter, 1994), which can be described as discourse that advances through a shared commitment to advancing the frontiers of group knowledge (Bereiter, Scardamalia, Cassels, & Hewitt, 1997).

Knowledge building is supported by the Knowledge Forum (KF) online environment, which is specially designed to support knowledge building discourse and principle-based learning (Scardamalia, 2004). Knowledge Forum includes a suite of analytic tools built to help knowledge building communities work creatively with ideas and advance collective knowledge (Burtis, 1998; Teplovs, Donahue, Scardamalia, & Philip, 2007).

Knowledge building for understanding evolutionary biology

The research reported in this paper is an exploratory case study that provides an in-depth look at the knowledge building discourse of Grade 2 students. The intent is to explore the extent to which primary-aged students can meet and exceed curriculum benchmarks and standards of achievement through engagement with idea improvement and pervasive knowledge building discourse. Whereas a large portion of knowledge building research investigates online discourse and activities mediated in Knowledge Forum (e.g. Zhang, Scardamalia, Lamon, Messina & Reeve, 2007; Chuy, Zhang, Resendes, Scardamalia, & Beretier, 2011) this study explores both the online and offline discourse of students during a sustained period of study. At the primary level, students' capacities for conveying their thoughts and meaning in oral communication are typically more advanced than in writing, in part because of mechanical challenges as well as the cognitive load involved in planning, translating and revising text (see Kennedy, Dunphy, Dwyer, O'Connor, Hayes, McPhillips, Marsh, & Sheil, 2012; Beringer & Swanson, 1994). Thus, exploring students' verbal talk as well as their writing can be a particularly important component for assessing primary-aged students (Resendes, Chen, Acosta, & Scardamalia, 2013). Also, looking at both face-to-face and online discourse helps researches achieve a more holistic understanding of a knowledge building classroom culture (Lossman & So, 2008).

In this study, students were participating in a knowledge building study that corresponded to one of four main subject strand in the *Ontario Elementary Curriculum for Science and Technology, Grades 1-8,* (2007), namely, "Understanding Life Systems." The theme in this strand for Grade 2 is "Growth and Change in Animals," which engages important concepts related to evolutionary biology, such as adaptation and species transformation. The curriculum framework includes three "Big Ideas," (e.g.*"Animals have distinct characteristics,"* p. 58); three "Overall Expectations," (e.g. *"demonstrate an understanding that animals grow and change and have distinct characteristics,"* p. 58); and 14 "Specific Expectations (e.g. "*describe an adaptation as a characteristic body part, shape, or behaviour that helps a plant or animal survive in its environment*," p. 59). All of the curricular expectations are framed by a student achievement chart that includes four overarching competencies: 'Knowledge and Understanding of Content,' 'Thinking and Investigation,' 'Communication,' and 'Application.' These areas represent meta-level competencies that apply to all subject strands in elementary science, and provide a means to assess not only content acquisition but important underlying competencies.

One may ask—is it plausible to expect children as young as the second grade to productively raise and probe concepts bound up to such complex issues as evolutionary biology beyond the levels identified in the Grade 2 curriculum? This would be a challenging task indeed, given that research shows that achieving an understanding of advanced (Darwinian) evolutionary thinking can be very difficult for both young students as well as adolescents and adults (Almquist & Cronin, 1988). Literature shows that even advanced graduate students exhibit a range of misconceptions and long-lasting misinterpretation of important ideas like natural selection (e.g. Brumby, 1979; Bishop & Andersen, 1990; Greene, 1990). The development of novice explanatory frameworks at a very early age can make it very difficult for students to restructure those frameworks to integrate Darwinian concepts through traditional instruction in evolutionary biology (Samarapungavan and Wiers,1997, p. 172). This study explores how a knowledge building approach can help students gain deep understanding of concepts related to complex subjects such as evolutionary biology by engaging students in sustained idea improvement and pervasive knowledge building discourse.

The main research questions guiding this study are as follows:

- To what extent does early primary students' discourse engage, and potentially exceed, specific science curriculum expectations for Grade 2?
- To what extent does a knowledge building approach help students' engage with indicators of student achievement, as outlined in the curriculum document?
- Are there any notable differences between students' online and offline discourse in either of these aspects?

Methodology

Participants and Classroom Context

Participants for this study include 22 Grade 2 students (11 boys, 11 girls), and their teacher. All participating students were introduced to knowledge building pedagogy in kindergarten, and Knowledge Forum technology in Grade 1. The knowledge building study ran approximately three months, and focused on the study of birds. The students typically had one 60 minute session a week dedicated to "KB time." During this period, students engaged in active research, observation and experimentation, whole group discussions known as "KB Circles," and writing on the Knowledge Forum database. During group "KB Circles," students sat in a circle and discussed any questions or thoughts they had about their bird inquiry for 20-25 minutes. Afterwards, they had 30 minutes to enter their ideas, questions, theories, etc., into the online database. As components of active research, students engaged with authoritative sources on birds, participated in "nature walks" to observe neighbourhood birds, and took notes and drew diagrams in their "nature notebooks."

Data Analysis

The data for this study consists of discourse emerging from episodes of both online and offline discussion that occurred throughout the study and is comprised of the following: i) 119 student notes as archived on Knowledge Forum, representing eight distinct episodes of online discussion (approx. 30 minutes each) ii) transcripts of five "KB Circle" group discussions (approx. 20-25 minutes each).

Data analysis consists of both quantitative and qualitative measures. In this study, two major components of the curriculum 'Student Achievement Chart,' namely 'Knowledge and Understanding of Content' and 'Communication,' are used as a framework for analysis of knowledge building discourse, as elaborated below:

Knowledge and Understanding of Content: This component is defined in the provincial curriculum document as "subject-specific content acquired … and the comprehension of its meaning and significance," and includes the following indicators: use of facts, definitions and vocabulary, as well as concepts, ideas, principles and procedures (p. 26). Two researchers conducted content-based analysis on student discourse using the curriculum as a guideline, specifically the "Understanding Life Systems" strands for Grades 1-8, which becomes "Biology" for Grades 11-12. The unit of analysis was an individual discursive contribution. Verbally, a contribution was an individual's complete verbal utterance. Online, each individual note was counted as a contribution. Each contribution, either on or offline, was assessed according to the "Specific Expectations" corresponding to the "Understanding Life Systems" stream, as outlined in the two curriculum documents. If a contribution "hit" more than one expectation, all expectations were counted. If a contribution did not engage an expectation, no score was given.

Communication: This refers to "conveying of meaning through different forms," (p. 26), and is indicated by the "use of conventions, vocabulary, and terminology of the discipline in oral, visual, and written forms" (p. 26). Lexical analysis was conducted to explore students' use of language according to three attributes: i) total words per discussion episode; ii) vocabulary density per episode (the greater the density the richer the discourse); iii) use of domain-specific vocabulary. To create the domain-specific word list, the main author consulted the curriculum document to identify key vocabulary corresponding to the "Understanding Life Systems" and "Biology" strands. This list contains 453 words in total which were divided into three levels, below Grade 2 (54 words) at Grade 2 (74 words) and above Grade 2 (307 words). The online text analysis software, Voyant (www.voyant-tools.com), was used to trace word frequency and density in student discourse.

Results

Findings from lexical analysis show that out of the eight online discussion sessions, students wrote an average of 141.5 words in total and 68.13 unique words, with a vocabulary density score of 482.23. Interestingly, averages for the five face-to-face discussions showed 2237 words in total, 457 unique words, and a vocabulary density of 233. This suggests that, while students' notes might be much shorter than their verbal utterances, they are using a richer vocabulary set on average in their writing.

In terms of use of domain-specific vocabulary, students used 122 key terms (roughly 11% of their total written words) in their online discourse. Of these key terms, 23.77% were at a Grade 1 level (e.g. "survive," "food," "trees"), 59.01% were at the Grade 2 level (e.g. "beak," "life cycle," "predator"), and 17.2% were above the Grade 2 level (e.g. "dependent," "food chains," "extinction"). In their oral discussions, students used 571 key terms (roughly 5% of their total spoken words), that included 27.32% of total key words at the Grade 1 level (e.g. "experiment," "nature," "warmer"), 50.79% at the Grade 2 level (e.g. "adapt," "burrowing," "mammals"), and 21.89% above the Grade 2 level (e.g. "evolve," "attract," "vulnerable"). Interestingly, while students use more domain-specific words in writing in general, the terms they use in their oral discourse more frequently correspond to higher grade levels.

With respect to content analysis, researchers individually coded the data with an agreement rate of 97.5%. Discrepancies were resolved with discussion. Overall, researchers found that students' online discourse engaged a total of 23 expectations across Grades 2, 4, 6, 7, and 11. More specifically, students' engaged five out of a total of 14 expectations for Grade 2, eight out of 18 expectations for Grade 4, seven out of 14 for Grade 6, and even touched up three expectations from Grade 11. With regard to face-to-face discussion, discourse engaged 31 expectations, including ten expectations from Grade 2, eleven from Grade 4, five from Grade 6, one from Grade 7, and four from Grade 11. In general, analysis shows that both the online and offline discourse demonstrated diverse vocabulary, and consistently exceeded curriculum targets set for Grade 2. Also, students' oral discussions involved more sophisticated ideas, and mapped more frequently onto higher grade level curriculum expectations than their written dialogue.

7.4.1 Students advancing knowledge about the "Big Ideas" in evolutionary biology

To support quantitative findings, the following section examines episodes of student discussion, both on and offline. A study by Samarapungavan and Wiers (1997) helps to provide an evaluative framework for qualitative exploration of discourse here. They propose four types of explanatory frameworks that children demonstrate in their ideas about speciation: i) Non-Evolutionary—species are immutable "natural kinds" that spring "full blown" from seeds or eggs, or from God; species change only occurs due to extinction; ii.) Hybridizationist—species perpetuate by cross-breeding; iii.) Micro-Evolutionary—species have basic essences but small changes can occur within a species due to environmental change, such as a "dinosaur-tiger" changing into a modern day tiger; iv.) Macro- Evolutionary—species emerge from pre-existing species over time in an evolutionary process. Findings from existing research (Evans, 2000) show that primary and junior grade children (6-9) tend to express non-evolutionary concepts in their ideas about species origins and mechanisms of change, with older students (11-12) more likely to express micro or macro-evolutionary ideas. This scale provides a means to situate student discourse from this study on a developmental trajectory for conceptual understanding in the subject area.

Looking at the online discourse, the entries below include the initial questions and ideas the students had at the onset of the study that corresponded to the subject of evolutionary biology:

-"I wonder where birds came from?"
-"I wonder why birds are so different?"
-"I wonder why birds are different from other birds?"
-"I don't know [where birds came from]. Because some birds might have come from somewhere, but this is the thing that I don't know, is how different birds came from. I don't know how an owl could come and a crow could come after. I think they came from different ways, but I don't know how to explain. I'm not sure if they came from a different way or the same way."
-"Because they're different kinds, maybe. They look different because they're different kinds"
-"Because there are so many different birds in the world. Some can fly. They live in different places. They eat different things. Some are heavy and some are not. And some can be colourful. And some have long tails and some have short tails."

As these examples suggest, the students were able to pose meaningful questions that could frame a deep and sustained inquiry on such ideas as speciation and adaptation. The theories also contain basic conceptions about how species might transform or why there are a wide variety of species within a single genus. Notably, contributions also reflect the key "Big Ideas" of the Grade 2 curriculum, which revolve around recognizing and investigating similarities and differences amongst different animals (pg. 58). As their inquiry progressed, students began probing other complex ideas. In the episode of talk below, students elaborate on their explanations about why there are so many different birds:

Teacher: So you're saying there are different kinds of birds within one species so one species might look very different. And then, there are different kinds of birds...
Student B: If there are different kinds of birds and they mate, that doesn't make a different kind of bird.
Teacher: What makes a different bird?
Student B: If just a different species mates a different species, like a hummingbird marries a pigeon...
Teacher: And then what do you get?
Student B: You get like a half hummingbird and a half pigeon
...
Student C: I'm adding onto [Student B's] idea, because I heard in this book that a zebra married a horse, and it was a horse with zebra stripes.
Student B: That is true there is one like that.
Teacher: So you're saying that this can also happen with birds, like it happens with horses and zebras. So species can intermix? So that might be why there are so many different kinds of birds?
Student B: So they can make new birds.

Teacher: So does that answer where do birds come from?
Student B: Ya, they come from one bird... it's...
Student C: I think that they might come from a different family, and maybe it's something like, um, they I don't really know, but like, I don't really know, but it might be like, an animal married another animal that becomes a bird, and then a bird, maybe, ya...
Teacher: So it changes over time? Does anyone know the big word for that?
Student B: Extinction?
Student D: Transformation...?

In this excerpt, students are explicitly engaging with ideas around evolutionary transformation, a subject which does not formally appear in curriculum documents until Grade 11 (e.g. "Specific expectations: Understanding Basic Concepts" 3.3, p.53). The discussion clearly reflects "hybridizationist" ideas, as students discuss the notion of species intermixing to create new species. Because cross-breeding can occur in nature, it is not difficult to see children can adopt these ideas, and how examples such as the "Zebroid" can reinforce Lamarckian ideas of genetic inheritance, rather than natural selection, as mechanisms of evolutionary change. In fact, this is a common misconception in children's understanding of biological causal mechanisms (Backscheider, Shatz, & Gelman, 1993; Rosengran, Gelman, Kalish, & McCormick, 1991), and is found to be evident even in the ideas of undergraduate science students (Ferrari & Chi, 1998). The fact that students discourse reflects this misconception here is not a surprise nor a weakness; on the contrary, discussions of this nature contribute to the system of knowledge students build up around evolutionary concepts. By engaging students in sustained discussion about their own ideas, allowing space and time for misconceptions to arise and for students to reject or improve different ideas, students can expand their knowledge base around the subject. This is important because the stronger the knowledge system children possess, the better the position they are in to make conceptual advances within that system over time (Carey, 1985).

As the study proceeded, students continued to ask questions about evolutionary change as well as species diversity. The following examples represent more online contributions:

-"I need to understand: where birds came from, and why there are so many different kinds of them, and what birds are made of?"
-"I need to understand: what came first people or birds?"
-"Why are birds different colours?"

Students contributed a wide variety of theories in response:

-"There are so many different birds because that's how they survive. And birds need other birds to survive."
-"They live in a different place and eat different things."
-"My theory is birds came from extinction."

In relation to the Ontario curriculum documents, these examples reflect engagement with expectations that appear in Grade 4 and 6, where the concepts of habitats and biodiversity become more prominent (e.g. Gr. 4, "Specific expectation: Understanding basic concepts" 3.1 and 3.4, p. 86; Gr. 6, "Specific expectation: Understanding basic concepts" 3.5, p. 114). The opportunity to explore a diversity of ideas here allows students to test out a range of explanations that, in this case, leads them beyond a hybridization explanatory framework and towards a deeper understanding of biological transformation. The excerpt of discussion that follows begins with the teacher re-reading one of the online contributions cited above:

Teacher: So really, this is a three-part note. It looks like it includes I need to understand where birds came from, that's one part, why there are so many different kinds of them, and what they are made of. What do you think of that note? [Student A]?
Student A: Evolution.
Teacher: What does that mean?

Student A: It means that birds were dinosaurs of a different kind, and then they "evoluted", or um, or, like us.
Student B: We were apes, and then we turned into humans.
Teacher: [Student C], what did you have to say? Was it about evolution?
Student C: Everyone used to be an ape. That everyone's ancestor used to be an ape.
Teacher: Everyone's ancestor? What does that mean?
Student C: It means people from a long time ago, that you don't even know.
Teacher: So what's the difference between something that you used to be and what your ancestor is?
Student D: Because when you were in your mom's stomach, you weren't hairy and "apey"!
Teacher: So that's evolution? That's your definition of evolution. Does anyone else have a definition of evolution?
Student E: The first people on the world were apes. It was ape, human, caveman, and then human.
Student D: No, it was fish, rat, ape, caveman, human.
Student C: No, its cells!
Teacher: Oh my, keep going...
Student D: Cell, ape, caveman, then human.
Teacher: Does anyone have another definition?
Student A: Something that was formed...Okay, something that is formed from something else.
Teacher: So where do birds fit into this? You said they "evoluted." You were talking about how man evolved. How do birds fit in? We talked about cells, we talked about fish…
Student F: They probably formed from something.
Student G: We are living through the time, so birds are probably adding onto something.
Teacher: So how sure are we about this notion of evolution? So pretty much everyone here is saying that humans evolved. So are we pretty sure about this notion of evolution for birds?
Class: Yes! [Nods].

In this example, the term "evolution" is stated explicitly for the first time and incites a dialogue that emphasizes the importance of change over time to the evolutionary process. Student A's ideas that "birds were dinosaurs of a different kind...that evoluted" represents a conceptual advance over "hybridizationist" ideas. The timeline students create is very simple, but nonetheless reflective of a "macro-evolutionary framework," as it explains that species emerge from pre-existing species over time in an transformative process. Moreover, the subject matter itself again involves ideas not explicitly outlined in the curriculum until Grade 11. While content is engaged at a much simpler level in students' talk than the curriculum expectations detail, nevertheless, students' sustained interest in the subject and their efforts at understanding the phenomenon of evolution speaks to the value in allowing them to engage in open-ended discussion rather than a strictly guided conversation or a discussion with predetermined objectives.

The high level of student discourse was evident in another episode of discussion students participated in, which took place during the second last week of the unit:

Student A: How would they [birds] survive if they didn't have other birds to protect them? Like hummingbirds, they build their nests around hawks. Even though they might try to eat them, but they're too fast so the hawks don't bother them. But hawks eat other kinds of birds, so if the hummingbird was the only kind of bird... so... if hawks were the only kind of birds, what would they eat?
…
Student F: I'm sort of adding onto [Student A]. If there was only one hawk and one bird, the hawk wouldn't survive that long because he only has one bird to eat...[*inaudible*]. So it's kind of like a cycle of food. A food chain.
Student D: I think hawks because they're like... there tons of pigeons in Toronto.
...
Student H: And more people put out food for them.

Student I: I think maybe pigeons because people feed them bread.
Student H: I think that the last one makes a bit more sense... they have I think that pigeons has the highest chance of survival or the hummingbird because they are getting protected by the hawks and no other birds would like to be next to a hawk...
Teacher: So, the red-tailed hawk is doing really, really, well. Pigeons are doing really, really, well...
Student J: But the red-tailed hawk is really, really rare. And that's why you don't see them?...I think I know why they're there, because they're close to pigeon park.
Teacher: And where are the pigeons in pigeon park?
Class: Everywhere!
...
Student H: Pigeons, lots of people like to litter, because if they have bread, leftover bread they just shred it and throw it on the ground, so the pigeons get to eat it all up in pigeon park … So the red-tailed hawk has a high of survival because there is a lot of pigeons in pigeon park.
Teacher: So, somehow or another we just entered into this whole food chain conversation didn't we?
Student L: I think its called a food chain because, like, a bird needs little to survive, a bird needs a person to survive because a red-tailed hawk does because...If most red-tailed hawks like pigeons and so, the pigeons eat the litter and then the red-tailed hawk eats the pigeon and that's one chain, and then there's another chain, so there's different chains.

This discussion demonstrates students' impressive capacity to talk about various aspects of static adaptation within a wider conversation addressing the phenomenon of species variation. For instance, students had a strong sense that adapting to a particular environmental niche is important for an animal's survival and that species (plant or animal) interdependency is a critical concept that feeds into an animals ability to thrive. The concept of the food chain is also prominent, and is explored as a vehicle through which to decide the fitness of different types of species. The idea posed by "Student L" that "there's different chains" represents quite a profound insight for a student so young, and hints towards the idea of a "food webs" that represents a complex system rather than a linear pathway of feeding relations. Again, this discussion reflects engagement with curriculum content marked two to four years above Grade 2.

Overall, the discourse examples reveal that students engaged more advanced ideas and were able to better elaborate their theories in verbal conversation compared to online discussion. This is not surprising, however, it is important to note how online and offline discourse plays off of and supports the other, with students continuing to question ideas raised in face-to-face discussion in their online dialogue, while also elaborating theories contributed to the database during their group conversations.

Discussion and Conclusions.

This study highlights the benefits of a knowledge building approach to helping even the youngest students engage in deep disciplinary learning while also fostering important communication skills such as vocabulary development. The findings reported here show that students went above and beyond the "Big Ideas" that frame the "Understanding Life Systems" curriculum strand for Grade 2, which emphasize that students recognize that animals have unique traits, and can be both similar and different from other animals (p. 58). Their dialogue shows evidence of idea improvement around important concepts such as evolutionary change, adaptation and speciation. Their discourse also reveals their collective capacity to move beyond naive or more intuitive conceptual frameworks found to be characteristic of young children, towards a more scientific understanding of these complex ideas.

It must be noted that the present research represents a very small case study, and any results therefore are not generalizable beyond the study participants. However, we can speculate that the depth of verbal discourse is bound up with the opportunities enabled by KB Circles, which support fluid and direct student-to-student interaction, and provide space for students to express their ideas and build off the thoughts of others. Indeed, the learning opportunities KB Circles engender, such as listening and time to engage in informal conversation, are gaining popularity in early childhood education literature. For instance, because vocabulary development is a strong predictor of writing and reading skills (Stahl, 1991; Hirsh, 2003; Snow & Oh, 2011), researchers have called for more attention to nurturing listening skills in the early years of schooling so that children can listen and expand their own vocabulary sets (Rose, 2006). There is also increased demand for learning contexts in which informal discussion can take place, in order to foster children's excitement in naming and learning about the world (Kennedy, Dunphy, Dwyer, O'Connor, Hayes, McPhillips, Marsh, & Sheil, 2012; Beringer & Swanson, 1994). As results show, students used a range of key terms in their conversations and, while discussion was informal, it was nonetheless on-topic and stayed consistently in line with important curriculum content.

Another important point to note here is that the KB Circle discussion examples are idea-centric, rather than information-centric. That is not to say students' did not introduce and discuss important facts, but that information was often used to help *develop ideas* rather than presented for its own sake to demonstrate content acquisition. In addition, while the Grade 2 teacher is highly present throughout each discussion, her contributions are responsive to the children's ideas, rather than evaluative of them. Her contributions constitute either gentle probes for further clarification or elaboration, such as: "What does that mean," "does anyone else have another definition?," "what's a big word for that?"; or are reflective in nature: "So does that answer where do birds come from?," "So pretty much everyone here is saying that humans evolved. So are we pretty sure about this notion of evolution for birds?" Furthermore, while the teacher at times suggested a question to be discussed, all questions originated from the students' own inquiry. While examining the teacher's role in community discourse is beyond the scope of this paper, exploring her role in KB Circles in more depth is a promising direction for future research. Such studies could help to inform efforts at scaling up knowledge building in practice by offering new knowledge building educators effective models for practices conducive to effective knowledge building work in primary classrooms.

This study also raises questions around ways to support KB Circle talks in primary grades. For instance, what technical innovations can be designed to help primary level teachers and students capture salient episodes of discourse? How could such tools enhance existing knowledge building online environments? Such questions can inform critical next steps for research programs geared to improve knowledge building technology and to scale knowledge building practices in classrooms.

References

Almquist, A.J., & Cronin, J.E. (1988). Fact, fancy, and myth on human evolution. *Current* Anthropology, 29, 520-522.

Anders, M., Cheung, W., Wong, K., Liu, J., Lee, C., Lam, M., & Tang, J.(2005). Grounding Collaborative Knowledge Building in Semantics-Based Critiquing, *International Journal of Distance Education Technologies, 5*(2), 40-55.

Backscheider, A.G., Schatz, M. & Gelman, S.A. (1993). Preschoolers' ability to distinguish living kinds as a function of regrowth. *Child Development, 64*, 1242-1257.

Bereiter, C. (1994) Implications of postmodernism for science, or, science as progressive discourse. *Educational Psychologist, 29*(1), 3-12.

Bereiter, C. Scardamalia, M. Cassels, C. & Hewitt, J. (1997). Postmodernism, knowledge building, and elementary science. *The Elementary School Journal, 97(*4), 329-340.

Berninger,V.W., & Swanson, H. L. (1994). Modifying Hayes and Flower's model of skilled writing to explain beginning and developing writing. In E. C. Butterfield, Series Ed.), & J.S.Carlson, (Ed.), Advances in cognition and educational practice:Vol. 2. *Children's writing: Towards a process theory of the development of skilled writing*. New York: JAI Press.

Bishop, B.A. & Anderson, C.W. (1990). Student conceptions of natural selection and its role in evolution. Journal of Research in Science Teaching, 27, 415–427.

Bransford, J. D., Brown, A. L., & Cocking, R. R. (Eds.) (1999). *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press.

Bransford, J., Brown, A. L., & Pellegrino, J. W. (2000). Learning and transfer. In J. D. Bransford, A. L. Brown & R. R. Cocking (Eds.), *How people learn: Brain, mind, experience, and school* (pp. 51–78). Washington, DC: National Academies Press. Retrieved from http://www.nap.edu/openbook.php?record_id=9853&page=51

Brumby, M.N. (1979). *Students' perceptions and learning styles associated with the concept of evolution by natural selection*. Unpublished doctoral dissertation, University of Surrey, United Kingdom.

Burtis, P. J. (1998). *Analytic toolkit for Knowledge Forum*. Centre for Applied Cognitive Science, The Ontario Institute for Studies in Education/University of Toronto.

Parsons & Beauchamp, (2012). *From Knowledge to Action: Shaping the future of curriculum development in Alberta*. Retrieved from: http://www.education.alberta.ca/department/ipr/curriculum/researchknowledgetoaction.aspx.

Carey, S. (1985). *Conceptual change in childhood*. Cambridge, MA: MIT Press.

Chuy, M., Zhang, J., Resendes, M., Scardamalia, M., & Bereiter, C. (2011). Does contributing to a knowledge building dialogue lead to individual advancement of knowledge? In H. Spada, G. Stahl, N. Miyake & N. Law (Eds.), Proceedings from CSCL 2011: *Connecting Computer-Supported Collaborative Learning to Policy and Practice, Volume I - Long Papers* (pp. 57–63). International Society of the Learning Sciences.

Evans, E.M. (2001) Cognitive and contextual factors in the emergence of diverse belief systems: Creation versus evolution. *Cognitive Psychology, 42*, 217–266.

Ferrari, M., Chi, M. (1998). The nature of naïve explanations of natural selection. *International Journal of Science Education, 20,* 1231-56.

Greene, E.D., Jr. (1990). The logic of university students' understanding of natural selection. *Journal of Research in Science Teaching*, 27, 875–885.

Hirsh, E. (2003). Reading comprehension requires knowledge-Of words and of the world: Scientific insights into the fourth-grade slump and the nation's stagnant comprehension scores. *American Educator*, *27*, 10-13, 16-22, 28-29, 48.

Kennedy, E. Dunphy, E., Dwyer, B., O'Connor, M., Hayes, G., McPhillips, T. Marsh, J., & Sheil, G. (2012). *Literacy in early childhood and primary education (children 3-8 years)*. Dublin: National Council for Curriculum and Assessment.

Landauer, T. K., Foltz, P. W., & Laham, D. (1998). Introduction to Latent Semantic Analysis. *Discourse Processes, 25*, 259-284.

Levin, B. (2007). Curriculum for the 21st century: Does curriculum matter? *Education Services Australi*a. Retrieved on November 25, 2011, from http://www.eqa.edu.au/site/doescurriculummatter.html.

Lossman, H., & So, H.-J. (2008). A comparative discourse analysis of online and offline knowledge building activities. In *Proceedings of the 8th International Conference of the Learning Sciences* (ICLS) 2008 (Part 3, pp. 77-78). Utrecht, The Netherlands: International Society of the Learning Sciences.

Mehan, H. (1979). *Learning lessons*. Cambridge, MA: Harvard University Press.

National Council for Curriculum and Assessment (2010). Curriculum overload in primary schools: An overview of national and international experiences. Retrieved from: http://www.ncca.ie/en/Publications/Reports/Curriculum_overload_in_Primary_Schools_An_overview_of_national_and_international_experiences.pdf

Chiarotto, L. (2011). *Natural curiousity: Building children's understanding of the world through environmental inquiry. A resource for teachers.* Toronto: Laboratory School at the Dr. Eric Jackman Institute of Child Study, Ontario Institute for Studies in Education, University of Toronto. Available at www.naturalcuriosity.ca

Ontario Ministry of Education. (2007). *The Ontario curriculum, Grades 1-8: Science and technology*. Retrieved from: http://www.edu.gov.on.ca/eng/curriculum/elementary/scientec18currb.pdf

Ontario Ministry of Education. (2008). *The Ontario curriculum, Grades 11-12: Science*. Retrieved from: http://www.edu.gov.on.ca/eng/curriculum/secondary/2009science11_12.pdf

Ontario Ministry of Education (2013). *Inquiry-based learning.* Capacity Building Series. Retrieved from:

Oshima, J., Oshima, R., & Matsuzawa, Y. (2012). Knowledge building discourse explorer: A social network analysis application for knowledge building discourse. *Educational Technology Research and Development*, *60*(5), 903–921. Retrieved from: http://link.springer.com/article/10.1007%2Fs11423-012-9265-2

Resendes, M., Chen, B., Acosta, A., & Scardamalia, M. (2013). The effect of formative feedback on vocabulary use and distribution of vocabulary knowledge in a grade two Knowledge Building class. *CSCL 2013 Computer Supported Collaborative Learning: To See the World and a Grain of Sand Learning across Levels of Space, Time, and Scale, Conference Proceedings.* Madison, Wisconsin: International Society of the Learning Sciences, Inc.

Rose, J. (2006). *Independent review of the teaching of early reading*. Retrieved from: http://webarchive.nationalarchives.gov.uk/20100526143644/http:/standards.dcsf.gov.uk/phonics/report.pdf

Rosengren, K.S., Gelman, S.A. Kalish, C.W., & McCormick, M. (1991) As time goes by: children's early understanding of growth in animals. *Child Development, 62*(6), 1302-1320.

Samarapungavan, A. & Wiers, R. (1997). Children's thoughts on the origin of species: A study of explanatory coherence. *Cognitive Science*, *21*(2), 147-177.

Scardamalia, M., & Bereiter, C. (2006a). Knowledge building: Theory, pedagogy, and technology. In R. K. 1131 Sawyer (Ed.), *The Cambridge handbook of the learning sciences* (pp. 97–115). New York, NY: 1132 Cambridge University Press.

Scardamalia, M. (2004). CSILE/Knowledge Forum. In *Education and technology: An encyclopedia* (pp.183-192). Santa Barbara: ABC-CLIO.

Scardamalia, M., & Bereiter, C. (2003). Knowledge building. *Encyclopedia of education*, *2*, New York; NY: Macmillan, 1370-1373.

Snow and Oh (2011)Snow, C. & Oh, S. (2011). Assessment in early literacy research. In S. Neuman, & D. Dickinson (Eds.), Handbook of early literacy research (Vol. 3, pp. 375-395). New York: Guilford Press.

Stahl, S.A. (1991). Beyond the instrumentalist hypothesis: Some relationships between word meanings and comprehension. In P. Schwanenflugel (Ed.), T*he psychology of word meanings,* 157-178. Hillsdale, N.H.: Lawrence Erlbaum Associates.

Teplovs, C., Donoahue, Z., Scardamalia, M., & Philip, D. (2007). *Tools for concurrent, embedded, and transformative assessment of knowledge building processes and progress*, 288, Rutgers, The State University of New Jersey.

Wilde, S., Wright, S., Hayward, G., Johnson, J., & Skerrett, R. (2006). *Nuffield review higher education in focus* England: Oxford University Press.

Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in the work of nine and ten year-olds. *Educational Technology Research and Development, 55*(2), 117– 145.

Naturalistic interaction of pre-service teachers in the socio-cognitive and technological interface: Missing opportunities for critical use of online resources

Aik Ling Tan, Seng Chee Tan, National Institute of Education, Nanyang Technological University, Singapore
aikling.tan@nie.edu.sg, sengchee.tan@nie.edu.sg

Abstract: Online resources such as Wikipedia, google, online textbooks and even social media are easily available sources of information. When faced with questions, students commonly 'google' for an answer. In this paper, we present how accessibility to online resources shape discussion among groups of four pre-service teachers (science graduates) who were engaged in discussion on the structure of proteins. Through analysis of their group discussions using interaction analysis, we noticed that the participants generally relied on their existing knowledge of structure of proteins to begin their discussions. Online resources generally serve as a means to complement their existing knowledge by (1) serving as a trigger to move onto the next discussion point; (2) providing a means for them to clarify and build on their existing ideas; and (3) enabling them to complete their task at hand. The accessibility to online resources provided a varied means of discussion interaction among the participants. However, as we compare the interactions of the pre-service teachers with the ways high school students in a knowledge building classroom used online resources, the lack of critical use of resources became apparent. These findings are important as they highlight the importance of intervention for learners, including university graduates, on harnessing rich online resources for idea improvement.

Introduction

Online resources such as google, online textbooks and Wikipedia are readily available resources that are available for learners to refer to. In fact, the available of information online has redefined the means of learning for many 21st century learners. Consequently for science learning in K-12 classrooms, teachers have to be able to re-design their lessons such that information available online can be used critically and meaningfully in face-to-face discussions in the classroom. In the science classroom for instance, students are exposed to hands-on experimentations and also discussions of their evidences after the hands-on experimentations. In fact, as highlighted in a study by Jocz, Zhai, and Tan (2013), group discussions related to connecting students' real-life experiences and ideas had a stronger relation to students' interest in school science among a group of 425 grade 4 students. As such, pre-service teacher education needs to take into account how group discussions can be facilitated so that they are productive in helping learners extend upon what they already know. Understanding how pre-service teachers interact with one another and with technology helps the pre-service teachers themselves as well as teacher educators to develop a greater awareness of what is going on during discussions. These principles and knowledge can then be used to plan learning experiences for students in school. Therefore, the research questions that guide this study are: (1) How do pre-service teachers interact with one another and with technology during group discussion? and (2) What are some roles that technology play in helping pre-service teachers discuss in a group context?

In the following sections, we present the theoretical ideas in the area of science learning as well as knowledge building that frame this particular study and analysis. These two theoretical lenses are chosen as conceptual development in science is closely akin to building knowledge based on available evidences and ideas that are generally acceptable within the larger community of scientists.

Science learning and knowledge building

Science learning is often characterized by working with and questioning evidence to construct scientific explanations. Three popular images of science were suggested by Lehrer and Schauble (2006) — (a) science perceived as logical reasoning, (b) science seen as a conceptual change theory, and (3) science as practice. Regardless of which of the three forms science takes on, all the three fundamental scientific sub-disciplines of biology, chemistry and physics are undertakings that require members of the community to discuss, argue, collaborate and finally agree upon what counts as knowledge. As such, in order for students to learn science, they will need to be exposed to the disciplinary practices and norms of the scientific community by engaging in activities that are defined by the discipline. Ford and Forman (2006, p.4) suggested three aspects that will help to define a science classroom or learning space. These three aspects are (1) social aspect of scientific practice (engagement in public debates using acceptable norms and means), (2) materials aspect of scientific practice (measuring, collecting evidence from nature to craft explanation for public debates), and (3) practice as an interplay of roles (enactment of Constructor of claims and Critiquer of claims).

The contemporary movement of science education towards science as inquiry offers learners of science with the three aspects of science learning as suggested by Ford and Forman. The National Research Council [NRC] (2000), for example, recommended learners of science should be given opportunities to engage in (1) identifying testable questions and concepts that will guide their investigations, (2) designing and carrying out scientific investigations using scientific concepts and equipment, (3) using appropriate technologies and mathematical principles to improve investigations and communications, (4) formulating and revising scientific explanations, (5) proposed models using logic and evidence, (6) recognize and analyze alternative explanations and models; and (7) communicate and defend a scientific explanations. (NRC, 2000). Science education research over the last 20 years has focused on how science as inquiry can be carried out in schools and the problems with the implementation of science as inquiry across different classroom learning contexts. Many studies have shown that questioning and dialogic interaction between teachers and students contribute to building an environment conducive to inquiry-based science classroom. Crawford (2000) worked with a high school science teacher, Jake, and found that Jake played 10 different roles to create an inquiry-based learning environment. These 10 roles include: (1) motivator, (2) diagnostician, (3) guide, (4) innovator, (5) experimenter, (6) researcher, (7) modeler, (8) mentor, (9) collaborator, and (10) learner. These roles played by the teacher in a science inquiry-based science classroom are important yet diverse. As such, teacher education and professional development are necessary in helping teachers develop these competencies to teach science.

McNeil and Krajcik (2008) found that when teachers engage in instructional practices of modeling scientific explanation, making the rationale of scientific explanation explicit, defining scientific explanation, and connecting scientific explanation to everyday explanation can influence student learning of scientific explanation. As such, teachers' abilities to model these scientific processes are crucial to helping students learn to make sense evidences when they construct scientific explanations. However, in Sampson and Blanchard's (2012) interview study with a group of secondary science teachers, it was found that the teachers relied primarily on their prior content knowledge to evaluate the validity of an explanation rather than using available data. Herein lies the need to look into teacher professional development focusing on the area of examining and making sense of evidence in the process of crafting scientific knowledge.

Knowledge building pedagogy (Scardamalia & Bereiter, 2006) has been used in many inquiry science classrooms (e.g., Yeo & Tan, 2010). Knowledge building is based on the socio-cultural approach of learning that leverages community's expertise and effort to advance understanding of a topic through collaborative work on communal knowledge artifacts (Scardamalia & Bereiter, 2006). The improvement of reified ideas captured in artifacts available in a public space (e.g., notes in an online forum) requires appropriate knowledge building practices. In a collaborative setting, learners need to engage in productive knowledge building discourse that applies epistemic criteria to improve the quality of the ideas. However, knowledge building discourse cannot exist in vacuum; the learners need to refer to authoritative sources of knowledge (e.g., textbooks or online resources) and need to do so critically and constructively. To be aware and able to apply epistemic criteria also means that the learners should be able to assess the quality of their ideas. Such assessment practices are an integral part of the knowledge building (assessment for learning and assessment as learning), rather than a separate end-of-learning activity (assessment of learning). As knowledge building practices require all learners to contribute to idea improvement, all learners have the opportunity to deepen their understanding of a topic. Students learn to compare their ideas with the interpretations accepted by the scientist community (as found in authoritative sources) and learn to use scientific standards and values to judge the values of the ideas. Thus, the emphasis is not so much of performing scientific inquiry to discover the truth (as presented by the scientist community), rather, the focus is on learning to use the language and tools of science to make progress and advance scientific idea. This is closer to the goal of helping students appreciate the nature of scientific knowledge as tentative.

In this study, we investigated a group of pre-service teachers, who are science graduates, on the ways they use online resources for learning prior to knowledge building intervention. By comparing their learning actions with group of high school students who underwent knowledge building intervention, we identify the potential contribution of knowledge building towards the goals of inquiry science.

Methods

This study took place in a national institute of education that prepares pre-service teachers to teach in schools. The 16 pre-service teachers in this study are science graduates who were enrolled in a one year Post-Graduate Diploma in Education (PGDE) course. They were all training to be high school biology or chemistry teachers. Data was collected from their participation in a biology methods course in a session that focused on the role of technology in facilitating learning.

The task given to the pre-service teachers is one whereby they have to make decision where three primary sequences of polypeptide chain would reside in a protein molecule. They were told that some sequences reside on the surface of the protein while others reside in the hollow on the protein surface. The pre-service teachers work in groups of four to examine the properties of the sequences of polypeptide chains and collaboratively decide on their location. Each group was give two laptops with internet access and they were told that they can look for information online should the need arise. They were given 30 minutes to complete the task.

Data Collection

Video and audio recording were carried out during the students' discussion. A total of 92 minutes of video and audio data collected. The video data captured how the various groups of pre-service teachers interacted with one another as well as with the laptop computer whereas the audio data serves to provide a clearer means to decipher the conversations that took place within the group.

Data Analysis

The aim of this analysis is to understand how much time pre-service teachers spend online within a group discussion and also to recognize how they make use of the information that they obtain online. The audio and video files were subjected to two rounds of analysis. The first round of analysis involved watching the video recording and noting the time spent on each phase during group discussion. This is done through time stamping at the transition point when the pre-service teachers move from one activity to another. The second round of analysis involves transcription of the audio files and analyzing them for what is uttered during conversation among the group members. Specifically, the analysis focused on reference to materials that they find online and how they use them to facilitate discussion to progress their ideas.

Results

Amount of time spent online

Within the context of a group discussion where there is access to online resources, the pre-service teachers show a wide range of preferences in how group discussions are carried out. As shown in Table 1, PS's group spent on 3% of their time talking to one another while WY's group spent up to 77% of their time talking to one another. Similarly, the time spent just reading and searching information on the web is also varied – only 3% of the time spent on online reading in Ed's group to 72% of the time reading from PS's group. All the four groups were generally uniform in terms of the percentage of time that they spent on discussion based on information available on the internet. The average time spent on dialoguing with one another is 51.25% which is the most dominant mode of interaction for these pre-service teachers within a group context. Reading and searching for information online is the least common form of interaction while dialogue around what is found online stands at about 26.5%.

Table 1: Time spent interacting with each other and with laptop

Groups	**Time spent (percentage with reference to total group discussion time)**		
	Talking to one another (%)	**Online Only (%)**	**Online-aided discussion**
Ed's group	59	3	38
Ly's group	66	14	20
PS's group	3	72	25
WY's group	77	0	23
Mean	**51.25**	**22.25**	**26.50**

How online resources are used

It is shown that on the average, the pre-service teachers spent 26.5% of their group discussion time around information found online. Based on their talk that followed after they have made reference to the online resources, we identified three different purposes of online access to facilitate their dialogic discussion.

Trigger. It is observed that after reading the task that was given to them, Ed's group began their discussion by referring to something that was found on the internet. This was found using a keyword search. Excerpt 1 shows how the discussion proceeds as they make use of the internet source as a starting point.

Excerpt 1: I would like to talk about this
S4: Ok, i would like to talk about this. Actually i got it from here (refers to internet sources)
S1: So what is it?
S4: I will talk about the protein first, then i will talk about amino acids. Because the way that i talk about amino acids is the subunit, is the building block of protein. Then i have to say what is protein first, as like the basic working molecule of life
S3: So what is it?
S4: I think is the basic working molecule of life
S3: But you still don't define what is it. You say is a basic working molecule...
S1: But he defines it in term of function already, so there's...
S4: That's why i am thinking right, why not we define the protein, basic molecule libraries (unclear) and then add middle a chemical structure at the back whatever, whatever...
S3: But...
S4: But your one is (unclear) to answer all this, put it below... Basic building block subunit of protein with... then yours put behind. And the protein is the basic working molecules of life. Then match loh

Clarification and building on. When pre-service teachers encountered a situation where all the members of the group were unable to recall their what they know or when they appeared to be in doubt about how they should proceed with the idea that has been raised, they referred to the information available online. For example, when someone in the group raises a question that requires an answer before the discussion can proceed and when no one in the group is able to answer the question, one member of the group usually refer to the laptop and use a keyword search to look for information. As can be seen from Excerpt 2, the members of the group were unable to figure out the ionic bonds which were formed between amino acid molecules, they turned to the internet as a resource for the information. It was evident that the information that was found was readily taken up by the group as can be seen from how they immediately recorded the charges of the respective amino acids on the task sheet that they were working on.

Excerpt 2: No, I don't remember
S3: Held by what kind of bonds?
S1: Is all the same what?
S3: The same three bonds ah? Ah the same bonds... Ok
S4: Ok, i think we need to try the second question
S1: Don't we have to know the side chains first?
S2: Ya, i don't know whether they need us to really examine each of the...
S4: Ok, i think we need to find the amino acids, their...
S3: So you all will remember which one are the ionic bonds right? And then which one are the...
S4: Yes
S1, S2: No, i don't remember
S4: I got it, i got it (online results)
S3: Ok, electrically charged side chains, polar uncharged... So is Arg... (refers to the information online)
S4: First, we need to identify all the negatively and positively charged...
S3: Ya, ok i will take the third sequence lah
(all check and write down the charges of amino acids)

In WY's group, as the discussion progressed, it was clear that the members of the group had ample knowledge of the chemical structures of the various amino acids. As such, they used resources available to build on their existing knowledge of the chemical structures of amino acids through confirming what they already know with the resources available online and also using the information online to continue with their dialogue. As can be seen from Excerpt 3, they used google to search for more hydrophilic amino acids and the comment by S14 on why S15 can remember so much information is indicative that the information online serves merely to confirm what they already know about the topic.

Excerpt 3: Google online to find
S15: I can remember... Hydrophilic are Glutamine, glutamine got NH_2 mah
S14: Google online to find
S15: Hydroxine also, is a phenol with OH
S14: Why you remember so much?
S15: Is chem mah, so is molecular structure
S12: Aspartic?
S15: Aspartic, it has an acid... Ya, so COOH
S15: The Leu, Val all is CH3, CH2, CH3, so...
S12: So those are not right? Those are...
S15: Those are hydrophobic. Ala, Val, Ile...
S12: Hey, this one is Glutamic right? Then this is Glutamine... Eh, this is Glycine
S13: No, this is not Glycine, this is Glutamine
S12: This is Glycine

Task completion. When told that they had four minutes remaining on the task, PS's group immediately referred to the laptop for an answer to complete the task. As evident from excerpt 4 where S9 was excited and gleeful when he searched online and appeared to have found the answer to the question of hydrophobic and hydrophilic side chains of amino acids, he was eager to take all in the information and transfer them onto the task sheet. This behavior is similar to what Jimenez-Aleixandre, Rodriguez and Duschl (2000) distinguished as "doing the lesson" as opposed to genuine discussion of science to characterize "doing science". Here, the accessibility of online resources is seen as an avenue where the correct or acceptable answers can be found. The pre-service teachers were eager to complete their tasks and hence ended genuine dialogic discussion. They sought to close their discussion with "authoritative" sources of information which is solicited online.

Excerpt 4: Let's copy
S11: The hydrophobic call (unclear) is just not accessible to these... while the call (unclear) is going up by hydrophobic amino acids polar over (unclear)
S9: Shiok (a gleeful expression), we have the answer. Oh, i got this one (refers to online sources)
S11: (unclear)
S9: Ok, let's copy

Discussion and Conclusion

With reference to the first research question about how pre-service teachers interact with one another as well as with technology, our results showed that the pre-service teachers in this study showed diverse ways of interactions from spending only 3% of discussion time talking to each other to dialoging with each other for up to 77% of the time. The three ways of interaction that are observed (speaking with one another, reading off the screen and referring to the laptop and using that as a basis for discussion) are the three pre-dominant ways of interactions that are observed. The pre-service teachers shuttled between these three different modes depending on what the issues that were raised during the discussions. With reference to the second research questions, we described three key purposes observed about how the pre-service teachers use online resources. These three ways – trigger, clarification and confirmation and task completion – are all essential in helping with understanding and developing their knowledge in science, particularly with formulating explanations and looking for evidence to justify their stance.

Nevertheless, when we compare the findings with that from another study (Yeo & Tan, 2010) that involved high school students solving a physics problem, we saw some similarities, and yet more critical use of online information among the students. In Yeo and Tan's study, high school students used online resources to bring in ideas that are new to them, which is similar to the use of online information as trigger in the current study. In effect, online resources help to expand their field of scientific knowledge. In Yeo and Tan's study, the students were able to deconstruct the scientific symbols found from the internet and interpret the meaning of these symbols in the problem context they were working on. When the application of the scientific equations failed to solve the problems, the students eventually questioned the equation that represents ideal situation, and improved on the ideal equation to take into account of air-resistance the real-life situation. No doubt the different contexts of the two studies (e.g., time provided for the activities) might contribute to the different outcomes, it illustrates that with appropriate intervention (knowledge building talk), even high school students could use online resources critically, to the extent of identifying hidden assumptions of scientific equations that often represent ideal situations. In contrast, the pre-service teachers (who are university graduates and who have much longer experience of being trained in the scientific disciplines) did not seem to engage in deep meaning making of the online resources. In future studies, it will be interesting to investigate whether with knowledge building intervention and with sufficient time, pre-service teachers can use online resources critically for interpretation of meaning of texts in scientific resources and discourse.

References

Crawford, B. A. (2000). Enhancing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching, 37*(9), 916-937.

Ford, M. J., & Forman, E. A. (2006) Redefining disciplinary learning in classroom contexts. *Review of Research in Education, 30*(1), 1-32.

Jimenez-Aleixandre, M. P., Rodriguez, A. B., Duschl, R. A. (2000). 'Doing the lesson' or 'Doing science': Argument in high school genetics. *Science Education, 84*, 757-792.

Jocz, J. A., Zhai, J., & Tan, A.-L. (2014). Inquiry learning in the Singaporean context: Factors affecting student interest in school science. *International Journal of Science Education,* DOI: 10.1080/09500693.2014.908327.

Lehrer, R., & Schauble, L. (2006). Scientific thinking and science literacy: Supporting development in learning in contexts. In W. Damon, R. M. Lerner, K. A. Renniner & I. E. Sigel (Eds.). *Handbook of child psychology*, 6th ed. (Vol. 4). Hoboken, NJ.: John Wiley and Sons.

McNeill, K. L., & Krajcik, J. (2008). Scientific explanations: Characterizing and evaluating the effects of teachers' instructional practices on student learning. *Journal of Research in Science Teaching, 45*(1), 53-78.

Mercer, N. (1995). *The guided construction of knowledge: Talk amongst teachers and learners.* Clevedon: Multilingual Matters.

National Research Council [NRC] (2000). *Inquiry and the National Science Standards: A guide for teaching and learning.* Washington, D. C.: The National Academies Press.

Sampson, V., & Blanchard, M. R. (2012). Science teachers and scientific argumentation: Trends in views and practice. *Journal of Research in Science Teaching, 49*(9), 1122-1148.

Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In Sawyer, R. K. (Eds.). *The Cambridge Handbook of the Learning Sciences* (pp. 97-118). NY: Cambridge University Press.

Yeo, J. & Tan, S.C. (2010). Constructive use of authoritative sources in science meaning making. *International Journal of Science Education, 32*(13), 1739-1754.

Leveraging Web 2.0 tools for Knowledge Building

Seng Chee TAN, National Institute of Education, Singapore, sengchee.tan@nie.edu.sg

Abstract: This paper is built on the premise that there should be a tight coupling of pedagogical practices and supportive technologies, for example, Knowledge Forum affords knowledge building practices and appropriate pedagogical practices. In recent years, the emergence of Web 2.0 tools brings new opportunities, but there is a need to consider pedagogical congruence of the Web 2.0 tool and knowledge building practices. This paper presents examples of how Web 2.0 tools can be used to augment knowledge building processes, including tools that support multimodal representation of knowledge artifacts and tools that engage learners in digital curation. On the other hand, it is argued that tools that support artifacts with numerous embedded ideas and embedded discussion may not be suitable for knowledge building. In addition, systems of tools that are developed based on different epistemological assumptions would be incongruent with knowledge building pedagogy.

Introduction

Research on knowledge building is one that epitomizes how supportive technologies can be developed in tandem with the progress in pedagogical research. In the 80s, Computer-Supported Intentional Learning Environment (CSILE) was developed to support idea-centric knowledge building pedagogy (Scardamalia, Bereiter, McLean, Swallow, & Woodruff, 1989). Some of the technological features of CSILE – representing ideas in text and graphics, storing and retrieving ideas in a communal space, referencing ideas in other notes, and linking to external resources – have endured the test of time to be included in recent versions of Knowledge Forum (www.knowledgeforum.com). The rapid advancement in networked technologies in recent years, however, presents new opportunities and ideas about employment of supportive technologies for knowledge building. The advent of Web 2.0 technologies, for example, has empowered users to create and share contents, which seem to support learning from the knowledge creation perspective. A new identity of online participants has also emerged; the term prosumer (Ritzer, Dean, & Jurgenson, 2012) is used to describe users who are not just consumers of information, but also producers of content. The use of Web 2.0 technologies seems to be consistent with the participatory culture of learning or "e-Learning 2.0" practices (Lim, So, & Tan, 2010). This paper suggests that while e-Learning 2.0 practices seem to be consistent with the knowledge building practices and that Web 2.0 tools can be integrated into knowledge building processes, we need to be cautious that it is not a contrived attempt to find new applications for existing Web 2.0 tools. In addition, while there are reports of conducting knowledge building using Web 2.0 tools such as wikis (e.g., Cress & Kimmerle, 2008), the theoretical perspectives of knowledge building could be different. This paper aims to clarify the affordances and usage of Web 2.0 tools with respect to the social cultural perspective of knowledge building (Scardamalia & Bereiter, 2006). While the technical usage and practices of Web 2.0 tools are important issues to practitioners, they are not the main focus of this paper. First, we could start with an analysis of the features of Knowledge Forum that afford the practices of knowledge building.

Knowledge Building Principles and Affordances of Technologies

Table 1 summarizes the key pedagogical principles of knowledge building, the corresponding requirements for supportive technologies and the features in Knowledge Forum.

Table 1: *Knowledge building principles and affordances of supportive technologies.*

Pedagogical principles	Technological requirements	Knowledge Forum
1. Focusing on authentic Ideas	• Representation of ideas	• Ideas represented as text or graphics in a note.
2. Idea diversity	• Accessibility of idea representations by multiple participants	• Notes are presented in a View; Participants are given rights to access a View and to build on the notes.
3. Improvable ideas	• Historical record of idea representation • Connections of idea representation that also	• Ideas in notes are responded to using Build On, Reference, Annotate, or Rise Above • "Threaded" forum with downward "tree" structure or visible lines linking notes (in

	indicate interactions among participants	Enhanced mode)
4. Rise above	• Integration of idea representations	• Rise above function
5. Collective Cognitive responsibility	• Joint Authorship • Joint maintenance of collaborative space	• Shared ownership of contribution and management of the knowledge database
6. Knowledge building discourse	• Thinking types scaffolds	• Customizable thinking cues that encourage participants to respond using certain phrases and thus engage in targeted types of thinking
7. Constructive use of authoritative sources of knowledge	• Repository or link to resources	• Link to external web addresses • Repository of documents and movies
8. Embedded transformative assessment	• Analytics • Critical comments by others	• Analytics that provide information on participation and interactions • "Building on" by others
9. Democratizing knowledge	• Shared cyber space for all participants; • Instructor does not filter all information and actions	• Membership assigned by the database administrator • Shared ownership of contribution and management of the knowledge database
10. Epistemic agency	• Scaffolds • Rights and controls of actions by users	• Thinking cues • Shared ownership of contribution and management of the knowledge database • Flexible organization of notes in a View • Notes can be copied to new Views and be reorganized
11. Symmetric advancement in knowledge	• Virtual visits, co-constructions	• Include members of different expertise • Flexible organization of notes in different Views • Advancement of ideas in shared knowledge databases
12. Pervasive knowledge advancement	• Expansible knowledge work space	• New Views can be created for other topics • Notes can be copied to new Views and be reorganized • View Links can be created

There must be a tight coupling of the pedagogical practices and the technologies – while Knowledge Forum affords knowledge building practices, appropriate pedagogical practices must also be enacted to leverage these affordances. It can be difficult to achieve some knowledge building principles without the supportive technologies. For example, pervasive knowledge advancement is difficult to achieve without an expansible knowledge space that can be linked in a meaningful way. We have attempted using paper Post-It notes for idea generation and organization, but keeping these notes intact in a classroom and linking these notes to different topics of investigation posed a considerable logistic challenge, and consequently the knowledge building activities could not be sustained. On the other hand, the affordances of Knowledge Forum can be leveraged for knowledge building only with appropriate pedagogical practices. Failing that, it might lead to "lethal mutation" of practices (Brown & Campione, 1996). For example, the analytics can be used to assign participation points by counting the number of notes contributed by each member, which leads to coerced participation rather than development of epistemic agency.

Unlike Knowledge Forum and a few other tools (e.g., Future learning environment or FLE http://fle3.uiah.fi/) that are developed for knowledge building, many Web 2.0 tools were not developed specifically for the purpose of knowledge building. It would be difficult to find a tool that has affordances matched to all the key processes of knowledge building. This paper proposes an approach of analyzing and integrating a Web 2.0 tool with knowledge building practices and existing supportive technologies (e.g., Knowledge Forum).

Web 2.0 Technologies for Knowledge Building

In the above section, to illustrate the intentional design of Knowledge Forum, the affordances of Knowledge Forum were matched to the pedagogical principles of knowledge building. Using these 12 principles to analyze a Web 2.0 tool, however, may not be feasible. It tends to fall into the fallacy of treating the 12 principles as the qualifying criteria for knowledge building. From my teaching experience, one question that novices of knowledge building commonly ask is, “how many of the 12 principles must be fulfilled in order for my lessons to be called knowledge building?” It tends to oversimplify teacher’s pedagogical practices into a dichotomy – Knowledge building or not knowledge building – and risks losing the developmental perspective of improving the practices. Likewise, treating a tool as knowledge-building tool versus non knowledge-building tool will lose the opportunities to leverage Web 2.0 tools to enrich knowledge building practices. In this paper, an approach that can integrate Web 2.0 tools into knowledge building and focus on pedagogical considerations is proposed. In essence, to avoid the pitfall of using tools just because they are available, the key is to analyze the pedagogical practice of using a Web 2.0 tool and how it can augment the broader knowledge building effort.

Multimodal Representation of Ideas

Figure 1. An animated graphic illustration of the Water Cycle (created by Robert Friedley, retrieved from http://www.educreations.com/lesson/view/water-cycle/683307/)

One of the key tenets of knowledge building is working with students’ ideas, which are captured as knowledge artifacts. In Knowledge Forum, students’ ideas are represented by mainly texts and sometimes graphics in a note. We can expand the range of knowledge representations with Web 2.0 tools. Various tools are now available for easy creation of content in multiple modalities. For example, using EduCreation (http://www.educreations.com/), students can illustrate a process coupled with voice narration. Figure 1 shows an example of water cycle. Compared with static 2-D illustration, this animated graphic gives a better depiction of a process. This artifact can be embedded as a link in a Knowledge Forum note and serve as the focal point for discussion for improvement in explanations of the processes in this water cycle system. Such multimodal content creation tool can also be used for rise above that includes several ideas. For example, after discussions on the conversion of states and the system concept, students can create an animated illustration of their higher level knowledge representation of the water cycle. For that matter, tools like GlogsterEdu (http://edu.glogster.com/) can also be used to pull together several ideas.

In addition to animated graphics and digital posters, another type of tool that can be used for idea representation is concept-mapping and mind-mapping tools. Figure 2 shows a concept map of “knowledge creation” constructed by a graduate student using CMap (http://cmap.ihmc.us/). There are several Web 2.0 concept-mapping or mind- mapping tools available, for example, Popplet (http://popplet.com), Mindomo (http://mindomo.com), Spider Scribe (http://www.spiderscribe.net), and Bubbl (https://bubbl.us).

These Web 2.0 tools allow a user to create concept maps (Novak & Gowin, 1984) that include concept terms and relationships or mind maps (Buzan, 2006) that represent related ideas. Our discussion here focuses on concept mapping which entails critical thinking. The main difference between a concept map and a typical note in Knowledge Forum is that a concept map (a) contains more than one idea, (b) has ideas expressed as concept terms, (c) includes relationships among ideas, and (d) can include information on hierarchies of concept (superordinate, coordinate or subordinate concepts). A map is thus a more complex representation of ideas.

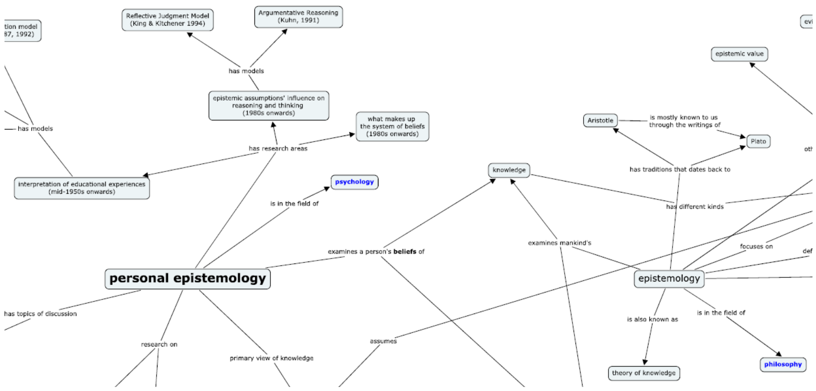


Figure 2. A concept map on Knowledge Creation.

Concept mapping can be traced to cognitive learning theories, for example, meaningful learning (Ausubel, 1968). When students construct a concept map, they have to identify the key concepts of the topic and connect the concepts with meaningful labels. Students are therefore engaged cognitively in analyzing and processing the information. As a concept map represents interrelationships between concepts, a student needs to make appropriate connections and label the relationships with appropriate link words. Theoretically, the process of concept mapping helps the student to make connections between new knowledge and existing knowledge, which is a key characteristic of meaningful learning (Novak & Godwin, 1984). Despite the cognitive roots of concept mapping, in research years, researchers have explored collaborative concept mapping (Kwon & Cifuentes, 2007) that presents opportunities for students to negotiate their perspectives in how related concepts can be organized. In knowledge building vernacular, we can treat it as one of the ways to get students to "rise above" by analyzing and organizing facts or information that they have discussed.

There are several ways to integrate Web 2.0 concept mapping tool into knowledge building. We can, for example, after some knowledge building activities, ask students to co-construct a map on a topic as a "rise above" activity. The students then post their respective group concept map in Knowledge Forum and these maps can become the focal point of discussion as students compare their maps. It is a potential way to deepen rise above as a discussion on concept representation and relationships among concepts propels students to epistemic discussion at a high level of abstraction. Using Figure 2 as an example, the graduate students can discuss about relationship between "personal epistemology" and "epistemology". Lower level students can also learn to co-construct concept maps and use them as background graphics in Knowledge Forum to organize clusters of notes.

Constructive Use of Authoritative Sources of Knowledge Using Digital Curation

The term curation has been used traditionally by museum or library to refer to collecting, organizing, tagging and maintaining a collection of artworks or historical artifacts. Digital curation is a recent development in response to the exponential growth in digital artifacts and resources and the need to "maintain digital research data and other digital materials over the entire life-cycle and over time for current and future generations of users (Beagrie, 2006, p. 4). The Digital Curation Center describes digital curation as an activity that "involves maintaining, preserving and adding value to digital research data throughout its lifecycle" (DCC, 2004-2014). It emphasizes the preservation and maintenance of knowledge and intellectual asset in digital forms for research purposes.

The educational applications of digital curation began to emerge only in the past few years. Antonio, Martin, and Stagg (2012, p. 1) provided a description of the process of digital curation for education:

> an active process whereby content/artefacts are purposely selected to be preserved for future access. In the digital environment, additional elements can be leveraged, such as the inclusion of social media to disseminate collected content, the ability for other users to suggest content or leave comments and the critical evaluation and selection of aggregated content. This latter part especially is important in defining this as an active process.

Searching for and the critical use of relevant authoritative sources of knowledge is an important process in knowledge building. However, the amount of information in the Web can be daunting and searching for relevant information is not only time consuming, but sometimes distracting for a student. Tools like Diigo (https://www.diigo.com) allow groups or community to be formed to pool resources around topics of common interest. Figure 3 shows the collection of bookmarks on the topic Classroom 2.0 where the search term "Diigo" was entered to identify relevant resources. This bookmark helps to point to relevant resources and enhance the efficiency for identifying information.

That said, however, the values of social bookmarking tools go beyond crowdsourcing of relevant information. Students can be taught to identify relevant websites, categorize and tag the website, highlight key phrases, annotate key information with sticky notes, share the bookmarks, search through bookmarks to find relevant information, or even comment on bookmarks created by others. This process engages a student in deeper processing of information from the Web. The interactions among students afforded by some social bookmarking tools can be leveraged for students to process the information critically, rather than using them at face values. As part of a knowledge building activity, when constructing a note, students can add reference to external bookmarks and point to the relevant segment of the text with highlight or their annotation. In this way, it can extend the referencing actions beyond notes in Knowledge Forum, but also to specific points in external web-based resources.

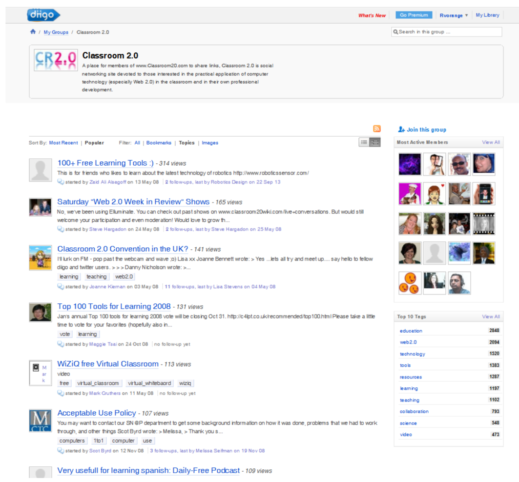


Figure 3. A Diigo group on Classroom 2.0

Cases of Misfit

The examples above show the potential applications of Web 2.0 tools to support some processes of knowledge building, mainly through the pedagogical processes that can augment knowledge building activities. There are, however, many other Web 2.0 tools or platforms that may not fit well.

Tools like blogs and wikis can be used for rise above, but there is no apparent advantage of linking to an external platform when Knowledge Forum has better affordances for such purpose. Two important considerations for the appropriateness of tools for construction of knowledge artifacts are the granularity and "embeddedness" of ideas. Given that knowledge building focuses on idea improvement, a knowledge representation containing numerous embedded ideas may not be viable. For example, while an essay can be collaboratively composed, edited and improved using wikis, the entire essay may contain ideas or themes presented in an intended sequence to represent some arguments. While it may be possible to edit and work on individual ideas in the essay, the outcome of the edited essay is shown in wikis but discussions surrounding the ideas are not explicitly represented. It is quite different from deepening our understanding of a phenomenon through knowledge building. Unlike wikis, blogs are used mainly for personal reflection. Blogs do not invite co-construction, but responses and comments to a text.

Besides wikis and blogs, another case of misfit to knowledge building is Web 2.0 Learning Management System (e.g., Schoology, Edu2.0, and Fakebook).

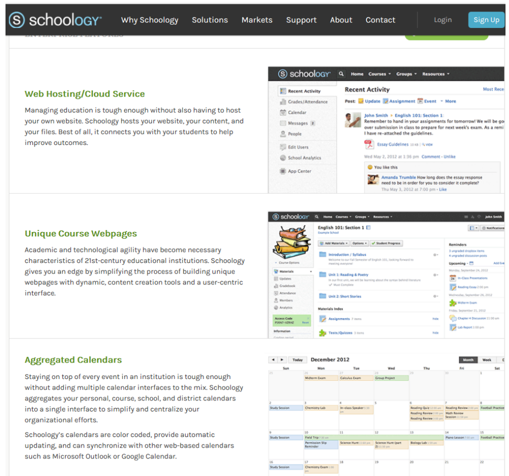


Figure 4. Learning Management using Schoology

A learning management system (LMS), as the name implies, focuses on managing learning processes. Some common features include Announcement, Enrolment of Users, Calendar of Events, Assessment Modules, Discussion Forums, and Content Repository (see Figure 4). Many school leaders are attracted to LMS that facilitates the process of course administration and exchange of information, rather than idea elicitation and idea improvement. Palloff and Pratt (2001) argued that learner's needs and outcomes should be given priority rather than the needs of instructors or administrators. While communication tools are embedded in the system, the structure of the system does not facilitate idea improvement. Take for example a message tool in Schoology. The messages are linearly displayed in chronological order rather than linked by ideas. The fourth message, for example, could contain a reply to questions raised in the first and second messages, but such relationships are not explicit. A threaded discussion board comes close to one of the interface design of Knowledge Forum. It presents a downward tree structure to indicate relationships among the ideas, but it lacks other essential features like using scaffolds for knowledge building discourse, referencing ideas among notes, and constructing rise above notes. Assessment tools in a learning management system usually facilitate implementation of tests and quizzes that focus on assessment of learning, rather than assessment for learning or assessment as learning. Most critically, when users enter a learning management system, their attention is likely to be directed towards learning events and activities, rather than idea improvement. This is because the underlying philosophy of many LMS focuses on management of learning processes.

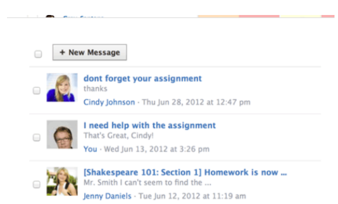


Figure 5. Communication tools in Learning Management Systems

Conclusion – Pedagogical Congruence with Knowledge Building

The development of Knowledge Forum technology in tandem with knowledge building pedagogy results in a tight coupling of the pedagogical practices and the technology. In general, Web 2.0 tools support creation of knowledge artifacts and participatory culture of learning that leverages distributed expertise among learners. From this perspective, it seems congruent with knowledge building practices. However, the current Web 2.0 tools are not developed for knowledge building; it is not realistic to expect a close fit with knowledge building. Web 2.0 tools, however, can be used to augment knowledge building activities. One key criterion to assess the appropriateness of tools is the pedagogical congruence with knowledge building. Given that knowledge building is idea-centric, an appropriate Web 2.0 tool can be used to support collaborative improvement of student ideas, which means the tool affords the followings:

1. Construction of knowledge artifacts that represent ideas at an appropriate level of granularity and "embeddedness"
2. Collaborative work on the same artifact

Tools like digital poster, animated graphics or concept mapping tools, when used appropriately, can support idea representation, idea improvement or rise above. In addition to idea representation tools, digital curation tools like social bookmarking tools can engage students in critical analysis of web-based information, and the product of this (the social bookmarks) can act as external resources for knowledge building activities.

Using these criteria, tools that support artifacts with numerous embedded ideas and embedded discussion – such as wikis and blogs – may not be suitable for knowledge building. In addition, systems of tools that are developed based on different epistemological assumptions (e.g., Web 2.0 learning management tools) are likely to be incongruent with knowledge building pedagogy.

References

Antonio, A., Martin, N., & Stagg, A. (2012). Engaging higher education students via digital curation. In M. Brown, M. Hartnett, & T. Steward (Eds.), Future Challenges, sustainable futures. In *Proceedings ascilite Wellington 2012*. (pp. 55-59)

Ausubel, D. (1968). Educational psychology: A cognitive view. New York: Werbel and Peck.

Beagrie, N. (2006). Digital curation for science, digital libraries, and individuals. *The International Journal of Digital Curation, 1*(1), 3-16.

Brown, A. L., & Campione, J. C. (1996). Psychological and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289–325). Mahwah NJ: Lawrence Erlbaum Associates.

Buzan, T. (2006). *Use your head*. BBC Active.

Cress, U., & Kimmerle, J. (2008). A systemic and cognitive view on collaborative knowledge building with wikis. *Journal of Computer-Supported Collaborative Learning, 3*(2), 105-122.

Digital Curation Center. (n.d.). What is digital curation? Retrieved from http://www.dcc.ac.uk/digital-curation/what-digital-curation.

Kwon, S. Y., & Cifuentes, L. (2007). Using computers to individually-generate vs. collaboratively-generate concept maps. *Educational Technology & Society*, *10* (4), 269-280.

Lim, W.Y., So, H.J. & Tan, S.C. (2010). Elearning 2.0 and new literacies: Are social practices lagging behind? *Interactive Learning Environments, 18*(3), 203-218.

Novak, J. D., & Gowin, D. B. (1984). Learning how to learn. Cambridge, London: Cambridge University Press.

Palloff, R. M., & Pratt, K. (2001). *Lessons from the Cyberspace Classroom: The realities of online teaching*. San Francisco: Jossey-Bass.

Ritzer, G., Dean, P., & Jurgenson, N. (2012). The coming of age of the prosumer. *American Behavioral Scientist, 56*(4), 379-98.

Scardamalia, M., Bereiter, C., McLean, R. S., Swallow, J., & Woodruff, E. (1989). Computer supported intentional learning environments. *Journal of Educational Computing Research, 5*, 51-68.

Analysis of Constructive Interaction using KBDeX as a Scaffold for Students' Learning about Collaborative Learning

Sayaka Tohyama, Technical Division, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu, 432-8011 Japan, tohyama@inf.shizuoka.ac.jp
Yoshiaki Matsuzawa, Graduate School of Informatics, Shizuoka University, 3-5-1 Johoku, Naka-ku, Hamamatsu, 432-8011 Japan, matsuzawa@inf.shizuoka.ac.jp
Hajime Shirouzu, National Institute for Educational Policy Research, 3-2-2 Kasumigaseki, Chiyoda-ku, Tokyo, 100-8951, Japan, shirouzu@nier.go.jp

Abstract: Constructive Interaction, KBDeX, DASK, Discourse Analysis. Collaborative learning often leads to better learning, but it does not mean that participants know its merits or why. We have tried to help university students grasp them, the last year trial of which we found promising enough to report. We hypothesized that analyzing processes of deepening understanding helps the students' understanding of merits and mechanisms of collaborative learning. Such kind of interactions which deepens one's understanding is called "constructive interaction". We provided following ones to the students to help analysis of constructive interaction: a simple discourse data of constructive interaction, discourse analysis support tool called KBDeX, and DASK which suggests the important points when analyzing constructive interaction. The students in the 2013 "Learning Management" class studied the effect of constructive interaction through analysis activity of constructive interaction. The students in the 2012 class read texts about the effect of constructive interaction and explained it each other. The students in the 2013 class compared with the 2012 class using design research. We analyzed the students' beliefs about the effect of collaborative learning focusing on (1) the effect of KBDeX, and (2) the effect of activity changes between the 2012 class and the 2013 class. Furthermore, (3) we analyzed the students' references to the mechanism of constructive interaction in their group work. The result is that the students in the 2013 class changed their beliefs about the effects of collaborative learning than the students in the 2012 class. KBDeX was effective when it is used in the analysis process about constructive interaction.

Introduction

In this study, we investigated scaffold for students' learning about the effect of "constructive interaction" through discourse analysis and rebuilding students' beliefs regarding collaborative learning.

In recent years, students have been expected to have the skill of deepening their understanding, which is one of the "21st century skills" (Griffin, McGaw, & Care, 2012) necessary for creating an innovative future society. The mechanism of constructive interaction improves students' understanding in collaborative learning (Miyake, 1986). In Japan, Miyake and her collaborators suggest that students in junior high and high schools could deepen their understanding of academic subjects (CoREF, 2013). However, some students think that collaborative learning consists of simply dividing tasks among group members with little discussion, even when they experienced group activities before entering the university (Matsuzawa, Tohyama, & Sakai, 2013). Thus, learning about the effect of collaborative learning from the meta point of view is difficult for these students. We hypothesized that if students recognize that collaborative learning could improve the depth of their understanding, they will try collaborative learning as a learning method.

The importance of concrete experience with reflection has been confirmed in previous studies of metacognition (Brown & Campione, 1996; National Research Council, 1999). We hypothesized that metacognition about collaborative learning will help change students' beliefs about collaborative learning. And we could not teach students how to reflect on their learning from the meta point of view without concrete learning experiences (NIER, 2014). So we tried to teach the effect of collaborative learning to university students using activities that involved both collaborative learning and reflection in Learning Management class. We expected the students to perceive the relationship between collaborative learning as a concrete experience and reflective activity, and to learn about the learning process.

In this study, we focused on discourse analysis activities for the students' meta learning about collaborative learning because we can observe the mechanism of constructive interaction when we analyze discourses from meta point of view (Tohyama, 2013). We expected the students to recognize the effect of collaborative learning through discourse analysis activity from the meta point of view. We provided the curriculum for learning about the mechanism of constructive interaction in Learning Management class in 2013, and the main activity of the curriculum was discourse analysis. In the activity, we provided Knowledge Building Discourse eXplorer (KBDeX), which is an effective discourse analysis tool (Oshima, Oshima, & Matsuzawa, 2012). Also we provided an example discourse data which shows the processes of constructive interaction, and worksheets which was called Discourse Analysis Sheet for KBDeX (DASK) to provide the analysis points of constructive interaction. We then analyzed how the curriculum enhanced the students' learning about the effect of collaborative learning compared with the results of Learning Management class in 2012. In this study, we analyzed the students' beliefs about collaborative learning in the 2012 class and the 2013 class, focusing on changes in the Learning Management class curricula using design research (Brown, 1992).

Research Method

To teach the effect of constructive interaction in the Learning Management class, we focused on the reflective activity. We did not change the theories of learning that suggest the characteristics of collaborative leaning of the data recorded in the students' activities between the 2012 class and the 2013 class. For the reflective activity, we selected the discourse analysis. If the data of discourse analysis contains the characteristics of the important point of deepening understanding, the students could capture such characteristics. However, finding these characteristics is difficult when these points exist: analyzing inappropriate data that does not contain the processes of constructive interaction or knowledge building, analyzers are novices of the theories of learning so that the analyzers have difficulty for visualizing the characteristics of the data. To solve these problems, we provide data for analysis that contains the simple processes of constructive interaction, a worksheet that suggests the viewpoints of analysis for constructive interaction such as "KB-Worksheet" and DASK, and KBDeX.

We selected the class of Learning Management because the objective of the class was to teach students the meta point of view in order to enhance their study processes. The purpose of the class was appropriate for analyzing the students' belief change about collaborative learning. The class of Learning Management was held at a Japanese university during the autumn term as a required class. The students of the Learning Management class were first-year undergraduates. Fifty-five students were enrolled in the class each year. These students had their own laptop computers that were connected to the Internet, so they could install KBDeX on their own laptops. The second author was a class teacher, and the first author assisted him in both classes. To assess the effect of the discourse analysis activity in 2013, we considered the 2012 class as the baseline of our research. The 2012 class had the same introduction as the 2013 class, but the activities about constructive interaction differed between the 2012 class and the 2013 class. An overview of the classes of Learning Management is presented in Table 1.

We replaced a "Jigsaw" (Aronson, 1978) about the 21st century skills (ITL Research, 2013) in the 2012 class with a discourse analysis activity about constructive interaction in the 2013 class. In the jigsaw, we expected the students' learning to be supported by both concrete and reflective ways of learning because they studied the effect of collaborative learning from a formal description of texts with concrete experiences of their own collaborative learning. Before these activities, the students experienced an introduction activity called "Collaborative Figure Description Building" (CFDB) (Araki et al., 2008) and its reflection. The CFDB activity was placed before jigsaw in 2012 and discourse analysis activity in 2013 to present the students a variety of ways of understanding clearly; this diversity of understanding contributes to the creation of new ideas and to using KBDeX.

Table 1. Overview of Reflective Activity of Learning Management in 2012 and 2013.

	Activity in 2012	Activity in 2013
Students' Activity	Jigsaw	Solving bobbin problem
Theory of leaning to teach the students	21st century skills (including Knowledge Building and Constructive Interaction)	Constructive Interaction
Analysis data	Students' own discourse of Jigsaw (not distributed as printed version)	Sample discourse about solving bobbin problem (distributed as printed version)
Worksheets for analysis	-	DASK
Tools for analysis	-	KBDeX

Collaborative Figure Description Building (CFDB)

We regarded doing CFDB and the reflection of CFDB are appropriate for the first phase of learning about the importance of collaborative learning. The overview of the CFDB and its reflection from the viewpoints of table 1 are shown in Table 2. With CFDB, a student converts the other student's request into a tangible product. Four students are in each group. A student writes on the request sheet an idea about a sign that would be useful in our daily lives but does not yet exist. Another student is passed the request sheet and makes a specification about the request. Another student is passed the specification and writes a procedure about the specification (e.g., coding on computers). Another student is passed the procedure and draws an image of the requested sign. The drawn sign is returned to the student who made the original request. After finishing this activity, the students discuss possible improvements in the communication process. In this study, most of the students noticed difficulties in communication when creating products with colleagues due to differences in their understanding.

After that, we asked the students to analyze their own discourse using KBDeX for additional reflection activity of collaborative learning. We provided the discourse of the discussion to the students for analysis. The discourse in CFDB of each group consisted of 100 lines. Although the discourse could be read on KBDeX, we provided a printed version to the students in order to improve its readability. We provided a worksheet which suggests the analyzing points from the viewpoints of knowledge building for all the students. We call it as "KB- worksheets". The KB-worksheet requires them to find remarkable sentences and keywords, and determine which sentence will be distinguished as "knowledge sharing", knowledge construction" and "knowledge creation" in the discourse. In the reflective activity of CFDB, we provided the students' own discourse as a data of analysis activity using KBDeX.

Table 2. Overview of CFDB in 2012 and 2013.

	CFDB in 2012 and 2013
students' concrete Activity	Collaborative Figure Description Building
Theory of leaning	Knowledge Building
Analysis data	the students own CFDB's discourse (distributed the printed version)
Worksheets for analysis	KB-worksheets
Tool for analysis	KBDeX

Jigsaw about 21st century skills

The jigsaw was provided to the students in the 2012 class. The jigsaw activity deepens understanding about discussed topics (CoREF, 2013) if the theme of the topics is related to the students' experience. In the jigsaw, the students were divided into four groups and provided one of four texts about the effects of collaborative knowledge building (ITL Research, 2013). The students read the text within each group. Next, the students were rearranged into new groups and explained the texts to each other. After that, the students were asked to think what is effective in collaborative learning from the viewpoint of these texts.

Discourse analysis activity of constructive interaction

The bobbin problem was used in the 2013 class of the discourse analysis activity about constructive interaction. The bobbin problem is an appropriate subject for observing constructive interaction because the structure of the problem is simple but difficult to explain (Fig. 1). The workflow of the bobbin problem was explained in Shirouzu & Miyake (2013), so we only briefly explain the problem here. In the first phase of the bobbin problem, the students independently hypothesized about which direction the bobbin will go. Second, student pairs discuss the mechanism of a bobbin's rotation when its string is pulled. The discussion was used for as an example of constructive interaction. In constructive interaction, when a student offers an opinion to a collaborator, the collaborator may ask questions about the student's opinion. The student answers the collaborator, taking into account the collaborator's viewpoint. Such interactions cause rebuilding of the student's own knowledge and deepen the understanding of the subject. The students analyzed the discourse using KBDeX.

In the analysis, the students used DASK. DASK promotes understanding the important mechanism of constructive interaction when analyzing discourse by providing viewpoints of understanding levels, keywords, and the strength of network between speakers'. The speakers' level of understanding could be determined for each subject, and changes in the speakers' understanding level in the discourse could be plotted in graphs (Tohyama, 2013). The understanding level and words used by the speakers are deeply connected (Shirouzu, 2013). The relationships between the speakers become closer or more distant when the words used change (Oshima, Oshima, and Matsuzawa, 2012). We provided discourse data that describes the solving process of two master course students. In the final phase of the discourse, they completely understood the mechanism (Yamanaka, 2002). The discourse included 235 lines separated by the speakers' pauses. We provided a printed version to the students in order to improve its readability.

"The centers of two circular frames are interconnected by an axle, and a string is wound around it like a bobbin, as illustrated in the figure below. What will happen if you pull the string as shown in the figure? The discs may roll, but never slide. Mark the number that you think is correct. Let's discuss your reason for selecting it."

(1) The bobbin rolls to the left (counterclockwise).
(2) The bobbin rolls to the right (clockwise).
(3) The bobbin does not move.
(4) Other. (Write your answer concretely.)

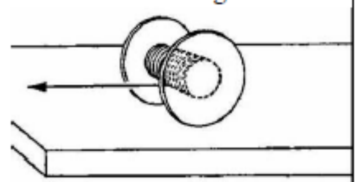


Fig 1. Bobbin's problem.

Class Design

The activities in Learning Management in 2012 and 2013 are presented in Fig. 2. The target activities are indicated with thick frames. Each box represents one class, except the reflection activity of CFDB that was adopted in two classes. Both the introduction activity (CFDB) and target activity were in the first phase of Learning Management in the 2012 class and the 2013 class. We adopted four classes for CFDB and jigsaw about 21st century skills in the 2012 class. However, we adopted five classes for CFDB and discourse analysis activity of constructive interaction in 2013 because of the activities' volume. After the jigsaw of 21st century skills, the students analyzed the discourse about their reflection of CFDB. After both the introduction activity and target activity were over, the students were given the mid-test.

In order to analyze the effect of KBDeX in the CFDB reflection activity, half of the students in the 2012 class used KBDeX and half did not. They switched conditions in another discourse analysis activity, so that all the students had used KBDeX discourse analysis by the end of the class. In this study, we analyzed the students who used KBDeX. The students did the same CFDB activity as the 2012 class.

After the target activity, there was a jigsaw activity using four texts for learning how to make collaborative learning more effective. The four texts were the mechanism of constructive interaction, functional fixedness in collaborative problem solving, the effect of children's curiosity in collaborative learning, and the conformity experiment. After this jigsaw is over, we expected the students to gain skills of building an effective collaborative learning environment.

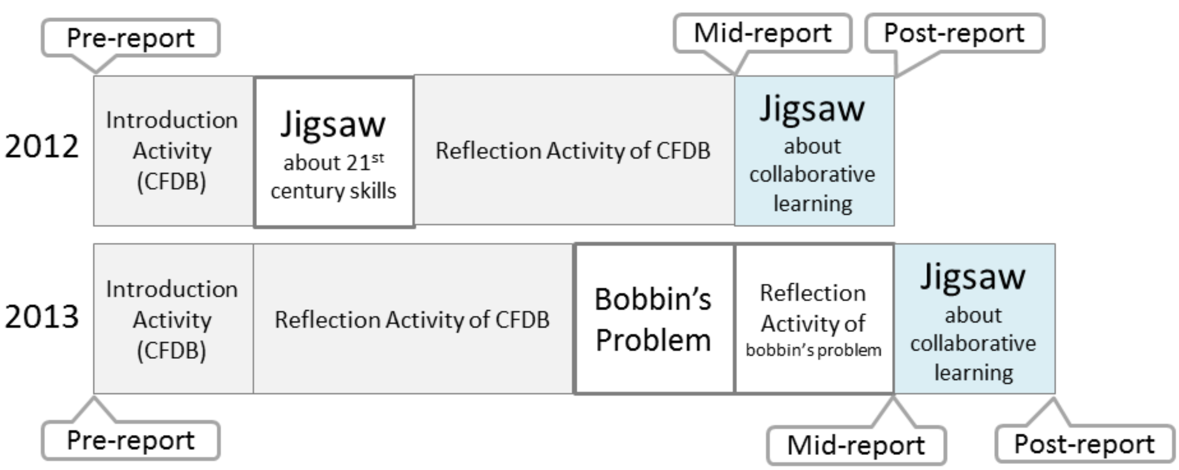


Fig 2. Activities in the 2012 and the 2013 classes.

Scaffolding

KBDeX

KBDeX supports discourse analysis in collaborative learning from the perspective of complex network science (Oshima, Oshima, and Matsuzawa, 2012) by visualizing the network structures of discourse based on a bipartite graph of words × discourse units (e.g., conversation turns or sentences). The network structures are: (1) the speakers' network structure, (2) the unit network structure, and (3) the network structure of target words (Fig. 3). We input discourse data (in .csv format) and a list of target words for bipartite graph creation (a text file).

DASK

DASK supports students' understanding of the relationship between depth of understanding and features of collaborative interaction using KBDeX. This method of analysis is effective when we try to determine what is important for deepening understanding through constructive interaction (Tohyama, 2013). First, DASK provides a graph indicating the speakers' understanding level with a timeline of the discourse (Fig. 4). Speakers' discourse was separated into phases based on when their levels of understanding had changed. Second, DASK requires the students to find the characteristics of each phase based on the appearance of target words, the remarkable statements' Ids in the discourse, and the degree of association of the speakers (Table 4). The students selected some target words that appeared frequently in each phase. An Id number from the discourse in each phase was also selected by the students. The students selected one of three options (e.g., loose, medium, and tight) for their degree of association in each phase. The graphs of networks depicted in KBDeX help the students with these activities.

The first author, who has researched constructive interaction for ten years, analyzed the understanding level indicated in DASK. Understanding levels are determined using the theory of Clement (2008), who suggested that explanations of subjects containing concrete examples with general theories or mechanisms result in a greater understanding than explanations containing only concrete examples. We categorized correct explanations about mechanisms with the evidence of subjects as level 3, incorrect explanations about mechanisms or correct explanations without evidence of subjects as level 2, and explanations containing only evidence of subjects as level 1. Explanations not categorized into level 1, 2, or 3 were assigned to level 0. The sample explanations of each level were shown in Table 4. The first author selected target words that were strongly involved in changing students' understanding levels.

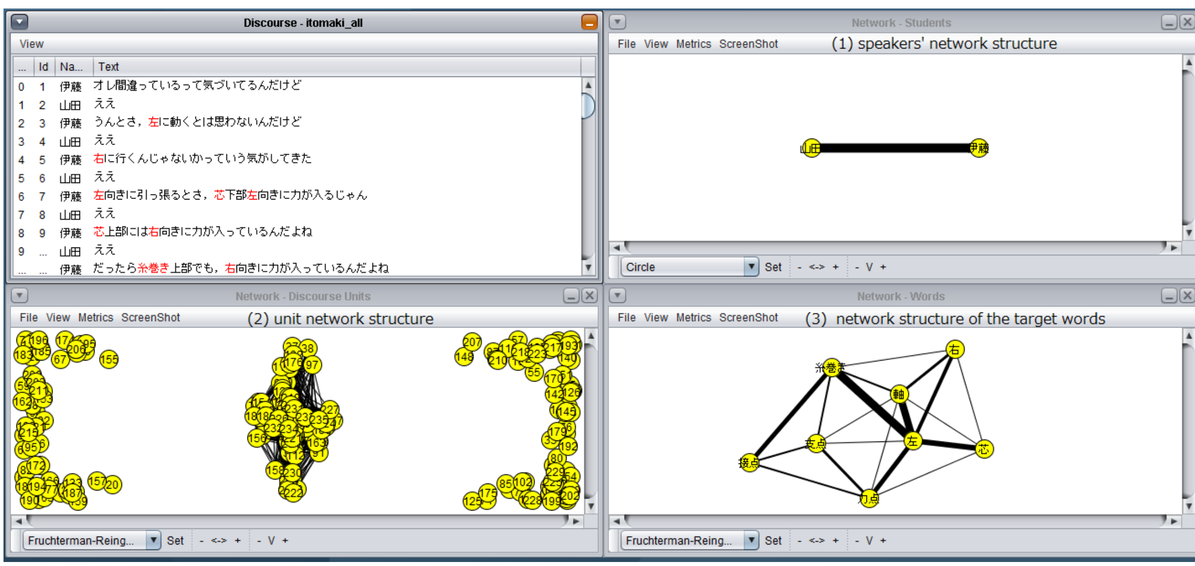


Fig.

Fig. 3. KBDeX Software Interface.

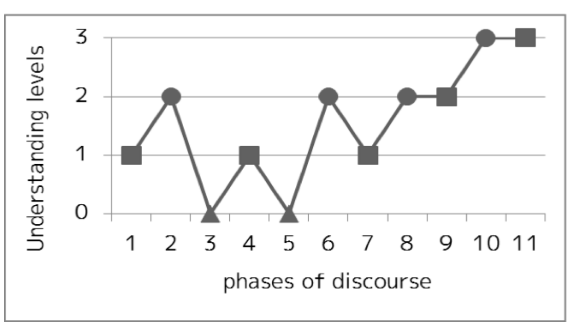
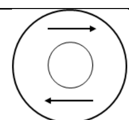
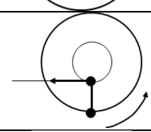
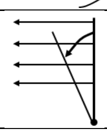


Fig. 4. Graph of understanding level in DASK. (■: Speaker A. ●: Speaker B, ▲: Both speakers.)

Table 3. Worksheet for finding characteristics of constructive interaction in DASK example.

Phase	frequently appearing target words	Selected Id # from the discourse	degree of association of the speakers	characteristics of the phase
(1)	left , rotate	Id: 4	loose medium tight	The speakers focused left
(2)	left, right	Id: 30	loose medium tight	The speakers talk on their own ways
(3)	power, left	Id: 45	loose medium tight	The speakers started to talk each other

Table 4. Sample explanations of bobbin's rotation.

	model of bobbin's rotation	example of explanation
level 1		If the bottom is pulled left, the top will move right because the bobbin is circular in shape.
level 2		There is fulcrum point at the bottom of the axis, so if the bottom of the axis is pulled left the bobbin will be rotated to the left.
level 3		The axis is in the center of the bobbin, so wherever we pull the axis to the left, the bobbin will be rotated to the left.

Expected effects

Using DASK with KBDeX, the students could analyze the discourse answering the columns shown in DASK's table. In the discourse, phases (1) 1 and 2, (2) 6 and 7, and (3) 10 and 11 are pivotal for understanding the processes of constructive interaction. We expected the students to capture these characteristics using DASK and KBDeX. In (1), phases 1 and 2 show that the speakers made their own answers about which direction the bobbin will go using words such as "left," "right," "power" and "rotate" which mean concrete objects or daily-used vague words, but their explanations were different each other. In (2), speaker B explained at level 2 in phase 6 which is very close to the correct explanation using the word of "axis", but speaker A did not copy speaker B's explanation and made his own explanation (because he explained at level 1 in phase 7). In (3), both speakers reached level 3. Their explanations were differed each other, but both of them used "axis" in their explanations as the pivotal word. In short, (1) indicates that each person have their initial thinking, (2) indicates the mechanism of deepening understanding does not mean copying one's collaborator's thinking, (3) indicates the ways of the understandings were differed each other. Throughout (1) to (3) suggest the effect of collaborators viewpoints which enhance building one's own understanding. These characteristics strongly suggest that the objective of collaborative learning is to deepen the participants' understanding thorough discussions, not dividing tasks among group members. We expected the students to learn such characteristics in collaboration.

Analysis

We analyzed the effects of the discourse analysis of the mechanism of constructive interaction in the 2013 class using design research in order to determine the influence of scaffolding. First, we focused on the effect of KBDeX for discourse analysis by comparing the 2012 group of students who used KBDeX with the 2012 group who did not use KBDeX.

Second, we investigated the effect of curriculum change between 2012 and 2013 by analyzing the students' pre- and mid-reports (Fig. 2) on their beliefs about the effects of collaborative learning. This analysis will directly capture the students' belief change along with the CFDB and target activities. The question in the pre-report was "what is the ideal group work for you?" and the question in the mid-report was "what will you do making your group work ideal?" We believe responses to these questions reflect the students' thinking about what collaborative learning is. If students wrote that dividing tasks among group members is important, they may not understand the relationship between knowledge building and collaborative learning because they do not realize the benefits of discussion. If the students wrote that externalizing their own thinking and revising it repeatedly in collaborative discussion is important, they may understand the relationship between knowledge building and collaborative learning.

Third, we analyzed the students' answers in DASK using the viewpoints of (1) to (3) of expected effects to capture the benefits of DASK. If the students could find the characteristics of (1) to (3), it suggests that DASK scaffolds the students' learning of the mechanism of constructive interaction.

Finally, we analyzed the post-reports to assess the students' understanding about the effect of collaborative learning in the transferred subjects. If the students learned the essences of constructive interaction and not just the characteristics of specific subjects like the bobbin problem, they will refer to the effect of constructive interaction. The question in the post-report was the same as in mid-reports, and we analyzed post-reports in the same way as mid-reports.

Students who submitted pre-, mid- and post-reports were selected as subjects of the analyses. There were 40 such students in the 2012 class and 41 in the 2013 class. The first author as well as other staff members who worked at Japanese universities analyzed these reports independently. The results were 80% matched.

Results

Result 1: The effect of KBDeX on students' discourse analysis

For the 2012 class, we compared the mid-reports of the students with KBDeX and those of the students without KBDeX. The pre- and mid-reports are categorized into "task dividing" (indicating that the student thinks of collaborative learning as task dividing) or "exchange opinions" (indicating that the student thinks that the importance of collaborative learning is exchanging opinions). The example of task dividing is "If we do not finish our own work, we cannot accomplish our group's work." On the other hand, the example of exchange opinions is that "I enjoyed the group process as I watched knowledge being built, developed, and expanded from the initial personal ideas. In addition, I experienced the growth of knowledge through diversity of viewpoints." The result is presented in Fig. 5. We checked the difference between students with KBDeX and those without KBDeX using chi-squared analysis. No significant difference was found between the two conditions ($\chi^2 = 0.90$, df = 1, n.s.). This result indicates that discourse analysis using KBDeX does not improve the students' understanding of the effect of collaborative learning without scaffolds.

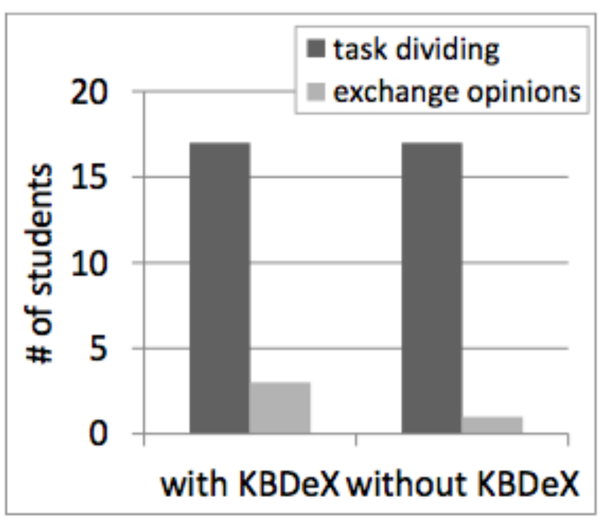


Fig. 5. Comparison of thinking about collaborative learning between students with KBDeX and those without KBDeX.

Result 2: Students' thinking about what collaborative learning is

We analyzed changes in students' beliefs using the reports of the 2012 class (Fig. 6) and the 2013 class (Fig. 7) in the same way as result 1. There were many more post-reports in the "exchange opinions" category in the 2013 class than in the 2012 class, even though the numbers of pre-reports in the two classes were almost equal. We checked the difference between the results of the pre- and mid-reports within each class using chi-squared analysis. No significant difference was found for the 2012 class (χ^2= 0.83, df = 1, n.s.); however, a significant difference was observed between the pre- and mid-reports for the 2013 class (χ^2 = 10.92, df = 1, $p<.01$).

These results indicate that half of the students in the 2013 class learned what is important in collaborative learning through the activity of discourse analysis via KBDeX with DASK. In contrast, the jigsaw activity had almost no effect in changing students' thinking on the benefit of collaborative learning.

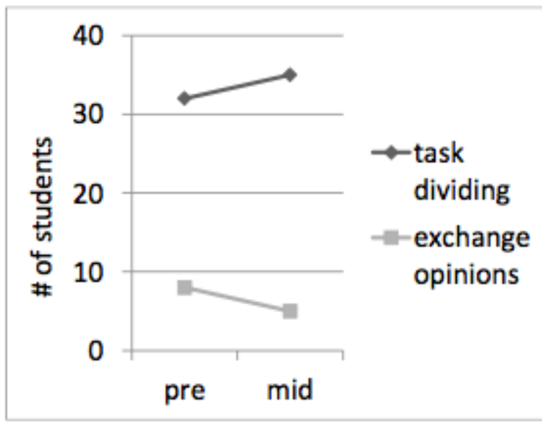


Fig. 6. Students' thinking about collaborative learning in the 2012 class.

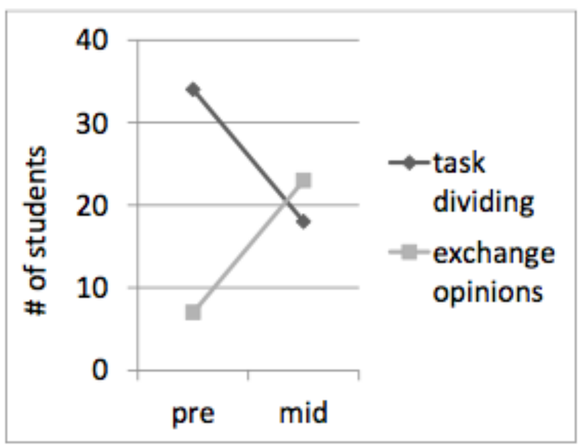


Fig. 7. Students' thinking about collaborative learning in the 2013 class.

Result 3: Students' analysis activity using DASK

We analyzed the students' answers in DASK using the viewpoints of (1) to (3) of expected effects. A horizontal line in Fig.8 shows the phases of 1, 2, 6, 7, 10 and 11 which are determined as pivotal phases, and a vertical line shows the number of the students. The students who referred "left", "right" or "power" in (1), "axis" in (2), "axis" ,"fulcrum" or "point of load" in (3) were counted as "words" in the graph. These were one of words suggested by KBDeX. The bar of "main speaker" shows that the students who detected the main speaker correctly in each phase. These characteristics were shown in the discourse data in KBDeX (top left) and the students could sort lines of discourse by the speaker's name. The analysis of the words suggests that the students had difficulty in the phase of 10 and 11. The analysis of the main speaker suggests that about 1/4 of the students failed to know the main speaker of the phases of 6, 7, 10 and 11. These results suggests that the students were helped to learn the initial thinking were differed each other, but we could eventually use physics terms in discourses. However, it shows the difficulty of teaching the students that the speakers deepened their understanding independently.

Result 4: Students' beliefs of post-reports

We analyzed the post-reports to capture the students' understanding of collaborative learning. The students were categorized as "task dividing" or "opinion exchanging." The result was that most of the students in the 2013 class thought that the effect of collaborative learning is exchanging opinions in collaborative learning, but in the 2012 class, only about the half of students thought that (Fig. 9).

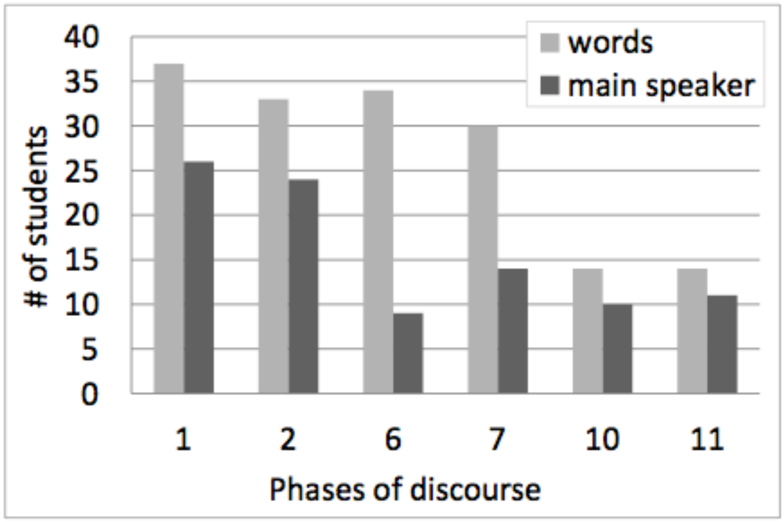


Fig. 8. Students' answers in DASK.

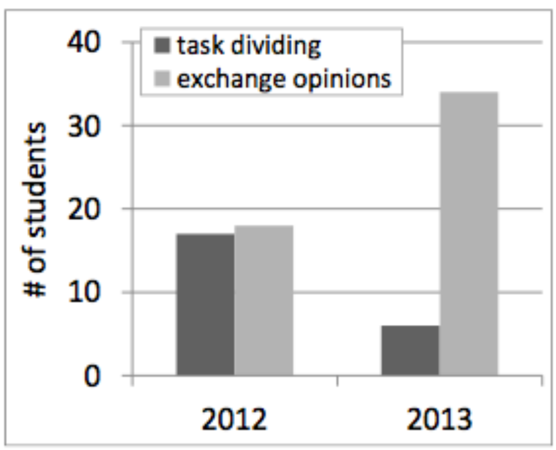


Fig. 9. Students' thinking about collaborative learning in the post-reports.

These results were supported by the students' feedback about the discourse analysis activity in the 2013 class. One of the students wrote, "KBDeX helps us to analyze discourse objectively." Another student wrote, "We can take an objective viewpoint, but without KBDeX, we may not find the characteristics of the discourse." These results suggest that KBDeX supports students in learning the benefits of interaction, even though discourse analysis requires professional techniques. DASK may provide the viewpoint of quantities when we use KBDeX. One student wrote in the column of "characteristics of the phase" in DASK, "I thought the two speakers were linked with each other when I first saw the discourse of phase 1, but I noticed that the speakers were not linked in the graph of KBDeX." Another student wrote in the same column in DASK, "When I saw the discourse of phase 3, I thought that both of the speakers talked about the same theme, but their statements were not linked with each other in the graph of KBDeX." There were no similar comments in the discourse analysis activity on CFDB. Discourse analysis in the 2013 class seemed to help the students to grasp the characteristics of constructive interaction.

Discussion

The students in the 2013 class recognized the effect of collaborative learning; however, those in the 2012 class did not. This result indicates that students' discourse analysis is not sufficient for them to learn about the effect of collaborative learning if they use KBDeX; the students need the appropriate data for the analysis and suggestions of the analysis. KBDeX was effective when the students visualize the characteristics of discourses, whereas there was no effect when no guidelines (e.g., DASK) were provided. The students in the 2013 class noticed that externalizing their own thinking is necessary for deepening their own understanding when engaging in constructive interaction. We provided a simple lecture about the mechanism of constructive interaction in both the 2012 class and the 2013 classes; however the students in the 2012 class did not change their beliefs. These results suggest that students can change their beliefs when they recognize the merits of constructive interaction along with a concrete data. However, the students have difficulty capturing that each person build one's own understanding even though they were supported by KBDeX and DASK.

This research is the first step in our plan; therefore, the results of this article are limited. Our final goal is to build students' collaborative learning skills in order to deepen their understanding. In the future, we hope to improve students' learning abilities for deepening understanding of subjects which could be used in the companies and societies.

Acknowledgments

This work was supported by JSPS KAKENHI Grant Number 26242014, 25910031 and 26910029.

References

Araki, M., Matsuzawa, Y., Sugiura, M. & Ohiwa, H. (2008). A proposal of "Describing Illustration with Language" for introduction education of programming. Research report of JSET Conference in2008 (3), 111-117. (in Japanese)

Aronson, E. (1978). *The jigsaw classroom*. Beverly Hills, CA: SAGE Publications.

Brown, A. L. (1992) Design experiments: Theoretical and methodological challenges in creating complex interventions in classroom settings. *The Journal of the Learning Sciences, 2(*2), 141-178.

Brown, A. L., & Campione, J. C. (1996). Psychological theory and the design of innovative learning environments: On procedures, principles, and systems. In L. Schauble & R. Glaser (Eds.), *Innovations in learning: New environments for education* (pp. 289–325). Mahwah, NJ: Lawrence Erlbaum Associates.

CoREF (Consortium for Renovating Education of the Future) (2013). *Annual report 2013*. CoREF. (in Japanese)

Clement, J. (1987). Generation of spontaneous analogies by students solving science problems. In Topping, D., Crowell, D., and Kobayashi, V. (Eds.), *Thinking across cultures* (pp.303-308). Hillsdale, NJ: Lawrence Erlbaum Associates.

Clement, J. (2008). The role of explanatory models in teaching for conceptual change. In S. Vosuniadou (Ed.), *International handbook of research on conceptual change*, 479-506. New York, NY: Routledge.

Griffin, P., McGaw, B. & Care, E. (2012). *Assessment and teaching of 21st century skills*. New York, NY: Springer-Verlag. ITL Research (2013). *LEAP21: Learning Activities Coding Guide*. http://www.itlresearch.com/. (visited 2014/4/28)

Matsuzawa , Y., Tohyama, S. & Sakai, S. (2013). The Course Design to Develop Meta-Cognitive Skills for Collaborative Learning through Tool-Assisted Discourse Analysis. *Collaborative Innovation Networks (COINs)* 2013, 2013.08. (http://arxiv.org/abs/1308.1612)

Miyake, N. (1986). Constructive Interaction and the iterative process of understanding. *Cognitive Science, 10*, 151-177.

Miyake, N. (2009). Conceptual change through collaboration. Paper presented at AERA 2009, SanDiego.

Bransford, J. D., Brown, A. L. & Cocking, R. R. (Eds.). (2001). *How People Learn*. Washington, D.C: National Academy Press.

NIER (National Institute for Educational Policy Research) (2014) *Project report of basic research about educational curricula (7)*. NIER. (in Japanese)

Oshima, J, Oshima, R. & Matsuzawa, Y. (2012). Knowledge Building Discourse Explorer: a social network analysis application for knowledge building discourse. *Educational Technology Research & Development, 60*, 903-921.

Shirouzu, H. (2013). Learning Fractions Through Folding in an Elementary Face-to-Face Classroom. In D. D. Suthers, K. Lund, C. P. Rose, C. Teplovs, & N. Law (Eds.), *Productive Multivocality in the Analysis of Group Interactions (Computer-Supported Collaborative Learning Series 16)*, New York: Springer, 63-101.

Shirouzu, H. & Miyake, N. (2013). Effects of Robots' Revoicing on Preparation for Future Learning. Rummel, N., Kapur, M., Nathan, M. & Puntambekar, S. (Eds.) *To See the World and a Grain of Sand: Learning across*

Levels of Space, Time, and Scale: CSCL 2013 Conference Proceedings (1), pp.438-445.
Shirouzu, H., Miyake, N., & Masukawa, H. (2002). Cognitively active externalization for situated reflection, *Cognitive Science, 26*, 469-501.
Tohyama, S. (2013). Scaffolding of Initial Understanding for Constructive Interaction : A Case Study of Collaborative Learning in Cognitive Science. Cognitive Studies, 20, 177-203. (in Japanese)
Yamanaka, Y. (2002). The elucidation: processes of understanding about solutions of “bobbin problem” by protocol analysis. The Bachelor’s thesis of Chukyo University. (in Japanese)

Ongoing Metadiscourse and Reflection on Collective Knowledge Progress Fosters Sustained Knowledge Building

Jianwei Zhang, Dan Tao, Yanqing Sun, Mei-Hwa Chen
University at Albany, jzhang1@albany.edu, dantao1106@gmail.com, ysun@albany.edu,
Ben Peebles, Sarah Naqvi
Dr. Eric Jackman Institute of Child Study, OISE, University of Toronto,
ben.peebles@utoronto.ca, sarahnaqvi@gmail.com

Abstract: This study was conducted in two Grade 5/6 classrooms that studied electricity over a three-month period using Knowledge Forum. Classroom A used Idea Thread Mapper (ITM)—a timeline-based collective discourse mapping tool—to engage in ongoing metadiscourse to review collective advances and gaps of knowledge as the knowledge building discourse unfolded online and in the classroom. Classroom B did not engage in this reflective practice until near the end of the inquiry. Video analysis of ITM-aided reflection sessions elaborated the processes of metadiscourse. Content analysis of portfolio summaries indicated that students in classroom A had more comprehensive awareness and deeper understanding of the various inquiry themes discussed in their community's discourse space. Informed by the reflective awareness of the inquiry themes, connections and challenges, classroom A also engaged in more active and connected online discourse to build on another's ideas and address deepening issues. Qualitative tracing of ideas in classroom A's online discourse elaborated the specific idea improvement moves leveraged by ITM-aided metadiscourse to sustain and deepen knowledge building.

Introduction

Various inquiry-based learning programs have been developed to engage students in authentic inquiry in line with creative knowledge practices that pervade many social sectors of today (Barron & Darling-Hammond, 2008; Bielaczyc & Collins, 2006; Chinn & Malhotra, 2002; Krajcik et al., 1998; Reiser et al., 2001; Slotta et al., 2013). The recent research on knowledge creation highlights it as a sustained and social practice by which new ideas are continually developed, tested, refined, and built upon by peer researchers, giving rise to more advanced ideas and knowledge goals (Dunbar, 1997; Sawyer, 2007). Education to cultivate creative knowledge practices needs to similarly support a progressive, collective trajectory of inquiry sustained over a long term for productive effects (Dean & Kuhn, 2007; Engle, 2006; Hakkarainen, 2003). Students engage in sustained inquiry and knowledge building discourse: They contribute diverse ideas to ongoing conversations and collectively advance the ideas through constructive criticisms, mutual build-on, and progressive problem solving, with new and deeper challenges identified as their understanding is advanced (Bereiter, 2002). Such progressive discourse sustains over time across the boundaries of different activities. Ideas generated through experiments, critical reading, debates, and so forth are brought to the shared discourse for careful examination and further improvement, shedding light on opportunities for deeper understanding and expanded work. This design-based research explores classroom processes to foster such sustained trajectories of knowledge building supported by a new software tool—Idea Thread Mapper (ITM), which makes students' collective progress in online discourse visible for ongoing reflection (Chen et al., 2013). The classroom designs enabled by ITM engage students in metacognitive conversation to identify shared focuses of discourse, review progress of ideas, and formulate coherent deepening efforts as a community.

Representing and Regulating Collective Knowledge Trajectories in Emergent Online Discourse

This study builds on research efforts to reform education in line with how knowledge work proceeds in a knowledge-creating culture (Bielaczyc & Collins, 2006; Scardamalia & Bereiter, 2006; Slotta et al., 2013; Zhang et al., 2011). Knowledge workers build on and advance the collective knowledge assets of their community by generating and improving ideas through sustained processes; by engaging in idea-centered dialogues involving multiple perspectives, constructive criticism, and distributed expertise; by formulating deeper problems as solutions are developed; and by assuming responsibility at the highest levels instead of relying on *the* leader to direct their actions (Amar, 2002; Bereiter, 2002; Csikszentmihalyi, 1999; Dunbar, 1997; Sawyer, 2007). Sustained knowledge building in the mode of knowledge creation is much more than active learning. By essence, it is "…the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts." (Scardamalia & Bereiter, 2003, p. 1371).

Education for knowledge building and creation needs to give student ideas a public and permanent representation, as part of collective knowledge (Zhang et al., 2007). Various collaborative online environments have been created to give student ideas an extended social life beyond segmented tasks and activities, so the ideas can be continually revisited, improved, and built upon by community members for deeper understanding. Knowledge that grows in such shared discourse spaces represents a product of the community, as a whole—their community knowledge (Scardamalia & Bereiter, 2006) or group cognition (Stahl, 2006) that goes beyond the sum of individual knowledge (personal notions). Despite the above potential support, current online environments lack effective means to represent collective community knowledge growing in extended discourse, making it difficult for students to monitor and advance it. In threaded discussions and online chatting, student ideas are distributed across individual postings over time (Hewitt, 2001; Suthers et al., 2008). It is hard for students to understand the conceptual landscape and unfolding trajectories of their collective work, causing short-threaded and ill-grounded discourse that lacks connected deepening moves (Zhang, 2009).

This research explores ways to represent and foster collective trajectories of progressive inquiry in online discourse. Our approach is informed by a view of collaborative knowledge building as multilevel emergent interactions in a dynamic social system (Sawyer, 2005; Stahl, 2013; Zhang, 2012; Zhang et al., 2009). New knowledge is continually generated over time through dynamic interactions across the social levels of individuals, small-groups, and community. Members of each community engage in interactive, knowledge building discourse to not only share, but to continually advance their understanding. Ideas contributed by each member are taken up by peers as the input to further reasoning (Dunbar, 1997). Interactive ideas connect and build on to one another over time, giving emergence to shared focuses, deepening goals, and knowledge advances of the community. In such interactive discourse, members dynamically maintain a shared focus of active consciousness, which constantly shifts and develops as the conversation proceeds. Interrelated focuses of conversation constitute larger focus clusters—discourse topics. "A topic in this sense is a coherent aggregate of thoughts introduced by some participant in a conversation, developed either by that participant or another or by several participants jointly…" (Chafe, 2001, p. 674) It is often presented in the form of a problem or gap yet to be filled that engages members' thinking in an active and determinate psychic way. Various focuses and topics contributed by different participants may be approached simultaneously as connected lines of conversation and inquiry. Various groups are either pre-organized or emerged from the interactions based on shared interest and ideas; creative organizations mostly involve adaptive, opportunistic groups or social "knots" (Engeström, 2008) that form and reform as connections are built to address evolving topics and deepening goals (Zhang et al., 2009). The whole course and scope of inquiry unfolds in an emergent and improvisational manner driven by the joint interplay of the participants that alters the collective conceptual and social landscape of the community. Meanwhile, once the collective goals and structures of inquiry have emerged in a community, they have significant influence on how members and groups position their work and structure their roles and collaborations. Such collective structures as high-level emergent properties of the community are often implicit or invisible to members. It is important to create explicit, reflective representations of collective knowledge emergent from the ongoing discourse and inquiry, so that members can collectively monitor the community's discourse and inquiry as it unfolds and direct productive deepening efforts of individuals, groups, and the community as a whole to continually advance collective knowledge (Zhang, 2012; Zhang et al., 2009; cf. Järvelä & Hadwin, 2013).

To represent collective knowledge trajectories emergent through extended knowledge building discourse, we created a timeline-based collective knowledge mapping tool: Idea Threads Mapper (ITM). ITM Interoperates with Knowledge Forum (Scardamalia & Bereiter, 2006) and potentially other platforms for collaborative knowledge building. In these collaborative online environments, students contribute and build on one another's ideas in interactive online discourse, with ideas presented in distributed postings (e.g. notes) and build-on responses. Beyond these micro-level representations of ideas as postings and build-on trees (physical conversation threads), we introduced "idea threads" or "inquiry threads" (Zhang, 2004; Zhang et al., 2007) as a larger, emergent unit of ideas in online discourse. Each idea thread is composed of a chronological sequence of discourse entries (possibly involving several build-on trees) contributed by a subset of the members of a community to address a shared problem or discourse topic. The defining feature of an idea thread is its conceptual object of inquiry: a shared problem or topic of investigation that opens up a conceptual stream of discourse (cf. Chafe, 2001). Each idea thread has its social, epistemic, and temporal profiles that characterize the discursive interactions of the participants to develop increasingly complicated understandings of the focal problems over a time period. In our previous research, we tested using idea thread (inquiry thread) analysis to examine continual idea improvement in collective discourse through organizing the online discourse as topic-based idea threads, tracing idea improving moves (e.g. questioning, theorizing, revising) in each idea thread, and profiling student contribution and interaction across the different idea threads. Conceptual understandings developed in the various idea threads were further compared against the related curriculum expectations to benchmark the scope and depth (Zhang et al., 2007). Inquiry thread analysis has been adopted by a number of researchers to organize and analyze online discourse data (e.g. van Aalst & Truong, 2011). ITM turns such organization and analysis of idea threads into a computerized classroom tool to engage students' metacognitive review and regulation of knowledge building.

ITM integrates three socio-epistemic units (levels) of representations: an idea contributed in a posting of a community member; an idea thread representing a line of inquiry conducted by a subset of members who are formally organized or spontaneously connected based on common interest; and clusters of idea threads of the community to address interrelated problems and topics in a whole inquiry initiative. ITM allows students to define focal topics of investigation and select important discourse entries that contribute to addressing each topic. The discourse entries (Knowledge Forum notes) of each idea thread are displayed on a timeline with the authors and build-on connections identified (see Figure 1). The knowledge progress in each idea thread is further made transparent by students through co-authoring a "Journey of Thinking" synthesis aided by a set of scaffold supports (e.g., *We want to understand…, We used to think…we now understand…, We need to do more…*). Both idea threads and the thread-based "Journey of Thinking" syntheses are co-editable by members of the classroom, with each version recorded for later review. The collective knowledge of the community in a whole inquiry initiative is further represented as clusters of idea threads (Figure 2) that address interrelated problems in a whole initiative through connected efforts of the members. Students select a cluster of idea threads and display them on the same timeline to examine the contributions, connections, and weak areas.

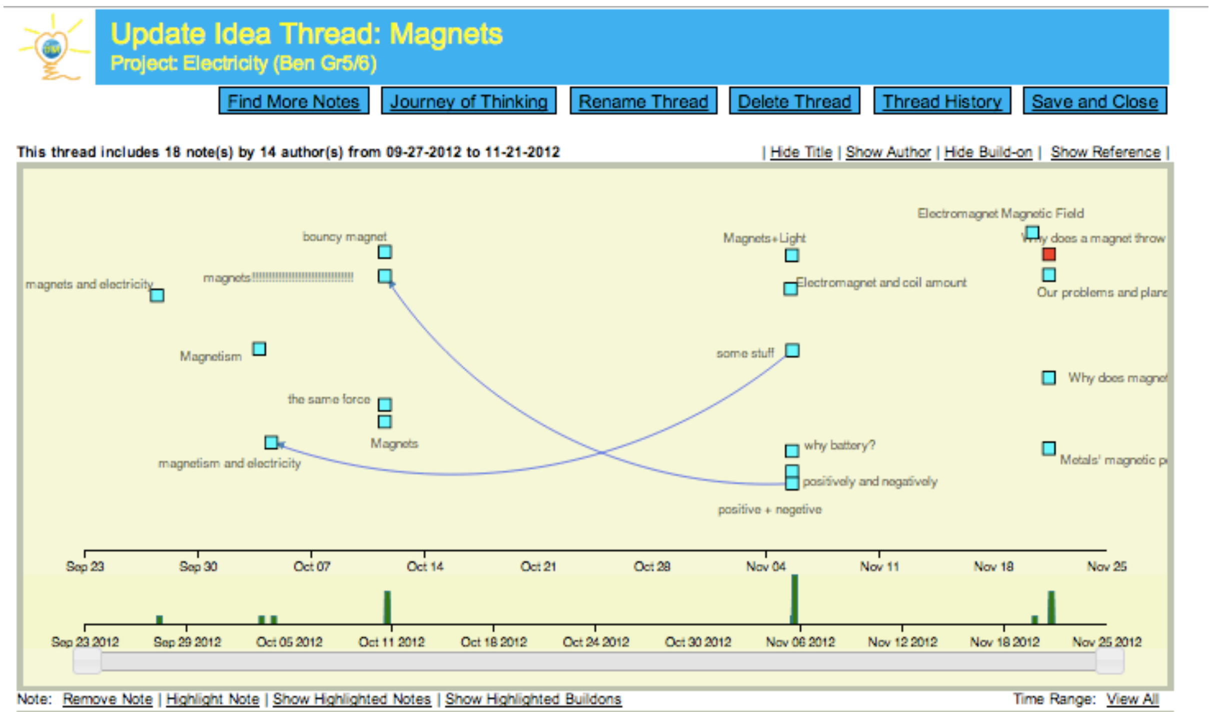


Figure 1. An idea thread on magnets created by a Grade 5/6 classroom studying electricity. Each square in the thread visual represents a note, and a line between two notes represents a build-on link. Clicking a note will open its content. The user can choose to show/hide titles, authors, build-on links; zoom into a specific time period; and highlight, add, or remove notes to update the idea thread as the knowledge building proceeds; and write a Journey of Thinking synthesis to summarize the problems, "big ideas," and deeper actions needed.

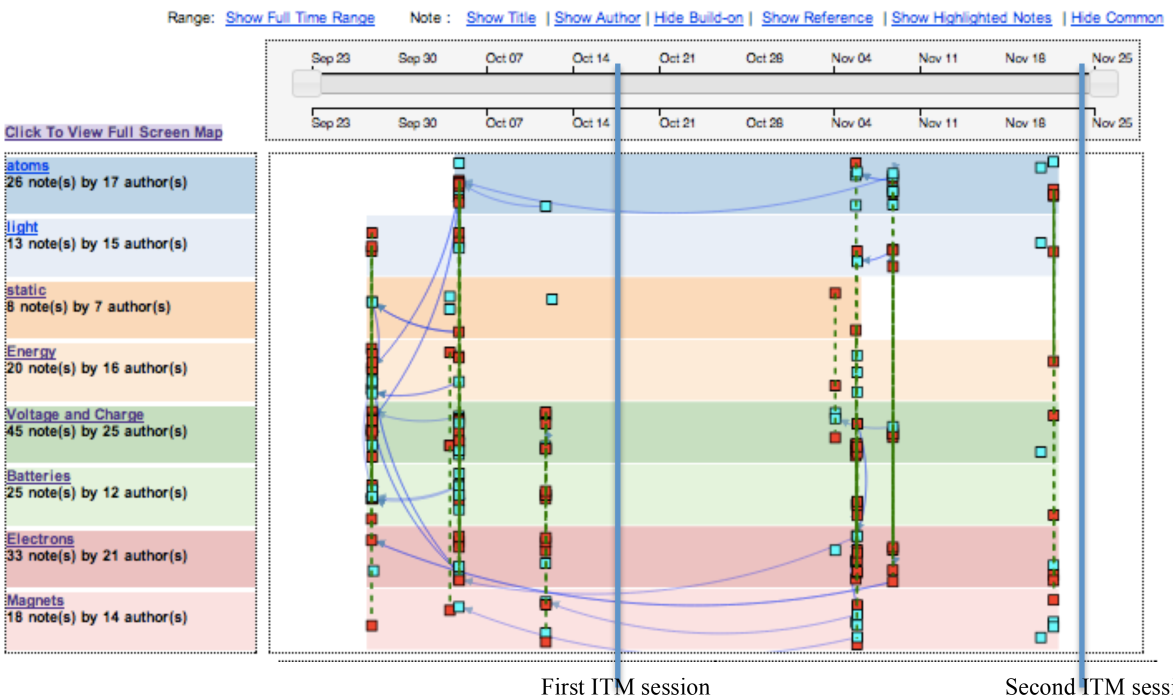


Figure 2. A map of idea threads created by a Grade 5/6 classroom studying electricity. Each colored stripe in the map represents an idea thread extending from the first till the last note contributed addressing its focal problem/topic. Each square represents a note. A blue line between two notes represents a build-on link. A dotted vertical line shows notes (in red) shared between different threads discussing interrelated issues. The user can hover the mouse over a note to see a preview of its content and open an idea thread by clicking its title on the left.

ITM-Aided Metadiscourse to Support Collective Regulation for Sustained Knowledge Building

ITM-based pedagogical design supports collective monitoring and regulation of sustained knowledge building across the social levels of individuals, emergent groups, and whole community. Collective, socially shared regulation is essential to collaborative learning in general and to sustained knowledge building in particular (Chan, 2012). Through collective regulation, members in a community construct shared goals or task perceptions, formulate plans of collaborative actions, monitor collective progress and engagement, and adapt group regulation processes to optimize members' contribution to achieving their shared outcomes (Järvelä & Hadwin, 2013). In this process, members develop a shared sense of their group's cognition and practices as well as their group's identity: their goal and function, beliefs, social and emotional cohesion, strengths, weaknesses, and so forth. With such shared regulation of the whole group, members further regulate their own work with mutual support from peers (Kempler & Linnenbrink-Garcia, 2011; Hadwin et al., 2010; Järvelä & Hadwin, 2013).

Collective and socially shared regulation of collaborative learning as an emerging line of research has mostly focused on short-term collaborative work by small-groups, oftentimes, to solve given problems or complete pre-specified tasks. In such contexts, students' collective regulation focuses on "regulating how to follow the directions, divide up task components, or complete superficial task components" (Kempler & Linnenbrink-Garcia, 2011, p. 394). Sustained knowledge building and creation requires students to take on higher-level collective cognitive responsibility as a whole community for progressively defining what they need to understand as their understanding is continually advanced over an extended time period (Scardamalia, 2002). They need to enact high-level regulation for monitoring the community's knowledge, formulating joint and complementary contributions, and engaging in shared decision making about high-level issues related to long-range planning, role structuring, evaluation of success, and so forth (Zhang et al., 2009).

Our research on ITM-enabled classroom processes investigates a high-level form of discourse by which students enact shared regulation of collective knowledge work: metadiscourse, or metacognitive discourse about the ongoing discourse (Zhang et al., 2013, 2014). In the linguistics literature, metadiscourse refers to discourse about the discourse. Different from the primary discourse that focuses on conveying the content, metadiscourse helps the audience to connect, organize, interpret, evaluate and develop attitudes toward the content (Vande Kopple, 1985). Linguistic analysis explores the use of metadiscourse marks in text and dialogues, such as text connectives, epistemology markers (e.g. hedges, emphatics), attitude markers, and so forth, to organize and evaluate specific contents in individual writing and interpersonal communication (Latawiec, 2012). Moving beyond such micro metadiscourse about individual ideas, our research using ITM investigates metadiscourse at a community level: collective metacognitive discourse to review, organize, and evaluate the ongoing discourse of a community focusing on the unfolding trajectories of knowledge building. Using ITM, students engage in metacognitive conversations to review interactive ideas in their ongoing discourse, monitor unfolding lines of inquiry in their community, synthesize and diffuse new insights gained, reflect on gaps and new directions of inquiry, and re-organize their discourse and inquiry activities accordingly.

The literature suggests the importance of metadiscourse in knowledge building communities (Scardamalia & Bereiter, 2006; Zhang et al., 2009, 2012); however, this form of discourse is rarely examined in research and hardly observed in practice (van Aalst, 2009). Our design-based research using ITM has made initial progress in understanding the operation of metadiscourse in the classroom and its role in helping students co-monitor their collective knowledge progress and develop coherent deepening efforts for sustained idea improvement. In the first iteration of this research, we conducted a set of pilot studies in a Grade 3 and two Grade 5/6 classrooms (Chen et al, 2013; Zhang et al., 2014). In the middle of a two-month long science unit implemented using knowledge building pedagogy and Knowledge Forum, students engaged in ITM-aided metacognitive conversation and reflection. They first worked as a whole class to review their ongoing discourse to identify high-interest "juicy" topics that had been discussed and to use ITM to select important Knowledge Forum notes for one of the topics to construct an idea thread. Temporary small groups were formed to construct idea threads and review progress for the rest of the topics and co-author a "Journey of Thinking" synthesis for each idea thread to highlight the focal goals, "big ideas" learned, and plans for deeper inquiry. The ITM session was concluded with a whole-class reflective conversation in which students examined their whole map of idea threads to review collective advances, connections, and areas that required deeper efforts and collaboration. Through the above metadiscourse, students constructed multi-level reflective representations of their community's knowledge emerged from interactive discourse, including creating idea threads with syntheses to frame various lines of work involving different subsets of members and mapping out clusters of idea threads on a timeline to represent the knowledge work of the whole community. These reflective representations served to explicate collective knowledge emerged from the community's discourse including its conceptual, social, and temporal profiles; and further guided student individual and collaborative contributions to deeper knowledge building work through the mechanism of representational guidance (Suthers et al., 2008). The results of these pilot studies suggest the benefits of ITM-aided metadiscourse in fostering student awareness of collective knowledge progress beyond their individual focuses and informing sustained and connected knowledge building discourse to address deepening questions and weak areas, leading to sophisticated explanations of complex issues at the intersections of different lines of inquiry (Chen et al, 2013; Zhang et al., 2014).

However, these findings were generated through exploratory studies without cross-condition comparison. Also, the ITM-aided metadiscourse was implemented as a single classroom session. Further expansions to fulfill the potential of collective metadiscourse need to organize it as a formative, ongoing effort while enabling easy connections between ITM-aided metadiscourse and ongoing online discourse in Knowledge Forum. To address these needs, the second iteration of this research further refines the design of ITM-aided metadiscourse and examines its role in sustained knowledge building through more comprehensive data analysis. Our research questions ask: How do students engage in ITM-aided collective metadiscourse to reflect on their collective knowledge building? In what ways does such metadiscourse and reflection help students to monitor and understand various inquiry themes in their community's discourse space and formulate connected, progressive discourse to continually improve their ideas?

Method

<u>Classroom Contexts</u>

This study was the second iteration of a multi-year design-based research carried out in two Grade 5/6 classrooms. Among a total of 23 students in each classroom, 21 in classroom A and 22 in classroom B agreed to participate in this study by allowing us to analyze their data. The students are culturally diverse and mostly come from middle class families. The two classes were taught by two experienced teachers, respectively, each having multiple years of experience with facilitating inquiry-based learning using technology. Students in each classroom investigated electricity over a three-month period with two science lessons each week. Their work integrated common classroom processes of knowledge building: whole class knowledge building conversations, individual and cooperative reading, student-directed experiments and observations, and so forth. Major ideas, questions, and findings generated through face-to-face activities were contributed to Knowledge Forum for continual knowledge building discourse online. The teachers encouraged their students to take on high-level responsibility for setting knowledge goals, planning activities, reflecting on progress, and formulating and adapting collaborative groups based on shared interests and changing needs.

For cross-classroom comparison, the design of ITM-aided metadiscourse and reflection was implemented as an ongoing effort in Class A beginning from the third week of the electricity inquiry; it was only implemented in Class B in the final phase of the inquiry in Week 9. This time-lag design allowed us to conduct detailed data analysis of Class A to elaborate the ongoing process of ITM-aided metadiscourse while enabling cross-classroom comparisons to examine the impact of ITM-aided metadiscourse on student knowledge building.

The Electricity Inquiry and the Focal Design of ITM-Aided Reflection

The knowledge building work in each classroom unfolded as a continuous process driven by students' deepening ideas; for the purpose of data analysis, we identified three phases of the inquiry process, as elaborated below.

(a) Phase 1 (week 1-3), as the baseline: This phase extended from week 1 to 3 till Class A implemented its first ITM reflection session. Examining student interaction in this phase when ITM was not yet used in either classroom provided the baseline data about student knowledge building facilitated by the two teachers. In both classrooms students began their electricity inquiry with hands-on explorations of static electricity, circuit and conductors, and magnets. They discussed their findings in small groups and further shared their questions and ideas through whole class knowledge building conversations. Extending their face-to-face interactions, students wrote and built on one another's notes in Knowledge Forum to discuss their ideas, observations, and questions. Students were encouraged to contribute notes to all aspects of the electricity research and were reminded that scientific research is about generating deepening questions and refined theories for continual idea improvement. Supporting their idea improvement, students engaged in critical reading of online and print materials while continuing their online knowledge building discourse to generate deepening questions and refined theories. As such, the online knowledge building discourse provided a window for us to examine the unfolding processes of knowledge building.

(b) Phase 2 (week 4-8), as the focus of the data analysis and comparison: This phase extended from Class A's first ITM reflection session to its second ITM session till Class B conducted its only ITM session. Comparing student engagement in this phase between classroom A and B helped to examine the impact of ITM reflection on sustained knowledge building. By the end of the third week, students in class A had created 89 notes in their Knowledge Forum view. They conducted the first ITM session to review collective progress. The whole class made an initial pass to co-review their Knowledge Forum view (discourse space) projected on a screen to identify high-interest "juicy" topics that had been discussed. Students were then given a printout of their Knowledge Forum view with a visual layout of all the notes and build-on links, which served as a bridging artifact to support more informed oral metadiscourse about their online written discourse. They worked in small groups to identify note clusters that discussed various topics, with the different clusters highlighted using different colors. The whole class then convened to share the topics identified, leading to the creation of a list of eight "juicy topics:" batteries, static electricity, magnetism, electrons, atoms, voltage & charge, energy sources, and light. The students then formed into topic-based voluntary groups, each of which constructed an idea thread for a topic using ITM. Members of each group decided keywords to be used to search for related Knowledge Forum notes and found and selected the notes that addressed the focal topic. This session was concluded with a whole class conversation to examine the map of idea threads (see Figure 2 till the first ITM session) and reflect on important advances, connections, and weak areas.

With deeper inquiry and discourse carried out in the subsequent three weeks, students in class A conducted a second ITM reflection session in which they revisited the map of idea threads to reflect on progress, updated each idea thread by including new Knowledge Forum notes addressing the deeper issues (see the threads extended after the first ITM session in Figure 2). Consolidating their reflection, students further worked as small groups to create a "Journey of Thinking" synthesis for each idea thread using a set of scaffolds that highlighted problems of understanding, collective progress, and deeper issues to work on.

(c) Phase 3 (week 9-12), final research and presentations. Following similar procedures used by class A, students in class B implemented ITM-aided reflection to review their online discourse as idea threads and authored Journeys of thinking syntheses to summarize their advances and deeper issues. In the rest of the inquiry, students in both classrooms concentrated on classroom-based inquiry to understand the deep issues identified through ITM reflection and preparing final presentations to share new knowledge about these issues. With these knowledge building efforts mostly enacted as face-to-face activities, students contributed a limited number of notes online in this phase (M = 0.83, SD = 0.58 for class A, M = 0.17, SD = .39 for class B). Therefore, we did not conduct statistical analysis of student online discourse in this final phase.

Data Sources and Analysis

Data sources included video records of the ITM-aided reflection sessions and other classroom activities, idea threads and Journey of Thinking syntheses recorded in ITM, online discourse in Knowledge Forum, students' portfolio summaries created around the midpoint of the inquiry (Phase 2) to summarize what they had learned about electricity, and their final presentations summarizing deepened knowledge about each topic.

(a) Video analysis of ITM-aided metadiscourse and reflection: The videos of the ITM-aided reflection sessions in each classroom were transcribed and analyzed using a narrative approach to video analysis (Derry et al., 2010), with more detailed analysis conducted for class A. Two researchers first browsed the videos and transcriptions to develop an overall sense of the reflective processes, and then identified "digestible" chunks in the videos—major episodes of the reflective conversations by which students identified and negotiated high-interest productive topics, selected important discourse contributions, synthesized progress, and planned for deeper inquiries. These chunks of videos were contextualized and linked to develop a storyline, showing how the community engaged in metadiscourse to review collective knowledge progress emerged from extended discourse and plan for deeper inquiry across the social levels of individuals, groups, and the whole community.

(b) Quantitative analysis of student contribution and interaction in online discourse. Using the analytic toolkit underlying Knowledge Forum, we retrieved quantitative data about student note contributions and build-on links in each phase of the inquiry. Comparing the level of contribution and interactivity between the two classrooms especially for Phase 2 helped us to gauge the benefits of ITM reflection in sustaining productive knowledge building discourse.

(c) Content analysis of individual summaries. To examine students' awareness and understanding of the various inquiry themes in their community's knowledge space, we asked each student in classroom A and B to create a portfolio to summarize what they had learned around the midpoint of the inquiry (after class A's first ITM session). Similar portfolio assessments have been used by van Aalst and Chan (2007) as well as in our previous studies (Zhang et al., 2007, 2009) to assess knowledge building. In these previous studies, students created written portfolios on computer to document their knowledge building progress and efforts. Such written portfolios of young students tended to be brief and lack details partly because that the students were typing for their own reflection. In this study we made a modification that allowed each student to orally summarize what he/she had learned, with a researcher on site to record their summary while asking questions for clarification, elaboration, and expansion (e.g. *Can you tell me what you have learned as a community? Can you say more about that? How does it relate to electricity? Anything else you've learned?*). The oral summary was transcribed and then analyzed using content analysis (Chi, 1997). Each student's portfolio summary was coded using the coding scheme presented in Table 1. Specifically, two analysts first read the online discourse and observation notes of the two classrooms to identify various topics of inquiry mentioned in relation to the content topics specified in the curriculum guidelines. They shared the identified topics and merged similar or closely related topics (e.g. atoms and electrons), with a final list of ten topics created (see Table 1). A primary coder then read each portfolio summary to identify utterances related to each of focal topics. The ideas related to each focal topic were further coded based on epistemic complexity and scientific sophistication.

Table 1. Content Analysis of Students' Individual Portfolio Summaries.

Dimension	Category	Definition
Topic of inquiry addressed	1. Atoms (including electrons)	Components and anatomy of atoms (electrons, protons, neutrons) as related to electricity
	2. Batteries	How batteries work; components and attributes of a battery
	3. Static electricity	Nature and reasons of static electricity, including specific examples of static electricity
	4. Electric current	How electricity flows; electric current and how it works
	5. Energy sources	Nature and types of energy, including how the different types of energy work

	6. Voltage and charge	Electric charges; voltage
	7. Circuits	What is a circuit? How does a circuit work?
	8. Conductors and insulator	Conductors and insulators, including specific examples
	9. Light	How is light produced (e.g. in a light bulb or lightning) and how does it travel?
	10. Magnets	How does magnet work and how is it related to electricity?
Epistemic Complexity of Understanding	1. Term only	Mentioning a topic without specific ideas
	2. Unelaborated facts	Description of terms, phenomena, or experiences without elaboration
	3. Elaborated facts	Elaboration of terms, phenomena, or experiences
	4. Unelaborated explanations	Reasons, relationships, or mechanisms mentioned without elaboration
	5. Elaborated explanations	Reasons, relationships, or mechanisms elaborated
Scientific sophistication of Understanding	1. Pre-scientific	Misconceptions based on naïve conceptual framework (scheme)
	2. Hybrid	Misconceptions that have incorporated scientific information but show mixed misconception/scientific framework
	3. Basically scientific	Ideas based on scientific framework, but not precisely scientific
	4. Scientific	Ideas that are consistent with scientific knowledge

The coding of scientific sophistication and epistemic complexity was based on coding schemes developed and validated through our previous studies (Zhang et al., 2007). Scientific sophistication examines the extent to which students' ideas align with a scientific framework of electricity based on a four-point scale: 1 - pre-scientific, 2 - hybrid, 3 - basically scientific, and 4 - scientific. Epistemic complexity indicates students' efforts to produce not only descriptions of the material world, but also theoretical explanations and articulation of hidden mechanisms, which are central to the goal of science (Salmon, 1984). A five-point scale (1- topic term only, 2 - unelaborated facts, 3 – elaborated facts, 4 – unelaborated explanations, and 5 - elaborated explanations) was used to code each idea. Two raters independently coded 12 portfolios to assess inter-rater reliability, which was found to be 0.88 for epistemic complexity and 0.89 for scientific sophistication (Pearson correlation).

In the curriculum area of electricity, students going through elementary and secondary education are expected to develop increasingly complex understanding about what electricity is and how it flows through an electric circuit. Existing research (Borges & Horizonte, 1999) identified increasingly complicated mental models used by students to explain how electric circuits work. These range from a general conception of electricity as the flow of energy to a more informed focus on positive and negative charges, a deeper explanation of the charges based on the movement of electrically charged particles, and a most complicated understanding of electricity as a field phenomenon. In light of these mental models of electricity, we created a coding scheme (see Table 2) to categorize each student's explanations of how electric circuits work based on their comments on electric circuits, conductors, batteries, current, and charges in the portfolio summaries. Two raters independently coded 21 portfolio summaries using this coding scheme, resulting in an inter-rater agreement of 95.24% (Cohen's Kappa = 0.97).

Table 2. Progressively More Complicated Explanations of How Electric Circuits Work.

Category	Description	Example
0. No explanation	Students mention related facts or terms, but no explanation is provided about how electric circuits work.	N/A
1. Electricity as flow of energy	Students describe batteries as the source of energy that provides electricity. Electricity flows through wires/conductors to the light bulb. No explanation is given about the internal mechanism and processes related to negative and positive charges.	"I learned that energy…goes through the wires… So if you have like a motor, from the battery if you connect it to the motor, the energy comes from the battery and it goes into the motor to make it move."
2. Electricity as positive and negative charges/currents	Students explain the flow of electricity in terms of positive and negative charges or currents. For electricity to flow, the wires need to connect both positive and negative terminals of the battery towards the bulb to form a closed circuit.	"So one of my theories about how a battery works is there's positive energy and there's negative energy ["energy" was used by students to refer to charge]. When like you put the battery in, you put the positive on one side and the negative on the other side and when the battery connects to like a light, let's say, the positive energy goes one way through the wire to the light [demonstrating with hands], and the negative energy goes one way through the wire…"
3. Electricity as movement of electrically charged particles	Students mention positive and negative charges and further understand them in terms of the movement of electrically charged particles including protons and electrons. Battery is seen as an active source of electricity by means of chemical reaction enabling the movement of electrically charged particles.	"So there's the positive side and the negative side [in a battery]. The electrons from the negative side want to go to the positive side, but there's an insulator here [demonstrating with his hands]. So what happens is when you connect a wire from the negative side to the positive side, the electrons see a way to get to the positive side, by doing this [sweeps hand] with the circuit. If there's a light-bulb, they'd go through the small wire, in the light-bulb and… heat it up and it starts to glow, but they still get through…"
4. Electricity as a field phenomenon	Beyond level 3, the movement of electrically charged particles is further explained in terms of time-dependent sequence of events involving interactions of the particles (under the action of a potential difference), indicating a view of the circuit as a whole interaction system.	No student was coded for this category.

(d) Tracing of idea improvement in each idea thread as related to students' final presentations. To understand the specific ways in which ITM-aided metadiscourse and reflection enhanced and sustained knowledge building, we qualitatively analyzed the online discourse in the idea threads organized by students in classroom A. Following inquiry thread analysis that traces progressive idea improvement in unfolding lines of online discourse (Zhang et al., 2007), we used each idea thread topic defined by students as a "tracer" (Roth, 1996) to trace interactive ideas and questions contributed to the online discourse over time, so that we could understand how students' conceptual focuses and ideas evolved before and after the ITM reflection sessions in relation to the classroom inquiry activities observed. The idea threads constructed by students classified notes based on conceptual topics of inquiry. For each idea thread, two researchers co-read the notes in a chronological sequence to develop an overall sense of visible idea improvement. They further identified new questions and ideas raised in the online discourse before the first ITM reflection session, during ITM reflection in the ITM Journey of Thinking synthesis, in the online discourse after the first ITM reflection, as well as in students' final presentations sharing deeper knowledge about each of the focal topics. The ideas and questions in each idea threads were compared between these different phases, and then related to ideas and questions in other idea threads to identify specific patterns of idea improvement enhanced by the ITM reflection. The initial idea improvement patterns observed were discussed and refined in light of the knowledge building principles (Scardamalia, 2002) that underline progressive inquiry of deepening problems, conceptual rise-above to create high-level conceptualizations, and shared advancement and use of collective knowledge.

Results

Video Analysis of ITM-Aided Metadiscourse

In the primary, ongoing knowledge building discourse, students contributed specific questions and diverse ideas to Knowledge Forum for interactive sharing and continual build-on. ITM-aided metadiscourse provided the opportunity for students to review the diverse idea input to envision shared conceptual themes, connections, and directions emerging from the ongoing work. Video analysis of the ITM sessions of classroom A identified the following processes of collective metadiscourse. A less detailed video analysis of Classroom B's ITM session revealed a similar iterative process of metadiscourse and reflection, although it was not as extended and integrative to the knowledge building process.

(a) Reviewing diverse ideas and connections to formulate focal inquiry themes of the community. In the first ITM reflection session, the teacher in class A projected the community's Knowledge Forum view on a screen and asked students to make an initial pass to co-identify conceptual themes that had been discussed. Students' initial proposals identified notes that discussed very specific topics such as lemon juice batteries. The teacher then facilitated conceptual thinking about such topics by asking, "what are these notes about?" leading to the identification of different types of batteries as a theme of inquiry. Each student then worked with a partner to conduct more careful review of high-interest topics addressed in the online discourse. Using a printout of their Knowledge Forum view, they identified topics of discussion and circled the related notes using various color markers. The whole class then convened to share the topics identified, with the teacher recording the topics on a board. A total of ten topics were recorded including batteries, static electricity, magnets, voltage and charge, energy sources, Leyden jar, atoms, electrons, positive/negative, and light. Reflective conversations took place to better conceptualize some of the specific topics based on the underlying concepts and connect them into higher-level themes.

> Teacher (T): Okay, this is a pretty good list. Are there any of these [topics] …that probably just fit exactly together and we probably don't need two different categories for?
> S1: Positive/negative and electrons.
> T: Positive/negative and electrons. OK. [draws an arrowed line between these two topics on the board] Any other ideas about that?
> …
> S2: Leyden jar and static electricity.
> S3: Yeah!
> T: Leyden jar and static electricity. Might be part of the same thing? [draws an arrowed line between these two topics on the board] Like that? Did some people put Leyden jar under static electricity?
> Several students talk together: Yeah.
> T: OK. …So we have eight main threads.

The eight topics of inquiry formulated through the above process provided a collective representation of the focal areas and goals of inquiry that had emerged from the ongoing discourse, with the following reflective process further organizing the key idea contributions and unfolding directions in each area.

(b) Reviewing knowledge progress in each focal area by constructing idea threads: To review progress achieved in their knowledge building discourse about the various focal topics, students created idea threads using ITM. The teacher explained the purpose of ITM and went through an initial pass with the whole class to co-construct one idea thread, as an example. Eight voluntary small-groups were then formed to construct idea threads for the eight topics of inquiry. Focusing on each focal topic, group members first discussed what key terms should be used to search for Knowledge Forum notes related to their topic. They reviewed the notes and selected those that contributed important understandings. ITM displayed the selected notes on a timeline as an idea thread (see Figure

1) and further retrieved authors involved in this line of work, with options to show build-on connections over time. The idea threads, once created, became accessible and editable to all the classroom members so they could add more notes to each thread as new progress was made in the following weeks. On the basis of their review of the notes in each idea thread as well as the related classroom work, each small-group working on an idea thread authored a Journey of Thinking synthesis to summarize the "big ideas' learned, focal problems to be further addressed, and specific actions of inquiry to be taken. For example, reviewing progress in the idea thread about magnets that included 8 notes by 10 authors by the time of the ITM reflection, two students co-created the Journey of Thinking synthesis shown in Table 3, highlighting "big ideas" learned as well as core explanation-seeking problems to be addressed through further actions of inquiry.

Table 3. The Journey of Thinking Synthesis on Magnets Organized as Three Sections.

Our Problems	"Big ideas" we have learned	We need to do more
-We need to understand how magnets relate to electricity -why do magnets throw compasses off? - how do magnets work?	- That magnets produce an invisible magnetic field. - Magnets have two sides, one positive one negative.	-I think that we should experiment with different types of metal to see which ones are more magnetic. - We need to understand the connection between magnets and electricity by looking on the Internet…

Thus, each idea thread with its Journey of Thinking synthesis provided a reflective representation of a focal line of inquiry of the community, including the conceptual focus, participatory structure, temporal progress, and unfolding directions. With reflective monitoring of these profiles of each idea thread, students made purposeful contributions and collaborations in the subsequent work, with new contributions added to the threads through further idea thread review and updating. Table 4 summarizes the number of notes and authors in each idea thread of class A before and after the first ITM reflection. For example, the idea thread on magnets was extended from 8 notes by 10 authors by the first ITM reflection to 18 notes authored by 14 students by the end of November.

Table 4. The Number of Notes and Authors in Each Idea Thread in Classroom A by the First and Second ITM Reflection Session.

	By the first ITM reflection		By the first ITM reflection	
Idea thread	Notes	Authors	Notes	Authors
Atoms	10	9	26	17
Light	5	5	13	15
Static	5	6	8	7
Energy	14	14	20	16
Voltage and charge	24	18	45	25
Batteries	20	14	25	12
Electrons	15	11	33	21
Magnets	5	7	18	14

Note. There were 23 students, a teacher, and an assistant in this community. Some of the threads had more authors than notes because of the co-authored notes involved.

(c) Mapping out clusters of ideas threads to review community-wide progress and connections: To reflect on the knowledge progress of the community, as a whole, students mapped out the eight idea threads on the same timeline (see notes before the first ITM session in Figure 2 and Table 4) to discuss their shared progress, temporal processes, potential connections, and weak areas, informing deeper inquiry and collaboration. When reviewing their map of idea threads, the whole class engaged in reflective conversations about their knowledge progress and directions:

> Teacher (T): …we can see the map [points to the map of the eight idea threads on the screen] of all the things we're thinking about. So take a look and tell me what you notice…So the lines that have gone all the way through are ones that we've been talking about all of the time. The ones that started and stopped are ones that we've been doing for some smaller portion of time. It also tells you the amount of notes there are.

There are 33 notes related to voltage and charge in some way, which is kind of interesting. S1, what do you notice?
S1: That atoms didn't really start to come up because N (an invited speaker) did that lesson about positive and negative and to help us find out about batteries, and then …you (the teacher) started to talk about atoms so it wasn't at the beginning.
T: Yeah,… this [note] about atoms came up later. What's one that someone else noticed, either about the number of notes or which ones have been going for a long time…
S2: Static electricity has been going on for the longest time…but it has one of the least notes.
T: Yeah, it doesn't have a ton of notes in it, right? Static electricity. S3, what do you notice?
S3: Some of the magnets… first of all, there were not that many notes and a lot of them were bad, like notes for no reason…
T: Oh, I see…now you have like a bunch of different threads with a bunch of different ideas that you can work on, what do you think would be a really good use of your time? So if you said, OK, I've got to work on one of these, what would you work on?
Student 4: The one with the least amount of notes…Either light…or magnets.

The students reflected on how the different idea thread topics emerged and reviewed the intensity, quality, and timespan of the contributions in each idea thread. They pointed out the threads that had few notes or needed more solid contributions, and proposed further actions to explore those areas at a deeper level in the coming weeks to add to the collective body of knowledge. Threads with very few authors were also easily identifiable using the map view of idea threads, informing potential opportunities for students to expand their participation and collaboration with their peers. The Journey of Thinking syntheses written for the different threads were further transferred to a piece of chart paper to share the "big ideas" learned and problems to be addressed. Sharing core understandings of the different themes sparked an interesting whole-class discussion on the interconnectedness of the eight topics being researched, as shown below. As the discussion unfolded, the teacher took notes visually on an electronic whiteboard to highlight the connections identified (see Figure 3).

S1: I think that maybe everything is related to each other. Once we learn more, we might see how all these threads relate to each other.
S2: When you put your finger on Leyden jar (when studying static electricity), it sparks. A huge number of electrons rush to your finger. If you took a whole lot of electrons together, all pressed together, they look like the spark…
S3: Everything is connected, so they are all the same thing: electrons are part of atoms and electrons have charge, and so charge is connected to atoms through electrons.... All are connected... Chain ends at atoms every time because atoms are everything and everything is made up of atoms. It is the essence…It all comes back to atoms and understanding how atoms work.

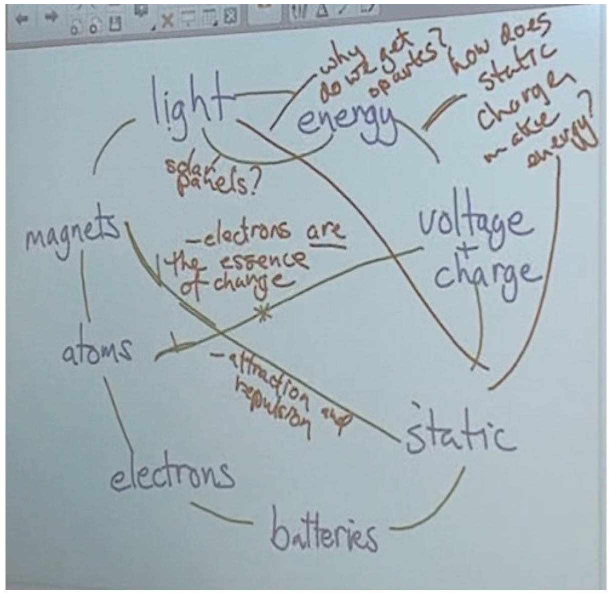


Figure 3. A visual graphic created through a whole-class discussion about the connectedness of the eight idea threads.

In sum, through the above processes of metadiscourse aided by ITM, students generated reflective representations of the knowledge trajectories of their community emerged from the ongoing inquiry and discourse. They identified focal conceptual themes from their diverse discourse input, and organized important discourse contributions to each theme as an idea thread to review the progress and deeper issues. Visualizing discursive interactions in each idea thread on a timeline and synthesizing the Journey of Thinking helped students to monitor each line of work carried out by various members. The community further mapped out clusters of idea threads to reflect on community-wide advancement and cross-theme connections, advancing the conceptualization of electricity as charges carried by electrons and protons. This fundamental understanding was later diffused to the inquiry and discourse about a wide range of specific topics such as static electricity, batteries, lightning, and so forth (see the qualitative analysis of the online discourse).

Content Analysis of Student Portfolio Summaries

To examine whether ITM-aided metadiscourse and reflection could help foster members' reflective awareness and understanding of the various inquiry themes emerged in the community's discourse space, we conducted content analysis of student portfolios that summarized what they had learned. The analysis examined inquiry topics addressed and epistemic complexity and scientific sophistication of ideas (see Table 5).

Table 5. Coding of Students' Individual Portfolio Summaries Created around the Midpoint of the Inquiry (Means and Standard Deviations).

Classroom	Number of topics included	Epistemic complexity of ideas	Scientific sophistication of ideas
A: With ITM-aided reflection	5.89 (1.63)	3.94 (.58)	3.41 (.34)
B: No ITM use yet	4.65 (1.18)	3.49 (.53)	3.34 (.44)

Through ITM-aided reflection, students in classroom A were able to summarize more topics of inquiry about electricity than students in classroom B (F (1.37) = 7.51, p = .009). Specifically, classroom A had many more students summarizing understandings of electrical charges, magnets, and atoms and electrons. The average scientific rating of students' ideas in both classrooms was between "3 - basically scientific" and "4 – scientific" without significant difference ($p > .05$). Students in classroom A articulated understandings of the various topics at a higher level of epistemic complexity than those in classroom B (F (1,36) = 6.51, p = .015) to explain the mechanisms, processes, reasons, and relationships beyond factual descriptions. For example, a student provided the following elaborated explanation of static electricity based on the movement of electrons: *"So when you rub two things together, it creates friction and heat, and then the electrons from one of them rub off and move to the other one, which is negatively charged and the other is positively charged…Let's say I rub my foot on the carpet, and I collect electrons and I tough the door-knob, I'd go "ow!" because the electrons are leaving me and going into the door-knob."*

Student explanations of electric circuits, conductors, batteries, current, and charges were further coded based on progressively advanced models about how electric circuits work (Figure 4). None of the students showed an understanding of electricity as a field phenomenon (category 4); this result was expected as this complicated notion of electricity is far beyond the level of Grade 5/6. The proportions of students coded for the different categories of explanations differ significantly between the two classrooms ($\underline{X}^2 = 16.03$, $\underline{df} = 3$, $\underline{p} = .001$). As Figure 4 shows, classroom A had higher percentages of students giving more advanced explanations that conceive electricity as negative and positive charges (category 2) carried by electrically charged particles (category 3). On the contrary, a majority of students in classroom B explained electric circuits at a general level based on energy flow from the battery to the light bulb (category 1).

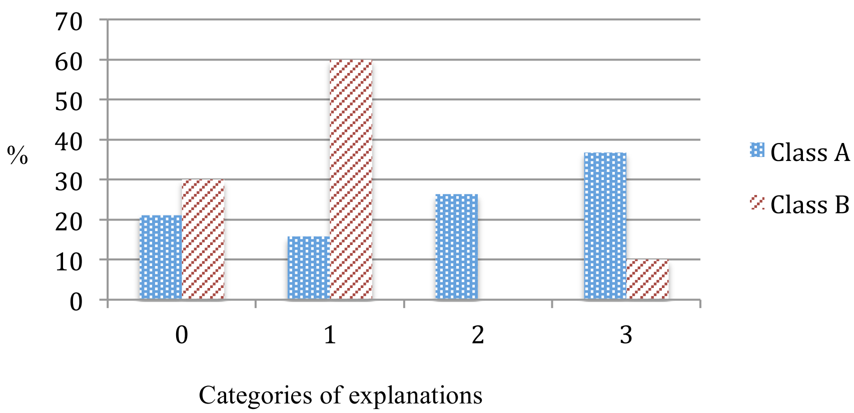


Figure 4. Percentages of students giving different explanations of how electrical circuits work. The categories shown in this figure are: 0: No explanation given; 1: electricity as flow of energy; 2: electricity as positive and negative charges and currents; 3: electricity as the movement of electrically charged particles.

Quantitative Analysis of Student Contribution and Interaction in Online Discourse

To gauge student contribution and interactivity in online discourse, we analyzed the number of notes contributed by each student and the percentage of notes in build-on links. Table 6 shows these two measures for each classroom in Phase 1 before ITM use and in Phase 2 after class A started its use of ITM (before class B used ITM).

Table 6. Analysis of Contributions to the Online Knowledge Building Discourse (Means and Standard Deviations).

Classroom	Phase 1: Week 1-3		Phase 2: Week 4-8	
	Notes written per student	% of notes linked	Notes written per student	% of notes linked
A: ITM Use after Week 3	4.86 (2.61)	37.19 (33.27)	3.57 (3.16)	35.00 (34.00)
B: ITM Use Delayed till after Week 8	3.32 (2.01)	40.23 (29.87)	1.36 (0.67)	15.00 (22.90)

In Phase 1, students in class A contributed more notes to the online discourse in Knowledge Forum than those in classroom B ($\underline{F}$ (1,41) = 4.59, $\underline{p}$ = .038). There was no significant difference in the percentage of notes with build-on links ($\underline{p}$ >.10). These measures of note contribution and linking (build-on) in this phase were included as covariates in the analysis of variance of students' note contribution and linking in Phase 2. Informed by their ITM-aided reflection on their collective knowledge advances, gaps, and connections, students in class A wrote a significantly larger number of notes in Phase 2 than class B (F(1, 40)=6.34, p=.016). A significant effect was observed for the covariate of student contribution rate in Phase 1 (F(1, 40)=4.08, p = .05). Classroom A in Phase 2 also had a significantly higher percentage of notes with build-on links than classroom B (F (1, 40) = 6.29, p = .016), with a significant effect observed for students' note linking percentages in Phase 1 as a covariant (F (1, 43) = 4.45, p = .041). These results demonstrate that the ITM-aided reflection helped class A to sustain more active and connected knowledge building discourse.

Qualitative Tracing of Idea Improvement across the Idea Threads

Deepening the above quantitative analysis of the online discourse, we qualitatively traced the process of idea improvement in each idea thread as reflected in the online discourse, ITM reflection, and related final presentations. ITM-aided metadiscourse fostered more sustained, connected, and productive knowledge building discourse through enhancing the following three patterns of idea improvement that were most salient in this data analysis.

(a) Conceptual rise-above: Identifying emergent conceptual constructs as shared objects of inquiry to develop increasingly powerful explanations. The whole knowledge building initiative began with student hands-on exploration of batteries, wires, light bulbs, magnets, and different types of fabrics to explore static electricity. Students then interacted online to discuss initial observations, questions, and ideas, which became the starters of the idea threads about batteries, static electricity, energy sources, and magnets. Sustaining inquiry in these idea threads, students searched for conceptual explanations of the empirical facts that they had observed. Abstract conceptual constructs developed through these explanatory efforts later became objects of inquiry in their own right, leading to the emergence of idea threads investigating electric charges, electrons, and atoms. For example, students' initial explanation about how batteries work assumed that there would be "mini batteries" inside the batteries to generate energy. This explanation was replaced with better theories, such as: "protons and electrons are…two parts of the battery" that carry positive and negative "energy" (a word used to refer to charges) and that there are "a lot of chemical reactions" inside the battery. Interest emerged among the students to understand electrons, atomic structure and protons, and positive and negative charges. Similarly, students' online discourse on fabrics that cause static electricity came across the concepts of negative and positive charges. In the first ITM reflection session, students explicitly identified such abstract concepts as electric charges and voltage, atoms, and electrons as core topics of inquiry in their community. Through examining their map of idea threads (Figure 2), students noticed deep connections between these concepts and all the other idea thread topics and identified electrons, atoms, and charges/voltage as the areas that needed deeper exploration. Core questions were raised in the Journey of Thinking syntheses regarding these topics, such as: What makes electrons move? What is the connection between atoms and energy? How do atomic bombs work? These areas and questions of inquiry became the main focus of the subsequent work. As Figure 2 and Table 4 show, the idea threads about charges/voltage, atoms, and electrons involved the most intensive discourse after the first ITM reflection in mid-October. Deep understandings were generated and further shared in students' final presentations that explained atomic structure and how positively and negatively charged particles interact.

(b) Progressive deepening: Identifying productive deepening questions as progressive goals in each line of work for specialized investigation. As a common challenge facing student-driven inquiry, it is often found hard for young students to generate productive questions that can drive their inquiry into educationally valuable directions (Krajcik et al., 1998). Knowledge building requires students to further generate progressively deeper questions as their initial questions are addressed and understandings improved (Scardamalia & Bereiter, 2006; Zhang et al., 2007). In this study, students in classroom A generated a diverse set of questions through initial hands-on explorations that caught their deep interest. On the basis of these initial specific questions, ITM-aided metadiscourse further fostered students' efforts to formulate and conceptualize deeper questions in light of major conceptual constructs emerged from their discourse, such as electrons and electric charges. ITM's feature of Journey of Thinking encouraged and scaffolded student efforts to generate progressively deeper questions in light of their advanced understandings.

Before class A's first ITM reflection, 35 out of 89 notes (39.33%) raised questions. Many were general wonderment questions that sought for explanations of broad issues: How do batteries work? What creates static electricity? How do magnets work? ("I know that medal is attracted to it but I have no idea why this happens.") As students developed understandings of these issues, they identified deeper and more specific problems in light of what they had understood: Is static electricity similar to other types of electricity? What makes it similar or different? When the electricity is in the Leyden jar and it comes out through the wire into your finger, how do the electrons travel through the wire? What does magnetism have to do with electricity? The ITM-aided metadiscourse and reflection explicitly encouraged students to review their progressive questions and ideas in each idea thread and co-author Journey of Thinking syntheses. When co-authoring the Journey of Thinking synthesis for an idea thread as a group, the students discussed their existing questions in the idea thread to consolidate overarching problems of understanding (e.g. how magnets work), and reviewed ideas to summarize the most important ideas learned (e.g. "magnets produce an invisible magnetic field … have two sides one positive one negative."). They further selectively highlighted deeper and more specific questions to be addressed in each focal area ("we need to understand how magnets relate to electricity", see Table 3). These deeper questions highlighted for different idea threads were later written on a piece of chart paper as a collective list of problems for their community. Students then formed into voluntary specialized teams to conduct focused research to address these issues. They authored individual and collaborative notes in Knowledge Forum to share their findings while identifying even deeper questions. Among the 72 Knowledge Forum notes written after the first ITM session, 30 (41.67%) raised questions, which included: why are some metals magnetic and some not? Why does static charge not work well under a high humidity? What can cause an atom to become unstable? If there is so much empty space in atoms, how can we, or anything be so solid? Students conducted deeper research through reading, discussions, and interactions with an expert speaker and developed specialized presentations near the end of this science unit. For example, two students investigated how magnets relate to electricity and why some metals are not magnetic and synthesized their findings in their poster presentation:

> *"Every tiny tiny tiny electron, neutron, and proton have a tiny bit of magnetism and when all of them are lined up in the same direction, lots of tiny bits of magnetism becomes a lot of magnetism, which creates a magnet. But what about the un-magnetic metals? Well you can probably guess but, if you can't, in un-magnetic metals there are [electrons], neutrons and protons but they are all jumbled and mixed up and that makes the magnetism all mixed up, which makes it un-magnetic. That is why some [metals] are magnetic and some are not."*

(c) Conceptual connection and diffusion: Reflecting on cross-thread connections to enable coherent use and broad diffusion of core conceptual ideas across the community's discourse. As reported in the video analysis, the students engaged in reflective conversations to review connections among the different idea thread themes, leading to the important insight that "everything is connected… electrons are part of atoms and electrons have charge, and so charge is connected to atoms through electrons." This insight in cross-thread connections was further developed and reflected in the Journey of Thinking syntheses authored by student groups. When synthesizing "big ideas" learned in each idea threads, students mentioned electron movement in six out of the eight idea threads:

> *"Everything is made of atoms. The atoms are made out of protons, neutrons, and electrons."*
> *"Electrons have a negative charge. It's always electrons that transfer onto your body when you rub your foot on the carpet."*
> *"Lemon batteries need a certain amount of electrons."*
> *"We also know that current can flow not just through electrons, but particles called Ions. They are charged atoms."*
> *"Electrons moving create energy."*

The understanding of electrical charges in terms of the movement of electrons and protons was continually used to enrich the discourse across all the idea threads after the first ITM session. Important insights were generated in the subsequent online discourse, including: *"Electrons are the essence of charge. Atoms are the root of everything having to do with electricity." "Whenever you charge one thing positively, you are always charging the other object negatively. It's because the electrons move from one to the other."* Atoms (including electrons) was the most frequently mentioned topic in the individual portfolio summaries, with 21 of the 22 students summarizing understandings related to this topic.

Discussion

Fostering sustained trajectories of collaborative knowledge building requires new tools to represent collective knowledge progress in extended online discourse and related classroom designs to facilitate student collective responsibility for shared regulation of knowledge building processes. The results of this research contribute to addressing these needs by elaborating the processes and roles of collective metadiscourse enabled by the ITM software, which serves to represent collective knowledge trajectories emerged from extended knowledge building discourse.

The Processes of ITM-Aided Collective Metadiscourse

Collective metadiscourse is essential to sustained knowledge building, but it is rarely researched and practiced (van Aalst, 2009). The video analysis elaborated the multilevel processes by which the community engaged in collective metadiscourse using ITM to identify high-interest topics of inquiry, review knowledge progress within and across the idea threads, and envision deeper goals and efforts of the community. The ITM-aided collective metadiscourse went beyond individual reflection and micro metadiscourse on individual ideas to organize, interpret, and evaluate the extended discourse of the whole community. Through the collective metadiscourse, students generated multilevel reflective representations of emergent collective knowledge: idea threads of opportunistic groups and clusters of idea threads of the whole community, which explicated the shared goals and progress of the community and further guided student planning and coordination of deeper knowledge building efforts. These reflective representations in the online space further extended into face-to-face settings through artifacts such as the concept map of idea thread topics and list of "big ideas" and deeper problems on the chart paper. These representations of the focal areas of inquiry of the community, "big ideas," and deepening problems as progressive goals were continually referred to by the students in their ongoing classroom and online discourse to frame, guide, and reflect on their contributions.

These processes of metadiscourse support essential components of collective, socially shared regulation, which involve collective goal-setting, reflective monitoring of collective progress and engagement, and ongoing planning and regulation of joint actions and personal contributions (Järvelä & Hadwin, 2013). The iterative and reflective metadiscourse enables an emergent and adaptive approach to these components: shared deepening goals emerged from student interest and input, collective understanding emergent through open-ended discourse and interactive ideas, and ongoing opportunistic planning for deeper actions and collaborative work to address emergent needs for continually idea improvement (Zhang et al., 2009, 2011).

First, students formulated emergent collective goals based on high-interest topics of inquiry developed in their ongoing discourse. During the metadiscourse, students' primary discourse in their Knowledge Forum view was projected on a screen and printed out on paper, serving as the object of metacognitive conversation and reflection. Driven by the epistemic need to review and organize their messy and extensive view that had a growing number of notes, students first reviewed diverse ideas represented in their discourse space to formulate connected focal themes and goals of inquiry for their community. This was done through an iterative process that involved initial whole class discussion, focused small-group review, and whole class consolidation. These topics were not pre-specified by the teacher, but emerged from the interactive input of students. Essential to this emergent process, students reflected on the focuses of their notes and the connections to suggest larger focus clusters—discourse topics (Chafe, 2001). Each individual student tended to be more attentive to the sections of discourse that he/she had personally involved in. Individual topic proposals were then reviewed and discussed to formulate the collective topics and goals of the community. Micro, specific topics (e.g. lemon juice battery) were integrated and reframed as larger, conceptually rich topics (e.g. how batteries work). The result was a collective list of eight high-interest topics of inquiry that represent the focal areas and goals of inquiry of the whole community.

Second, students monitored collective knowledge progress through reviewing the interactive ideas in each focal idea thread and proposed questions and plans for deeper inquiry. Aided by the modeling of the their teacher, the students work as small groups to review knowledge progress in each focal area through setting up idea threads in ITM. Each idea thread with its conceptual focus, social participatory structure, and temporal profile provided a reflective representation of a focal line of inquiry contributed by an informal group of members in the community. The knowledge progress in each idea thread was further made transparent through the Journey of Thinking synthesis that highlighted the "big ideas" learned, focal problems to be further addressed, and deeper actions of inquiry needed. These problems and actions for deeper inquiry set the directions for the subsequent work in each focal area, leading to deepened understandings.

On the basis of the small-group review of each idea thread, students further engaged in metadiscourse on an even higher social plane to co-reflect on their community's progress as a whole. The whole class mapped out clusters of ideas threads that show community-wide work and connections and discussed core insights gained in productive threads, cross-thread connections, and plans of deeper inquiry in the relatively weak areas. Such collective metadiscourse focusing on the discourse and inquiry of the community as a whole was most essential to raising student awareness of community-wide advances and challenges and envisioning deep conceptual connections between the different lines of work enacted by diverse groups and individual members. Core conceptualizations of electricity as the movement of electrically charged particles were widely diffused to community members and productively applied to the different lines of inquiry. The deeper actions of inquiry proposed in the metadiscourse were later taken on by various members who formed into voluntary groups to conduct collaborative work the classroom and online to address the focal problems. They shared their findings in further online discourse and updated the related idea threads in ITM to include the new discourse contributions.

The teacher co-participated in the metadiscourse with the students and provided support in the context. The support focused on highlighting the epistemic need to review collective knowledge, discussing what counts as "juicy" topics and what idea threads mean, modeling and supporting ITM use, and working with the students to synthesize progress and co-plan knowledge building in areas that needed deeper work (Zhang et al., 2013).

Overall, the above processes of ITM-aided metadiscourse are consistent with what we have observed in the previous iteration (Zhang et al, 2013, 2014). Changes were made in this new iteration to organize the metadiscourse as an iterative ongoing practice and build a natural flow between the metadiscourse using ITM and the primary discourse in Knowledge Forum (e.g. using the view printout as a metadiscourse aid and compiling a hardcopy of the Journey of Thinking syntheses to guide further inquiry). These changes served to ease the implementation of the metadiscourse among the young students so they could co-identify high-interest topics from their ongoing online discourse more easily. Compared to the metadiscourse analyzed in the previous iteration of this research, the students in this study appeared to have engaged in richer and deeper reflection on cross-thread connections and deeper questions and actions of inquiry.

The Role of ITM-Aided Metadiscourse and Reflection in Sustaining Knowledge Building

The results of the analyses further revealed the important role played by the ITM-aided metadiscourse in sustaining knowledge building. First, going through ITM-aided metadiscourse and reflection, students in classroom A demonstrated more comprehensive awareness and complicated understanding of the emergent inquiry themes of their community (see Table 5 and Figure 4). The iterative, multilevel processes to review the ongoing knowledge building discourse for shared high-interest topics, identify related contributions, and synthesize insights and challenges helped the members monitor the unfolding lines of inquiry in the community focusing on core issues about electricity. This finding is consistent with the findings of our first iteration in this design-based research, showing that ITM-aided metadiscourse and reflection helped bring more themes of communal inquiry to the attention of the community members (Chen et al., 2013). In a knowledge building community that encourages diverse expertise, each student needs to conduct focused inquiry with peers to address a few of their communal topics and issues while developing a shared awareness of the knowledge advances of the whole community beyond their own work (Zhang et al., 2007). ITM-aided metadiscourse helps students to address this need through collectively monitoring the unfolding lines of inquiry of their whole community, which helped to inform students' joint, purposeful contributions to advancing their community's knowledge as well as to diffuse the collective advances to all members for personal learning benefits. The benefits were reflected not only in broadened awareness of more themes of inquiry, but, more importantly, in reflective understanding of deep explanations in each idea thread (Table 5) and conceptual connections between the different threads focusing on the core conceptualizations (Figure 4).

With reflective awareness of the various lines of work in their community, including the deep concepts, connections, weaknesses, and challenges, students in classroom A engaged in more sustained and connected knowledge-building discourse online in the second phase of the inquiry. They contributed more notes to address deeper issues identified for each line of work, and their notes had more build-on links than those created by classroom B (Table 6). These results are also congruent with our previous findings suggesting an increased level of connectedness in the online discourse resulted from ITM-aided reflection (Chen et al., 2013). The design of ITM-aided metadiscourse to review collective advances, challenges and connections has the potential to help sustain productive online discourse among students, which, in current practice, often lacks active connected contributions and deepening moves (Guzdial et al., 2001; Suthers et al., 2008; Zhang, 2009).

As the qualitative tracing of idea improvement in different idea threads suggests, the ITM-aided metadiscourse and reflection enhanced essential patterns of sustained idea improvement in knowledge building discourse, including conceptual rise-above, progressive deepening, and conceptual connection and diffusion across different lines of inquiry. The inquiry process initiated by these young students tended to focus on concrete and tangible aspects of electricity, which needed to be explained using higher-level conceptual structures. The ITM-aided metadiscourse to review core topics of inquiry from the existing distributed discourse helped the students to explicitly define abstract concepts, such as electric charges and voltage, atoms, and electrons, as shared goals of research in their community, leading to intentional and intensive contributions to developing conceptual understanding in these areas. Through the ongoing metadiscourse and reflection to review Journeys of Thinking in various idea threads, students further identified deeper questions and issues as informed by their updated understanding, which brought forth deepening goals for progressive problem solving (Bereiter, 2002). These deepening goals served to guide individual and collaborative efforts to address these questions and issues through further reading, experiments, classroom discussions, online discourse that involved both individual and co-authored notes, and group-based presentations. Reflective conversations about the advances and connections across the different lines of inquiry further generated insights in the connectedness of the various electric topics, enabling the diffused use of core concepts (e.g. electric charges, electrons) throughout the community's discourse space to develop coherent and sophisticated understanding.

Conclusions and Implications

This study elaborated the iterative processes of collective metadiscourse supported by ITM, which serves to represent collective knowledge trajectories in the extended online discourse of knowledge building communities. Congruent with our previous findings (Zhang et al., 2013, 2014), the metadiscourse and reflection played a productive role in fostering student awareness of the unfolding lines of inquiry emerged from their collective discourse, including the focal themes, idea contributions and interactions, challenges, and deep connections. Such shared awareness of their evolving collective knowledge helped to guide students as they engaged in sustained and connected knowledge building discourse to address deepening issues and build sophisticated and coherent explanations.

These results contribute new conceptual understandings and designs that are needed to enable sustained knowledge building and progressive discourse driven by student interactive ideas in extended inquiry initiatives. Sustained knowledge building requires students to take on collective responsibility and engage in socially shared regulation to formulate collective progressive goals of understanding, to monitor and diffuse collective progress, and to plan for collaborative, complementary actions to address deepening issues. To help student enact such collective responsibility and shared regulation, this research using ITM supports student creation of multilevel representations to make collective knowledge trajectories visible in online discourse. With student input to the ongoing discourse represented as discourse entries and build-on trees, ITM enables higher-level representations that use timeline-based idea threads to represent various lines of work carried out by different subgroups of members and use clusters of idea threads to represent community-wide efforts and progress in an inquiry initiative. The collective metadiscourse using ITM provides a social practice by which students generate these high-level reflective representations and enact collective regulation for sustained knowledge building. The metadiscourse unfolds across the different socio-epistemic levels: to formulate shared focuses and goals as emergent from student diverse discourse input; to review contributions, advances, and deeper issues in each line of work focusing on a topic; to examine clusters of idea threads to synthesize community-wide advances, insights, connections, and challenges. Through such collective monitoring and regulation of collective knowledge progress, members of the community develop purposeful efforts as individuals and spontaneous groups to contribute effectively to addressing the community's deepening goals while taking advantages of the collective knowledge progress for personal learning benefits.

These findings were generated through a design-based study that included a time-lag design for cross-classroom comparison, drawing upon a combination of qualitative and quantitative data analyses. The cross-classroom comparison embedded in this design-based study was helpful for examining the role of ITM-aided metadiscourse. However, this cross-classroom comparison was by no mean an experimental-control comparison, which, if implemented in the future, may produce more robust analysis of the impact of ITM-aided metadiscourse. With rich data collected through this semester-long design-based study, we had to made strategic decisions to focus our detailed analysis on data that were most essential to our research questions; although with more time and resource we could have done more detailed coding of other pieces of data (e.g. detailed coding of the videos of the final presentations).

In light of the research findings, we have been refining the design of ITM to ease the flow between the metadiscourse using ITM and primary online discourse in Knowledge Forum and incorporated new visualizations to capture cross-thread connections. To ease the identification of shared topics of inquiry from online discourse entries, we have tested automated online discourse analysis using probabilistic topic models to identify topics and related discourse contributions (Sun et al, 2014). We are making further efforts to develop interoperation between ITM and other collaborative learning platforms to support the application of ITM in broader classrooms. Drawing upon the reflective representations of collective knowledge generated by students of each community, our further research will incorporate an even higher social layer to enable sustained build-on of ideas across communities and student cohorts. Students in each community review their progress in the form of idea threads and selectively share productive idea threads and syntheses with a network of communities investigating the same or related content areas. It is hoped that these efforts will enable a multilevel socio-technical system to foster sustained, progressive discourse across a network of communities that co-advances shared knowledge, supporting progressive discourse and inquiry in each community.

Acknowledgments

This research was supported by the National Science Foundation through a Cyberlearning: Transforming Education grant (IIS #1122573). We would like to thank the students of the Dr. Eric Jackman Institute of Child Study at the University of Toronto for their creative work enabling this research; and thank our team members for their contributions to the software development, data collection, and analysis.

References

Amar, A.D. (2002). *Managing knowledge workers: Unleashing innovation and productivity*. Westport, CT: Quorum Books.

Barron, B., & Darling-Hammond, L. (2008). How can we teach for meaningful learning. In L. Darling-Hammond et al. (Eds.), *Powerful learning: What we know about teaching for understanding* (pp. 11-70). San Francisco: Jossey-Bass.

Bereiter, C. (2002). *Education and mind in the knowledge age*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bielaczyc, K., & Collins, A. (2006). Technology as a catalyst for fostering knowledge-creating communities. In A. M. O'Donnell, C. E. Hmelo-Silver, & J. van der Linden (Eds.), *Collaborative learning, reasoning, and technology* (pp. 37-60). Mahwah NJ: Erlbaum.

Borges, A. T., & Horizonte, B. (1999). Mental models of electricity. *International Journal of Science Education, 21*(1), 95-117.

Chafe, W. (1997). Polyphonic topic development. In T. Givón (Ed.), *Conversation: Cognitive, Communicative and Social Perspectives* (pp. 41-53). John Benjamins Publishing.

Chafe, W. (2001). The Analysis of Discourse Flow. In D. Schiffrin, D. Tannen and H. E. Hamilton (Eds.), *The Handbook of Discourse Analysis* (pp. 673-687). Oxford: Blackwell.

Chan, C. K.K. (2012). Co-regulation of learning in computer-supported collaborative learning environments: a discussion*. Metacognition and Learning, 7,* 63-73.

Chen, M.-H., Zhang, J. & Lee, J. (2013). Making collective progress visible for sustained knowledge building. In N. Rummel, M., Kapur, M. Nathan, & S. Puntambekar (Eds.), *To see the world and a grain of sand: Learning across levels of space, time, and scale: CSCL 2013 Conference Proceedings Volume 1* (pp.81-88). International Society of the Learning Sciences.

Chi, M. T. H. (1997). Quantifying qualitative analysis of verbal data: A practical guide. *Journal of the Learning Sciences, 6*, 271-315.

Chinn, C., & Malhotra, B. A. (2002). Epistemologically authentic inquiry in schools: A theoretical framework for evaluating inquiry tasks. *Science Education, 86*, 175-218.

Collins, A., Joseph, D. & Bielaczyc, K. (2004). Design research: Theoretical and methodological issues. *Journal of the Learning Sciences, 13*(1), 15–42.

Csikszentmihalyi, M. (1999). Implications of a systems perspective for the study of creativity. In R. J. Sternberg (Ed.), *Handbook of creativity* (pp. 313-335). Cambridge, UK: Cambridge University Press.

Dean, D., & Kuhn, D. (2007). Direct instruction vs. discovery: The long view. *Science Education, 91*, 384 – 397.

Derry, S. J., Pea, R. D., Barron, B., Engle, R.A., Erickson, F. Goldman, R., et al. (2010). Conducting video research in the learning sciences. *Journal of the Learning Sciences, 19*, 3–53.

Dunbar, K. (1997). How scientists think: Online creativity and conceptual change in science. In T. B. Ward, S. M. Smith & S. Vaid (Eds.), *Conceptual structures and processes: Emergence, discovery and change* (pp. 461-493). Washington, DC: APA Press.

Engeström, Y. (2008). *From teams to knots: Activity-theoretical studies of collaboration and learning at work.* New York, NY: Cambridge University Press.

Engle, R. A. (2006). Framing interactions to foster generative learning: A situative explanation of transfer in a community of learners classroom*. Journal of the Learning Sciences, 15*(4), 451-498.

Hakkarainen, K. (2003). Progressive inquiry in a computer-supported biology class. *Journal of Research in Science Teaching, 40* (10), 1072-1088.

Hewitt, J. (2001). Beyond threaded discourse. *International Journal of Educational Telecommunications, 7*(3), 207-221.

Järvelä, S., & Hadwin, A. F. (2013). New frontiers: regulating learning in CSCL. *Educational Psychologist, 48*(1), 25-39.

Kempler Rogat, T. M., & Linnenbrink-Garcia, L. (2011). Socially shared regulation in collaborative groups: An analysis of the interplay between quality of social regulation and group processes. *Cognition and Instruction, 29,* 375–415.

Krajcik, J., Blumenfeld, P. C., Marx, R. W., Bass, K. M., & Fredricks, J. (1998). Inquiry in project-based science classrooms. *Journal of the Learning Sciences, 7*(3/4), 313-350.

Latawiec, B. M. (2012). *Metadiscourse in oral discussions and persuasive essays of children exposed to collaborative reasoning*. Unpublished doctoral dissertation of the University of Illinois at Urbana-Champaign.

Reiser, B. J., Tabak, I., Sandoval, W. A., Smith, B. K., Steinmuller, F., & Leone, A. J. (2001). BGuILE: Strategic and conceptual scaffolds for scientific inquiry in biology classrooms in S. M. Carver & D. Klahr (Eds.), *Cognition and instruction: Twenty-five years of progress* (pp. 263-305). Mahwah, NJ: Erlbaum.
Roth, W. M. (1996). Knowledge diffusion in a grade 4–5 classroom during a unit of civil engineering. *Cognition and Instruction, 14*, 170–220.
Salmon, W. C. (1984). *Scientific explanations and the causal structure of the world*. Princeton, NJ: Princeton University Press.
Sawyer, R. K. (2005). *Social emergence: Societies as complex systems*. Cambridge, UK: Cambridge University Press.
Sawyer, R. K. (2007). *Group genius: The creative power of collaboration*. New York: Basic Books.
Scardamalia, M. (2002). Collective cognitive responsibility for the advancement of knowledge. In B. Smith (Ed.), *Liberal education in a knowledge society* (pp. 67-98). Chicago, IL: Open Court.
Scardamalia, M., & Bereiter, C. (2006). Knowledge building: Theory, pedagogy, and technology. In R. K. Sawyer (Ed.), *Cambridge Handbook of the Learning Sciences* (pp. 97-115). New York: Cambridge University Press.
Slotta, J. D., Najafi, H., Zhao, N., & Tissenbaum, M. (2013). *Knowledge community and inquiry: A pedagogical model for collaborative inquiry and knowledge construction.* Paper presented at the Annual Meeting of American Educational Research Association, San Francisco, CA.
Stahl, G. (2006). *Group cognition: Computer support for building collaborative knowledge*. Cambridge, MA: MIT Press.
Stahl, G. (2013). Learning across levels. *International Journal of Computer-Supported Collaborative Learning, 8*(1), 1-12.
Sun, W., Zhang, J., Jin, H., & Lyu, S. (2014). Analyzing online knowledge building discourse using probabilistic topic models. In J. Polman, E. Kyza, K. O'Neill, & I. Tabak (Eds.), *Proceedings of the International Conference of the Learning Sciences* (ICLS 2014). International Society of the Learning Sciences.
Suthers, D., Vatrapu, R., Medina, R., Joseph, S., & Dwyer, N. (2008). Beyond threaded discussion: Representational guidance in asynchronous collaborative learning environments. *Computers and Education, 50*, 1103-1127.
van Aalst, J. (2009) Distinguishing knowledge-sharing, knowledge-construction, and knowledge-creation discourses. *International Journal of Computer-Supported Collaborative Learning, 4* (3), 259-287.
van Aalst, J., & Chan, C. K. K. (2007). Student-directed assessment of knowledge building using electronic portfolios in Knowledge Forum. *Journal of the Learning Sciences, 16,* 175-220.
van Aalst, J., & Truong, M. S. (2011). Promoting knowledge creation discourse in an Asian primary five classroom: Results from an inquiry into life cycles. *International Journal of Science Education*, 33 (4), 487-515.
Vande Kopple, W. J. (1985). Some exploratory discourse on metadiscourse. *College Composition and Communication, 36*, 82-93.
Volet, S., Vauras, M., & Salonen, P. (2009). Self- and social regulation in learning contexts: An integrative perspective. *Educational Psychologist, 44*, 215–226.
Zhang, J. (2009). Towards a creative social Web for learners and teachers. *Educational Researcher, 38*, 274-279.
Zhang, J. (2012). Designing Adaptive Collaboration Structures for Advancing the Community's Knowledge. In: D.Y. Dai (Ed.), *Design research on learning and thinking in educational settings: Enhancing intellectual growth and functioning* (pp. 201-224). Philadelphia, PA: Taylor & Francis.
Zhang, J., Lee, J., & Wilde, J. (2012). Metadiscourse to foster collective responsibility for deepening inquiry. In Jan van Aalst, Kate Thompson, Michael J. Jacobson, and Peter Reimann (Eds.), *Proceedings of the International Conference of the Learning Sciences* (pp.395-402). International Society of the Learning Sciences (ISLS).
Zhang, J.**,** Chen, M.-H., Chen, J., & Mico, T. F. (2013). Computer-Supported Metadiscourse to Foster Collective Progress in Knowledge-Building Communities. In N. Rummel, M., Kapur, M. Nathan, & S. Puntambekar (Eds.), *To See the World and a Grain of Sand: Learning across Levels of Space, Time, and Scale: CSCL 2013 Conference Proceedings Volume 2* (pp.197-200). International Society of the Learning Sciences.
Zhang, J., Hong, H.-Y., Scardamalia, M., Toe, C., & Morley, E. (2011). Sustaining knowledge building as a principle-based innovation at an elementary school. *Journal of the Learning Sciences, 20* (1), 1-47.
Zhang, J., Scardamalia, M., Lamon, M., Messina, R., & Reeve, R. (2007). Socio-cognitive dynamics of knowledge building in 9- and 10-year-olds. *Educational Technology Research and Development, 55*, 117–145.
Zhang, J., Scardamalia, M., Reeve, R., & Messina, R. (2009). Designs for collective cognitive responsibility in knowledge building communities. *The Journal of the Learning Sciences, 18*, 7–44.