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Editorial Volume 51 Issue 2

Martha Cleveland-Innes, Editor-in-Chief

Welcome to Volume 51, Issue 2 Canadian Journal of Learning and Technology (CJLT).

This journal has always supported research about learning, technology, and change. In the evolving landscape of education places and spaces, one truth is still emerging: learning is not confined to a traditional classroom or dictated by curriculum. It is shaped significantly by communities small and large, technologies of many types, and the beliefs and actions of those who teach and learn. Recent studies from Canada, France, Switzerland, and the United States offer a view to the continuing transformational change. Outlined are the problems, the promise, and the increasing complexity of techno-pedagogical reality.

In our Notes Section, Georges-Louis Baron and Solène Zablot from France explore the ecosystem of online teacher communities, as they produce and share resources. These collectives range from tightly organized "captive" groups to loosely formed "proto-communities," embodying a spirit of pedagogical freedom that is uniquely French. Teachers are not mere consumers of curriculum; they are co-creators, shaping materials to fit their students' needs and their own professional values. The authors argue that participatory research can amplify this action and offer a pathway to meaningfully influence policy and practice.

Our first empirical article brings us across the Atlantic, where the HyFlex model is gaining traction in postsecondary education, allowing students the freedom to choose between in-person and online learning. But as Laura Morrison and colleagues at Ontario Tech University reveal, flexibility comes at a cost. Their study, grounded in the Community of Inquiry framework, uncovers the logistical and technological hurdles that instructors face in non-lecture environments. Audio glitches, video lag, and the elusive goal of "mode neutrality" threaten to undermine the very flexibility HyFlex aims to provide. The solution, they suggest, is dependent upon institutional support beyond infrastructure in training and pedagogical design.

Natalie Nussli and Kevin Oh take the HyFlex conversation further, applying the POUR model (Perceivable, Operable, Understandable, Robust) to enhance digital accessibility. Their work bridges multiple frameworks: Universal Design, Mobile Seamless Learning, and Universal Design for Learning, which, in combination, create environments where all students can thrive. The journey of one instructor in Switzerland illustrates both the progress and the pitfalls of accessibility efforts. Students noticed the

improvements, but navigation and participation barriers persisted. Their final message: accessibility must be intentional, iterative, and deeply embedded in course design.

Article three reviews immersive learning with virtual reality at Georgian College. James Doran and his team are pushing the boundaries of engagement through virtual reality. Their study compares desktop-based and immersive VR experiences in anatomy courses, finding that students using headsets reported significantly higher motivation and enjoyment. However, the promise of VR is tempered by practical challenges: individual bias, curriculum integration, and survey fatigue. Authors caution that without strategic planning and institutional buy-in, VR risks becoming a novelty rather than a transformative tool.

Finally, Jennifer Walsh-Marr and Shihua Tan offer a quiet revolution in academic literacy. Their case study at the University of British Columbia shows how social annotation, where students comment on texts asynchronously, can foster both individual understanding and communal learning. For first-year international students, this method provided a scaffold into academic discourse, allowing them to engage meaningfully with peers and texts. It's a reminder that community isn't just built in lecture halls; it can flourish in the margins of a shared document.

Taken together, these studies illuminate a new pedagogical paradigm that values flexibility, inclusivity, and the lived experiences of educators and learners. They challenge institutions to move beyond one-size-fits-all models and invest in the messy, human work of teaching and learning. Whether through teacher collectives in France or VR labs in Canada, the future of education lies not in technology alone, but in how we use it to empower communities and cultivate agency. The question now is not whether we can reimagine learning, but whether we will.

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Éditorial Volume 51 Numéro 2

Bienvenue au volume 51, numéro 2 de la Revue canadienne de l'apprentissage et de la technologie (RCAT).

Cette revue a toujours soutenu la recherche sur l'apprentissage, la technologie et le changement. Dans le paysage évolutif des lieux et espaces d'éducation, une vérité continue d'émerger : l'apprentissage n'est pas confiné à une salle de classe traditionnelle ou dicté par un programme d'études. Il est façonné de manière significative par les communautés, petites et grandes, les technologies de toutes sortes, ainsi que les croyances et les actions de ceux qui enseignent et apprennent. Des études récentes menées au Canada, en France, en Suisse et aux États-Unis offrent un aperçu du changement transformationnel en cours. Les problèmes, les promesses et la complexité croissante de la réalité techno-pédagogique sont décrits.

Dans notre section Notes, Georges-Louis Baron et Solène Zablot, de France, explorent l'écosystème des communautés d'enseignantes et enseignants en ligne, qui produisent et partagent des ressources. Ces collectifs vont de groupes "captifs" étroitement organisés à des "proto-communautés" peu structurées, incarnant un esprit de liberté pédagogique typiquement français. Les enseignantes et enseignants ne sont pas de simples consommatrices et consommateurs de programmes d'études ; ils sont des co-créatrices et co-créateurs, qui façonnent le matériel en fonction des besoins de leurs étudiantes et étudiants et de leurs propres valeurs professionnelles. L'autrice et l'auteur soutiennent que la recherche participative peut amplifier cette action et offrir une voie pour influencer de manière significative la politique et la pratique.

Notre premier article empirique nous amène de l'autre côté de l'Atlantique, où le modèle comodal gagne du terrain dans l'enseignement postsecondaire, offrant aux étudiantes et étudiants la liberté de choisir entre l'apprentissage en personne et l'apprentissage en ligne. Mais comme le révèlent Laura Morrison et ses collègues de l'Université technique de l'Ontario, la flexibilité a un coût. Leur étude, fondée sur le cadre de la communauté d'enquête, met en lumière les obstacles logistiques et technologiques auxquels les enseignantes et enseignants sont confrontés dans les environnements autres que les cours magistraux. Le problème audio, le décalage vidéo et l'objectif insaisissable de la "neutralité de mode" menacent de compromettre la flexibilité même que la formule comodale vise à fournir. La solution, suggèrent-ils, dépend du soutien institutionnel au-delà de l'infrastructure dans la formation et la conception pédagogique.

Natalie Nussli et Kevin Oh poussent plus loin la conversation sur la formule comodale en appliquant le modèle POUR (Perceivable, Operable, Understandable, Robust) pour améliorer l'accessibilité numérique. Leur travail fait le lien entre plusieurs cadres : conception universelle, apprentissage mobile sans interruption et conception universelle de l'apprentissage qui, combinés, créent des environnements où tous les étudiantes et étudiants peuvent s'épanouir. Le parcours d'un enseignant en Suisse illustre à la fois les progrès et les écueils des efforts en matière d'accessibilité. Les étudiantes et étudiants ont remarqué les améliorations, mais les obstacles à la navigation et à la participation ont

persisté. Leur message final : l'accessibilité doit être intentionnelle, itérative et profondément ancrée dans la conception des cours.

L'article trois examine l'apprentissage immersif avec la réalité virtuelle (RV) au Georgian College. James Doran et son équipe repoussent les limites de l'engagement grâce à la réalité virtuelle. Leur étude compare les expériences de RV sur ordinateur et les expériences de RV immersive dans les cours d'anatomie, et constate que les étudiantes et étudiants qui utilisent des casques font état d'une motivation et d'un plaisir significativement plus élevés. Cependant, la promesse de la RV est tempérée par des défis pratiques : les biais individuels, l'intégration du programme d'études et la saturation des enquêtes. Les auteurs avertissent que sans planification stratégique et sans adhésion institutionnelle, la RV risque de devenir une nouveauté plutôt qu'un outil de transformation.

Enfin, Jennifer Walsh-Marr et Shihua Tan proposent une révolution tranquille dans le domaine de littératie académique. Leur étude de cas à l'université de Colombie-Britannique montre comment l'annotation sociale, où les étudiantes et étudiants commentent des textes de manière asynchrone, peut favoriser à la fois la compréhension individuelle et l'apprentissage collectif. Pour les étudiantes et étudiants étrangers de première année, cette méthode a servi d'échafaudage au discours académique, leur permettant de s'engager de manière significative avec leurs pairs et avec les textes. Cela nous rappelle que la communauté ne se construit pas seulement dans les auditoires, mais qu'elle peut s'épanouir dans les marges d'un document partagé.

Prises ensemble, ces études mettent en lumière un nouveau paradigme pédagogique qui valorise la flexibilité, l'inclusion et les expériences vécues par les enseignantes et enseignants ainsi que par les apprenantes et apprenants. Elles incitent les institutions à dépasser les modèles uniformisés et à investir dans le travail humain et désordonné de l'enseignement et de l'apprentissage. Qu'il s'agisse des collectifs d'enseignantes et enseignants en France ou des laboratoires de RV au Canada, l'avenir de l'éducation ne réside pas uniquement dans la technologie, mais dans la manière dont nous l'utilisons pour renforcer les communautés et cultiver l'autonomie. La question n'est pas de savoir si nous pouvons réimaginer l'apprentissage, mais si nous le ferons.

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Author

Martha Cleveland-Innes is Professor of Open, Digital, and Distance Education at Athabasca University in Canada and Editor-in-Chief of the bilingual *Canadian Journal of Learning and Technology.* She is the co-author of open source publications The Guide to Blended Learning (2018), Participant Experience in an Inquiry-Based Massive Open Online Course (2022), and Principles of Blended Learning (2024). The Design of Digital Learning Environments: Online and Blended Applications of the Community of Inquiry was recently co-edited by Dr. Cleveland-Innes (Taylor& Francis, 2024). Her research interest areas include 1) online and blended learning, 2) artificial intelligence and online communities of inquiry, 3) higher education reform and lifelong learning, and 4) leadership in education. She is currently Visiting Professor of Pedagogy at Mid-Sweden University (2018-present). For more information, see her Athabasca faculty profile.

Autrice

Martha Cleveland-Innes est professeure en éducation ouverte, numérique et à distance à l'Université Athabasca au Canada et rédactrice en chef de la revue bilingue La Revue canadienne de l'apprentissage et de la technologie. Elle est coautrice des publications en accès libre The Guide to Blended Learning (2018), Participant Experience in an Inquiry-Based Massive Open Online Course (2022) et Principles of Blended Learning (2024). The Design of Digital Learning Environments: Online and Blended Applications of the Community of Inquiry a récemment été coédité par le Dr Cleveland-Innes (Taylor& Francis, 2024). Ses domaines de recherche comprennent 1) l'apprentissage en ligne et hybride, 2) l'intelligence artificielle et les communautés d'enquête en ligne, 3) la réforme de l'enseignement supérieur et l'apprentissage tout au long de la vie, et 4) le leadership dans l'éducation. Elle est actuellement professeure invitée en pédagogie à l'université Mid-Sweden (depuis 2018). Pour plus d'informations, consultez son profil sur le site de la faculté d'Athabasca.

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Analysing French Teacher Communities Producing Online Resources: Perspectives on Teacher Agency

Analyse des communautés d'enseignants français produisant des ressources en ligne : Nouvelles perspectives sur l'agence des enseignants

Georges-Louis Baron, *Université de Paris, EDA, France*
Solène Zablot, *Université de Caen Normandie, CIRNEF, France*

Abstract

Online resources have become an important reality in education, accompanied by the phenomenon of the production, modification, and wide dissemination of educational resources by communities of teachers. This article explores the situation in France. First, we recall previous research on how teachers cooperate in order to create online resources. We distinguish between several types of collectives (captive communities, activist communities, proto-communities) and focus on their dynamics. Doing so implies considering the subjects as well as the instruments used and the social systems within which they evolve. Second, the issue of teacher agency relative to educational resources is analysed. In France, teachers are granted great freedom of pedagogical methods, a freedom not seen in all countries. Therefore, we analyse the activities of these collectives to understand how they view their activity and their role, specifically when using learning materials in class. An important related issue is the eagerness of administration to rely on evidence-based practice for orienting teacher action. We suggest that participatory research is a good investment for raising meaningful issues and proposing possible, short-term solutions.

Keywords: resources, teacher communities, theoretical frameworks

Résumé

Les ressources en ligne sont devenues une réalité importante dans l'éducation, accompagnée d'un phénomène de production, de modification et de diffusion à grande échelle de ressources éducatives par des communautés d'enseignants. Cet article explore la situation en France. Tout d'abord, nous rappelons les recherches antérieures sur la façon dont les enseignants coopèrent pour créer des ressources en ligne. Nous distinguons plusieurs types de collectifs (communautés captives, communautés activistes, "proto-

communautés") et nous nous concentrons sur leur dynamique. Cela implique de considérer non seulement les sujets, mais aussi les instruments que ces sujets utilisent et les systèmes sociaux au sein desquels ils évoluent. Deuxièmement, la question de l'agence des enseignants par rapport aux ressources éducatives est analysée. En France, les enseignants jouissent d'une grande liberté en matière de méthodes pédagogiques, ce qui n'est pas le cas dans tous les pays. Nous analysons donc les activités de ces collectifs pour comprendre comment ils perçoivent leur activité et leur rôle, en particulier lorsqu'ils utilisent des ressources pédagogiques en classe. Une question connexe importante est l'empressement des administrations à s'appuyer sur des bonnes pratiques fondées sur des preuves pour orienter l'action des enseignants. Nous suggérons que la recherche participative est un bon investissement pour soulever des questions significatives et proposer des solutions possibles (à court terme).

Mots-clés : ressources, communautés d'enseignants, cadres théoriques

Introduction

The idea of community has been much debated. From an etymological point of view, community (κοινότητα in Greek) shares a lot with society (κοινωνία), with the root κοινός indicating what is in common. Perhaps the first problematization of communities dates back to Tönnies (1987), at the end of the XIXe century, with a sharp distinction between *Gemeinschaft* (traditional communities, exploiting common goods with a strong solidarity) and *Geselschaft* (groups of people organised on the basis of contracts). From an economic and political perspective, the issue of the commons has raised different points of view, from the grim verdict of Hardin (1968), who discusses what he calls the tragedy of the commons, to the theses by Ostrom (1990) about what enables producer collectives to perform efficiently.

For our purpose, a community is considered a collective gathered around a common good, constituted either by a group of people combining their efforts or by an external impetus, which allows individual initiatives to unite their efforts. Many such communities exist in French education.

The typical classroom situation profile has slightly changed, even if the *forme scolaire* (the traditional model of the age-graded school) seems to be rather robust (Vincent, 2008). The role of textbooks is changing, and online resources tend to have a greater weight in education. These resources are produced and validated in different ways by an institution, company, community, or individual. This diversification has deep implications and calls for research into how educational resources are designed, produced, validated, and used. This discussion paper, which mostly relies on French examples, considers how teachers collectively design, produce, and share online educational resources (OERs).

Production of Educational Resources by Teachers in France

Online educational resources have developed alongside progressive education. Dewey (2016) used the term often in his *Democracy and Education*, mainly as an antonym for an obstacle or difficulty, referring to a resource as something that allows one to cope with difficulties. However, he uses the word “textbook” far less often and, when he does, it is seldom in positive terms:

> So far as schools still teach from textbooks and rely upon the principle of authority and acquisition rather than upon that of discovery and inquiry, their methods are Scholastic—minus the logical accuracy and system of Scholasticism at its best. (Dewey, 1916, Chap XX1, 1.)

The presence of OERs has spread rapidly since the beginning of the 21st century. These resources do not all follow the model of textbooks, even if textbooks, now digitised, often have digital complements (Gueudet et al., 2016). Something completely different may be offered, such as databases giving access to large amounts of information. The challenge is to go beyond the information given by relying on prior knowledge or external advice.

Digital resources have interesting, albeit potentially worrying, characteristics for education: almost anyone can produce, copy, transform, and widely disseminate them without any recognised authorisation, posing quality challenges. Bruillard and Baron (2018), studying issues linked to the design and evaluation of information, communication and technology (ICT) tools and resources for education in general, identified four key processes in the way teachers deal with online resources:

1. Inheritance and transmission (e.g., getting resources from university preservice training or from colleagues).
2. Participation (e.g., sharing and co-designing resources).
3. Collection (e.g., storing and organising educational materials).
4. Establishing trusted networks: This last consideration is crucial, trust being the ultimate criterion for accepting and disseminating the information or not.

They also remark that teacher action "depends upon their degree of pedagogical freedom. Teachers collect resources and, most of the time, rearrange them for their students, composing something new from several sources, according to their choices and priorities" (Bruillard & Baron, 2018, p. 1147).

It is noteworthy that educational resource markets have appeared and are developing rapidly. In 2019, Amazon launched a new platform that allows teachers to sell OERs[1], announcing that it "connects educational content creators with Amazon customers. Sell your original teaching resources—like printables, lesson plans, and classroom games—as digital downloads. It's free to join".

Resources may be produced and exchanged by people whose primary purpose is not monetary, but to produce free and open resources in the service of ideas and to create common goods and services. In France, Béziat (2003), Drot-Delange (2001), and Quentin and Bruillard (2013) studied these communities.

Our focus is to understand how teachers produce, modify, and disseminate pedagogical resources, drawing inspiration and strength from participating in a collective. What renders such collectives sustainable, how to study their development, and what factors favour it. What theories may

[1] https://www.edsurge.com/news/2019-11-13-amazon-starts-marketplace-for-teachers-to-sell-online-educational-resources

be used to orient research in this domain? We focus on the theoretical aspects, suggesting that a mix of systemic theoretical models are needed, considering subjects, institutions, communities, and interactions. We extend a reflection first presented in Baron and Zablot (2017) within the French research project – REVEA (Bruillard, 2019).

First, we present a typology of collectives of teachers, distinguishing between captive, activist[2], and proto-communities. Then we put into perspective several types of complementary theories and theoretical models that allow us to analyse the activity of producing and disseminating online resources.

Teacher Collectives Producing Online Resources

Collectives and Communities

Beauné et al. (2019) offer an analysis of the example of France, relying on data obtained in the national research REVEA project. They note that, in French, the word community first appeared in a religious context (before the historical separation of the catholic Church and the State in 1905). The word movement has been mostly used in a political context, and the word collective, for its part, is neutral and diverse in its meanings, while the word network is linked to an intricate organisation.

The French word *communauté* has two main meanings. Firstly, the term comes from its usage in mass media where it is linked with ethnic and religious affiliation. Secondly, in academia, the meaning is more flexible, referring to entities that are sometimes vague and equivalent to collective. For example, the expression *communauté scolaire* (school community) is often used to designate school participants and users, despite the interests and agenda differences of the categories of persons.

A collective of activists promotes didactical, pedagogical, and even political values (such as openness) not fully in line with those advocated by official bodies, such as the Ministry of Education in France (in particular, this is the case for activist communities). These *transgressions*, a sign of agentivity, are generally modest: we are not in a kind of counterculture but rather an environment of passionate innovators capable of anticipation and often benefiting, at least initially, from school institution support. This kind of community is commonplace in the French context, where teachers, by law, have a large autonomy in the choice of their methods.

Teacher collectives that produce resources are diverse and based on different models. Quentin and Bruillard (2013) studied such communities in France[3] and distinguish two main organisation types, called the sandbox and the hive. For them, the rules for sandbox communities are flexible and not always clear. They also show a strong asymmetry of roles, with core persons occupying a central position and the others far from this core. In contrast, the hive has explicit operating rules and regular member interaction to achieve a common goal. From an economic point of view, Mengual-Andrés and

[2]In French: *communautés militantes*. But the meaning of "militant" is more aggressive in English than in French.
[3]They use the expression 'online networks' in place of 'community' but consider it is very similar to what US researchers call communities.

Payá-Rico (2018) recall the three business models identified by OECD in a study of open education resources: community-based, philanthropy-based, and revenue-based.

The philanthropic model is "preferably to be adopted by foundations, governments and companies. Its financing is limited to donations and grants, with its sustainability linked to the financing received or the strategies anticipated by the possible donors" (Mengual-Andrés & Payá-Rico, 2018, p. 5). The revenue model depends on its ability to attract customers. Payments may be restricted to those who want to exceed a limited free offer.

We are interested in the dynamics of teacher collectives producing resources and will focus on several *attractors* that motivate these collectives. Our distinction is between captive communities, activist communities, and proto-communities.

Captive Communities, Activist Communities, and Proto-Communities

The term captive is used in the sense of captive market[4], i.e., communities existing only as long as there is support from an external institution. Captive teacher communities refer to situations where teachers are solicited by resource providers (private or public) to produce resources, which may be commercial or free depending upon the institution, in exchange for financial reward. For example, Baron and Zablot (2017) describe a working group of vocational teachers organised by the National Association for Automotive Training (ANFA), a private operator funded by the automobile profession. Created in 1952, this association is particularly present in apprenticeship training establishments (Centres de formation d'apprentis or CFA), where students share their time between the training centre and field experience where they are supervised by professionals.

In 1992, ANFA launched a training program for vocational teachers, asking the CFAs to participate in the Réseau des CFA pilotes (Pilot CFA) network. Since 2010, the Association has held the right, in partnership with the Ministry of National Education, to offer resources to teachers. To this end, ANFA involves teachers in designing these resources and compensates CFAs for the costs of inviting teachers to take part. Training centre network members have reserved access to resources stored on an Extranet during previous working groups. These online resources can be uploaded to the Educauto website, which is run by both the Association and the Ministry of National Education.

Many teacher communities attract pedagogical activists who produce online resources. Unlike captive communities, activist communities are founded on shared values and promote principles such as pedagogical liberty. This is a historical principle enshrined in France's national education code but it is also a fragile reality[5].

[4] Refers to a situation where consumers can purchase products from a voluntarily limited number of suppliers only (Bathelot, 2015).

[5] After a high school teacher, who taught about freedom of expression, was murdered in October 2020, the Ministry of Education imposed a lesson about freedom of expression requiring teachers to use only ministry-approved resources. Resources were posted on the Eduscol website.

One example of an activist community is the Institut coopératif de l'école moderne (Coop'ICEM) which was founded by the famous French pedagogue, Freinet. He was an important pioneer of student-centred pedagogy which was promoted as individualised learning (Acker, 2000; Freinet, 1990). This community was an early producer of paper resources, notably in the form of *bibliothèques de travail* (working libraries) and non-behaviourist programmed learning materials (*bandes enseignantes*). They were also among the first to start using online resources.

In contrast with the pilot CFAs network, which is subsidised by ANFA, activist communities like ICEM are not organised by an official institution and, in most cases, the resources produced are free and open. For example, Groupe Français d'Education Nouvelle (GFEN), an activist collective with the slogan *All able! All researchers! All creators!*, was similarly created during the Freinet movement (around 1920) and follows a Démarche d'Auto-Socio-Construction des savoirs (DASC; auto-socio construction of knowledge) approach, aimed at enabling students to build their own knowledge (through engaging with peers). It is organised into several thematic, geographic, and disciplinary groups.

Beauné et al. (2019) studied the way an activist collective specialised in language learning. Taking an ethnographic approach, they remarked that the modification of resources is like a goldsmith's work but that the resources themselves are not important for the collective members. What matters is the process. They state:

> Authors of resources may be compared to heroic figures who, each in her own style influence the community. This influence is however not oriented towards auto-promotion or improvements in the career. On the contrary, it seems associated with strong, quasi sacrificial values […] this commitment aims toward the development of commons of knowledge (p. 232)[6].

Sesamath is another example of an activist community evolving toward something different. Founded in 2001, Sesamath has gained influence in France by selling paper textbooks and offering free and paid-for premium online resources. Sesamath has created a trend with other associations implementing similar models.

Communities do not build themselves. We have discussed the emergence of informal online teacher collectives or proto-communities (Baron & Zablot, 2017). These collectives emerge from personal initiatives that gradually attract a nucleus of innovative colleagues who share common interests and affinities. They start modest actions to produce and diffuse resources outside established structures, generally for free, at least initially. For example, in France, some teachers create profiles on social networks, like Facebook and YouTube, to share classroom activity examples. These communities often have a limited duration and changes in their organisation frequently occur, a powerful attractor being commercial companies.

For example, Carton (2019) observed an interesting permeability between a teacher proto-community publishing resources on personal websites and a firm subsequently offering incentives to produce educational kits for the company, thus the teachers became recognised authors and received

[6]Personal translation.

both material and symbolic benefits. In this case, the relationships between participants were modest. Consequently, the teaching community is weak and dependent on the company. It is a pseudo-community.

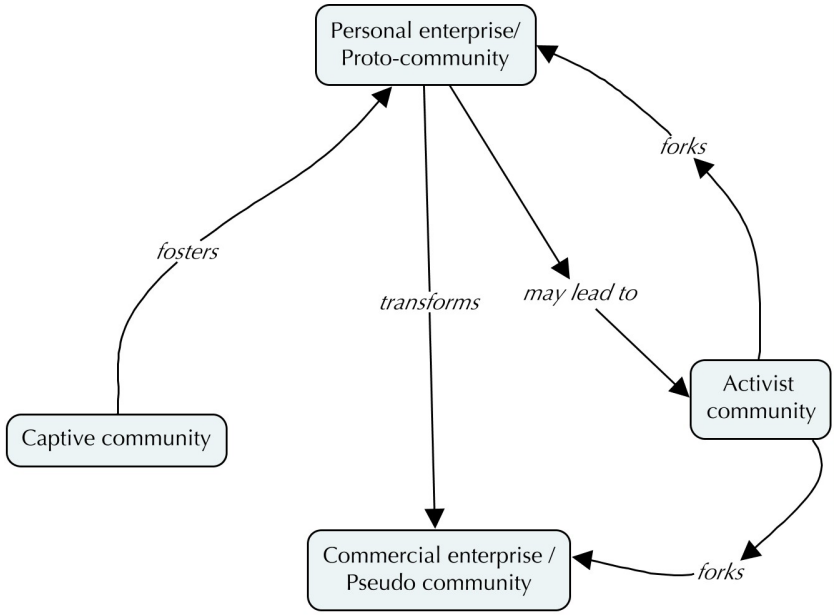
An example of a proto-community that later became a business is lelivrescolaire.fr. As of 2024, this company presented itself as a publisher founded in 2009 by a teacher interested in digital textbooks "we came up with the crazy idea of creating field textbooks, produced collaboratively by teachers and available free of charge on the internet"[7]. It claims to constitute a community producing textbooks that are written collaboratively (collaboration being for them a cardinal value), with free online access and premium solutions accessible for a fee without Internet access or on paper.

A Model of the Transformational Flux Between Different Types of Communities

Based on the analysis of captive, activist, and proto-communities, Baron and Zablot (2017) developed a model that illustrates several forms of evolutions from one type of collective to another.

Figure 1

Model of the Transformational Flux Between Different Types of Teacher Communities



Note. Baron & Zablot, 2017, p. 33.

Often splits occur within these latter activist communities with some members joining a commercial enterprise or founding another proto-community. Captive communities often play a role in training teachers, some of whom may later embark on their own projects. These new proto-communities

[7]https://www.lelivrescolaire.fr/collaboratif, consulted on 2024/11/13.

may have originated within a captive community and, as seen before, evolve. They can either dissolve into a pseudo-community or adhere to an activist community with whom they share affinities.

Social networks are changing the way teachers create new proto-communities by means of new functionalities of the Internet, and in particular, teacher activity tends to be more individual. Instagram, the social network created in 2010, is increasingly used by companies to showcase their products and/or services[8] and to facilitate commercial activity[9]. This activity, known as influence marketing, involves exploiting users' fame to sell products. Influencers promote products by creating short videos or posting photographs on their social media feeds[10].

Another type of economic activity exists, that of a content creator. However, differences between the terms content creator and influencer are not clear. In French law (2023), the two terms were grouped together under the heading *activity of commercial influence* and designate: "any natural or legal person whose activity consists, for consideration (in kind or in financial form), in creating and producing content aimed at promoting goods or services of which he is not necessarily the producer or provider, disseminated by means of digital communication, on the occasion of the expression of his personality". Content creators can be small or intermediate companies or individuals such as lifestyle coaches who have partnerships with companies to promote their products.

Zablot (2023) published preliminary research on teachers who share resources on Instagram. Zablot remarks that some primary teachers use similar strategies to influencers to promote themselves and show their practices in class (like lifestyle coaches). Zablot distinguishes three profiles—archivists, experimenters, and influencers—that reflect how these teachers organise their content and their eventual partnerships with companies:

- The first profile concerns teachers who collect and share resources they created using a website where those resources can be downloaded. There is no commercial partnership with companies[11].
- The other two profiles are hybrids: (1) teachers who may conclude commercial partnerships with companies that produce resources, but only in order to promote specific pedagogy; and (2) the motive is unclear: to have more material? to promote a pedagogy?. Some experimenters may become influencers.

In this context, proto-communities continue to emerge on this network, with the sharing of resources such as lessons and class activities ensured on teacher-designed websites. However, there are

[8] In 2023 the word *influenceur* appeared in France as a legal economic status to describe all online commercial activity in an attempt to regulate it.
[9] E.g., in 2016, Instagram developed a functionality to directly buy products online. See https://www.challenges.fr/entreprise/tech-numerique/instagram-s-aventure-dans-le-e-commerce_436355
[10] On social networks, a feed is a place where content (photos, videos) is grouped. For each content item, followers can react by adding a comment, leaving a like, or sharing the content with their own followers.
[11] In France, most teachers are civil servants of the national State. They are not allowed to have another professional activity. However, they may declare themselves as authors of textbooks or learning resources.

no signs of evolution towards a militant community. Instagram serves as a showcase: followers can collect resources by clicking on the website link created by the teacher and posted on the account.

Some teachers use their fame to capture the attention of publishing companies that produce educational resources (e.g., Nathan). The number of account followers becomes a recognised commercial element leading to authoring textbooks published by these companies. In this case, the links between teachers remain loose and social networks are used to promote personal careers, even if the motive is sharing resources.

Discussion and Perspectives

Central Issue of Teacher Agency

The findings show that teacher communities may form and innovate in a sustainable and affordable way to improve teaching by using new technological possibilities when conditions are favourable. This is *confirmation* of a well-established trend and not a new result.

In France, teacher agency is a historical fact. Most teachers have tenure, and there is a culture of public service and sharing among teachers. They must follow the national curriculum but benefit from freedom in pedagogical methods. To what extent does this finding exist elsewhere?

Fundamentally, this is a question of teacher agency, which therefore has a strong political dimension and is answered differently according to national histories. While administrations can influence textbook production, directly or indirectly, they cannot easily control the creation and usage of online resources, which depend upon global technical infrastructure.

The question of educational resources has gained a new actuality with the development of digital technology (Mochizuki & Bruillard, 2019). It is suggested that technology will allow for educational paradigm shifts, with the notion of "transformative learning", "the kind of learning that enables learners to go beyond the status quo and transform societies for the better" (p. 7). The perceived stakes are a transformation of traditional schooling methods. But which of these transformations are feasible?

Ideas about the necessity or ineluctability of de-schooling society and moving toward other forms of transmission between generations have been published since the early 1970s. Illich (1971) famously denounced the awful aspects of traditional schools and certified teachers, pleading for this disruption and advocating the need for something completely different:

> The current search for new educational funnels must be reversed into the search for their institutional inverse: educational webs which heighten the opportunity for each one to transform each moment of his living into one of learning, sharing, and caring. (p. 2)

This manifesto aroused interest but had no practical consequences: schools and school systems are remarkably homeostatic. However, the idea of learning outside the school structure has gained momentum, with renewed interest in non-formal and informal learning (Schugurensky, 2000).

Although specialists in disruptive innovation, such as Christensen et al. (2008), predicted a disruption to educational systems due to technological innovation, this has not occurred. Documents and resources for teaching and learning in different forms, economic models, and use cannot be predicted. A key question is how teachers can use, modify, design, and disseminate educational resources for their students in a creative way.

In democratic countries, one possible means of innovation is through participatory research.

Which Role for Research?

Education research holds a broad concept with many possible finalities. Among them, two are in tension: (1) evaluating educational actions to inform decision-makers and disseminate good practice and (2) understanding what is happening, identifying the main problems, and inventing possible ways to circumvent them.

Recently, we have seen some governments trying to control teachers' actions by promoting methods that have arguably been proven to work. This political trend may be tracked to the USA in the early 2000s and the seminal policies of the No Child Left Behind law launched by G.W. Bush's administration. Since then, the focus has been on school and teacher *accountability*, with unexpected consequences, like different forms of cheating in order to achieve good results in high-stake tests (Amrein-Beardsley et al., 2010).

In France, a scientific council for national education, created in 2016, clearly advocates pedagogies like direct instruction and calls for a coordination of educational research. Until now, however, it has had limited impact on teacher action. The general idea is to obtain evidence-based research *proving* the efficiency of certain educational interventions. This research is conducted from above the practitioners, who are the *subjects* being observed. The dominant interest is in what counts as a *proof* of causality, the gold standard being randomised control trials (RCTs) comparing different groups of people subjected to different treatments.

In education there has been strong criticism of policies for evaluating the efficacy of educational interventions, which Pogrow (2017) presents as a failure of effective practices policies. Among his criticisms are the fact that this research has critical flaws, such as relying on relative comparisons only, adjusted outcome scores, or considering a threshold for effect size (.2) that is too small to be easily detected.

> This methodology leads to confusion in the research and journalistic communities as to whether programs are producing actual (i.e., unadjusted, non-relative, non-normalized) improvement levels of student performance that are apparent in the real world. […] These problems provide a basis for explaining why prior iterations of implementing effective practices policies. (p. 12)

More generally, Deaton and Cartwright (2018) observe that RCT research is not very strong for inferring what works in other contexts. They remark that:

> The need for observational knowledge is one of many reasons why it is counter-productive to insist that RCTs are the gold standard or that some categories of evidence should be prioritized

> over others; these strategies leave us helpless in using RCTs beyond their original context. The results of RCTs must be integrated with other knowledge, including the practical wisdom of policymakers, if they are to be useable outside the context in which they were constructed. (p. 30)

The idea of normalising research by financing RCTs is not specific to Western countries. A report by the Global Education Evidence Advisory Panel (GEEAP, 2023), focused on the situation of low- and middle-income countries (LMICs), identifying great and bad buys based on evidence-based research. They offer a series of evaluations on educational interventions from an estimation of cost effectiveness. Their report is based on the convincing power of rigorous evaluative research considered as able to distinguish the causal effect of an intervention. Given the degree of causality established, to what extent can examples of good practice convince practitioners?

The situation is different in LMICs. Smart (2021) addresses the issue of teacher guides in the context of direct and scripted instruction. He notes that there is growing interest among international institutions and agencies to exert a greater influence on classroom practice to improve learning outcomes by prescribing how teachers should act in the light of research findings. This position has been held in LMICs and OECD countries and has been part of a long-standing debate about the merits and effects of prescribing methodology. Smart stresses that studying and developing effective teacher guides should be done in cooperation with practising teachers. He judiciously remarks that:

> A theory of change or improvement that communicates to teachers that policymakers have no confidence in them is unlikely to win over those on whom the policymaker counts most to make the improvements happen. (Smart, 2021, p. 18)

Whatever the technological advances, teachers will continue to instruct new generations.

The persuasive power of evidence-based research for practitioners is another key issue. Nelson (2021) remarks that evidence collected about the institution established by the G.W. Bush administration, the WWC, showed that it struggled to reach its intended users, and for those it did reach, its outputs were likely perceived as irrelevant.

A similar finding was published by Riordan (2023) based on a substantial British empirical study of policies designed to improve educational outcomes of students facing socio-economic disadvantages. Riordan remarks that "the determination to base school practice on research and the political motivation to improve social mobility—are failing to deliver their intended consequences" (p. 5).

The question of proving and disseminating these research results, and the process of constructing research questions, remains open. Research approaches that consider elements of a particular situation exist. It is important to consideration that their conceptual orientations are fruitful when served by an adapted methodology, and that each methodology has its own limitations. For instance, questionnaires administered only once are insufficient for explaining processes; and external analyses of textbook and resource collections without studying their implementation are also partial. While participatory research may bring interesting results and inspire practitioners, it cannot be generalised or replicated. These limitations may not be important when the aim is not to predict outcomes or establish guidelines, but

rather to understand the changes occurring in groups operating in areas where new forms of teaching expertise are being built, and where individuals collaborate to produce shared resources.

Sharing experience online goes beyond merely sharing resources. Through social networks, teachers may become a resource for younger colleagues, thus improving the profession's global agentivity. Baron and Fluckiger (2021) argue that developing multidisciplinary and multi-cultural forums for practitioner and researcher exchange to consolidate networks of diverse communities with a shared interest is important for forming sustainable hybrid collectives. While not an easy task and will not guarantee the sustainability of innovations in OERs, it will allow interesting ideas to be explored.

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Authors

Georges-Louis Baron is professor emeritus of education at Université Paris Cité. He has published on educational technology and its history, as well as, on the didactic issues involved in teaching computer and digital skills, especially in elementary school. His current research focus is on new forms of learning linked to peer cooperation around social networks. *Email*: Georges-louis.baron@u-paris.fr

Solène Zablot is associate professor of education at the university of Caen Normandie. Having studied the use of digital resources by vocational training teacher collectives for her PhD, she is now investigating how students and teachers use social networks for non-formal learning.
Email: solene.zablot@gmail.com

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Navigating the HyFlex Horizon: Uncovering Successes and Hurdles in HyFlex Undergraduate Education

Naviguer dans l'horizon comodal : découvrir les réussites et les obstacles de l'enseignement comodal au premier cycle

Laura Morrison, *Ontario Tech University, Canada*
Robin Kay, *Ontario Tech University, Canada*
Alison Mann, *Ontario Tech University, Canada*
Diane Tepylo, *Ontario Tech University, Canada*
Hannah Atkinson, *Ontario Tech University, Canada*
Iain Brodie, *Ontario Tech University, Canada*

Abstract

Since the COVID-19 pandemic, the demand for flexible, online learning models has increased in postsecondary education. The HyFlex approach, where students can attend class online or in-person, has emerged as one popular option. However, there remains limited research on implementing HyFlex in non-lecture undergraduate learning environments. This study investigated the affordances and challenges of HyFlex in non-lecture settings through the lens of the Community of Inquiry framework. Using a participatory action research design, data were collected from instructor-researcher field notes, video debriefs, and student interviews. A thematic analysis revealed that flexibility is the main affordance of the HyFlex model. Significant challenges emerged with attaining mode neutrality and managing technological issues related to audio and video quality. Practical implications include providing institutional support in the form of enhanced technical infrastructure and training for instructors. Limitations to the study include a small sample size, demographic homogeneity, self-report data, and a limited focus on learning outcomes. Future research approaches are offered to address challenges in HyFlex design.

Keywords: higher education, hybrid, HyFlex, online learning, technology

Résumé

Depuis la pandémie de la COVID-19, la demande de formules d'apprentissage flexibles et en ligne a augmenté dans l'enseignement postsecondaire. L'approche comodale, où les étudiantes et étudiants peuvent assister aux cours en ligne ou en personne, est devenue une option populaire. Cependant, les recherches sur la mise en œuvre de cours comodaux non magistraux dans des environnements d'apprentissage de premier cycle restent limitées. Cette étude a examiné les avantages et les défis du comodal dans des contextes autres que les cours magistraux à travers le cadre de la communauté d'enquête. En utilisant une méthodologie de recherche-action participative, les données ont été recueillies à partir de notes de terrain de l'enseignant-chercheur, de comptes rendus vidéo et d'entretiens avec les étudiantes et étudiants. Une analyse thématique a révélé que la flexibilité est le principal avantage de la formule comodale. Des défis considérables ont émergé, notamment la neutralité des modalités et la gestion des problèmes techniques liés à la qualité audio et vidéo. Les implications pratiques incluent le soutien institutionnel sous forme d'infrastructures techniques améliorées et de formation pour les enseignantes et enseignants. Les limites de l'étude comprennent la petite taille de l'échantillon, l'homogénéité démographique, les données autodéclarées et une attention limitée portée aux résultats d'apprentissage. Des approches de recherche futures sont proposées pour relever les défis liés à la conception des formules comodales.

Mots-clés : enseignement supérieur, hybride, comodal, apprentissage en ligne, technologie

Introduction

In March 2020, education systems worldwide shifted to online learning, adopting what is now known as "pandemic pedagogy" (Barbour et al., 2020, p. 17). During this crisis, educators prioritized moving classes online over focusing on informed design and equitable access. Barbour et al. foresaw the post-pandemic "new normal" (2020, p. 12), suggesting that online learning adaptation would surpass pre-pandemic levels, requiring a more robust and flexible online infrastructure to support students.

Demand for online learning has increased markedly in postsecondary education (Coffey, 2023), with students favouring flexible learning options (Kohnke & Moorhouse, 2021). Higher education has moved past emergency remote teaching, offering more effective online practices and increased learning flexibility. The HyFlex model has gained popularity because it offers flexibility (Lightner & Lightner-Laws, 2024; Zitter, 2021), allowing students to choose how they participate in class—in-person, synchronously online, or asynchronously (Chen & Lai, 2024; Mahande et al., 2024). While HyFlex is relatively new to higher education (Beatty, 2019), it aligns with the global need for resilient, adaptable education systems (Homer-Dixon & Rockström, 2022; OECD, 2018).

Key benefits of a HyFlex model are its flexibility related to diverse needs and student control over their learning environment (Binnewies & Wang, 2019; Howell, 2022). Key challenges include maintaining motivation and self-regulation (Badiozaman et al., 2024; Howell, 2022), ensuring students in-person and online receive equitable learning experiences (O'Ceallaigh et al., 2023), managing

technical challenges (Gedera, 2023), and implementing effective pedagogical strategies (Howell et al., 2023).

Five gaps in HyFlex research include exploring pedagogical strategies (Howell et al., 2023), addressing technological challenges (Howell, 2022), understanding social dimensions (Shek et al., 2022), the absence of ongoing assessment (Magana et al., 2022), and examining the type and quality of support. Most HyFlex classes are lecture-based, involving passive delivery of information in-person or online (O'Ceallaigh et al., 2023). Limited research has been conducted on how HyFlex works in non-lecture-based classes with active, collaborative learning strategies. Furthermore, researchers have not thoroughly analyzed the technological challenges in HyFlex classrooms or how to address them (Howell, 2022). The social dimensions and developing community in HyFlex environments also require further exploration (Shek et al., 2022). Moreover, most HyFlex studies implement end-of-term surveys (Magana et al., 2022), and ongoing assessment of the HyFlex model throughout the semester might provide a deeper understanding of the process. Finally, while researchers recognize the value of support in HyFlex learning environments (Beatty, 2019; Romero-Hall & Ripine, 2021), limited attention has been devoted to understanding the required type and quality of support.

To address these research gaps, we designed and evaluated HyFlex courses that maximized student interaction and minimized passive lectures. Participatory action research (PAR) and design-based research (DBR) approaches were employed to understand the affordances and constraints of HyFlex learning. In addition, the Community of Inquiry (CoI) framework (Garrison et al., 1999) was used to help understand the social dynamics of HyFlex classrooms. Data were collected in four courses over two semesters to help understand the longer-term impact of HyFlex and how perspectives might change over time. Finally, a systematic support network in the design of the HyFlex classrooms was integrated. This study, therefore, analyzes the affordances and challenges encountered in non-lecture-based and constructivist HyFlex classrooms, focusing on pedagogical, technical, social, and support issues over two semesters.

Literature Review

Flexibility

Student demographics in higher education are complex, where work and family responsibilities pose a challenge to attending class in-person (Bower et al., 2015; Cumming et al., 2024b). The HyFlex model offers a flexible alternative to traditional, in-person instruction (Chen & Lai, 2024; Cheng, 2023; Cumming et al., 2024b). Students can choose in-person or online formats based on their various restrictions (Cheng, 2023; Cumming et al., 2024b; Kohnke & Moorhouse, 2021; Wong et al., 2023). Further, Cumming et al. (2024a) reported that higher education students could better balance studying, work, and family with the HyFlex format. Heilporn and Lakhal (2021) added that recordings of flexible synchronous sessions helped students keep pace with their classes when family or work commitments were particularly demanding. Additionally, several studies (Beatty, 2019; Binnewies & Wang, 2019; Heilporn & Lakhal, 2021; Howell, 2022) indicated that higher education students appreciated being able

to have agency over their schedules. Chen and Lai (2024) noted that the HyFlex model allows students to choose their preferred mode of learning. Finally, some evidence has suggested that the flexibility inherent in the HyFlex approach can increase enrollment (Beatty, 2019) and attendance (Cheng, 2023). However, Howell (2022) noted that some students take advantage of the choice of mode and do not attend class.

Limited research exists on the impact of flexibility specific to non-lecture-based HyFlex classrooms designed to solicit active student participation and collaboration. In a lecture-based class, there may be minimal difference between listening to a professor in-person or online. However, in an interactive and collaborative environment with extensive discussion, students attending online may be disadvantaged.

Mode Neutrality

Mode neutrality refers to students achieving comparable learning experiences regardless of the delivery mode in a HyFlex environment (Penrod, 2022; Zydney et al., 2018). Several studies have indicated that students preferred in-person to online classroom formats (Bower et al., 2015; Cumming et al., 2024b). Kohnke and Moorhouse (2021) noted that students preferred in-person teaching because they had more opportunities for social interaction. Cheng (2023) reported that in-person students receive more attention from instructors than online students.

On the other hand, several researchers have claimed that some students have better learning experiences online. For example, Butz et al. (2016) noted that online students were significantly less bored than in-person students. Romero-Hall and Vicentini (2017) observed that online students felt more comfortable responding honestly to questions because they felt less peer pressure and were more relaxed without the non-verbal cues typical in an in-person class. Kohnke and Moorhouse (2021) added that such students perceived online as better because they had more access to relevant resources and received immediate instructor feedback.

Several large-scale literature reviews have suggested that mode neutrality can be achieved in HyFlex classrooms, at least in theory. Key suggestions have included focusing on the principle of equivalency (Beatty, 2019; Howell, 2022), intentional course design (Chen & Lai, 2024; Cumming et al., 2024b), creating and designing multimodal supports (Cheng, 2023), leveraging peer interactions and the use of discipline-specific guidelines (Chen & Lai, 2024), purposeful and thoughtful use of technological tools (Wong et al., 2023), developing strong community connections (Cumming et al., 2024b), and establishing robust supports for students and faculty (Chen & Lai, 2024; Howell, 2022).

To date, limited research has focused on the impact of specific pedagogical approaches to achieve mode neutrality (Kim et al., 2014). Most HyFlex studies have not focused on pedagogy and defaulted to the lecture-based approach in traditional higher education classrooms (Chen & Lai, 2024). While several reviews noted that developing interactive HyFlex classrooms would help develop high-quality learning experiences (Chen & Lai, 2024; Cumming et al., 2024b; Wong et al., 2023), to our knowledge, no research has been conducted on establishing mode-neutrality in non-lecture-based HyFlex classrooms.

Technical Requirements

A HyFlex learning environment is highly dependent on smoothly functioning technology, including high-quality video and audio, a reliable Internet connection, a learning management system (LMS), software to share material and engage students, and devices to connect to the HyFlex classroom (Chen & Lai, 2024; Cheng, 2023; Cumming et al., 2024b; Howell, 2022; Wong et al., 2023). Problems in hardware and software components can derail a HyFlex classroom. For example, Cumming et al. (2024b) and Cheng (2023) reported that poor-quality audio and video were common and limited online student participation. Wong et al. (2023) added that unstable networks were frequently reported as challenging.

Numerous training and support issues have been identified in HyFlex environments, including instructors' limited digital proficiency (Chen & Lai, 2024; Cumming et al., 2024), lack of administrative and technical support (Li et al., 2020; Wong et al., 2023), need for training and practice in using HyFlex equipment (Abdelmalak & Parra, 2016; Howell et al., 2023), support for online students (Romero-Hall & Ripine, 2021; Wang et al., 2018), and instructor cognitive workload to address technical and student issues during class (Bower et al., 2015; Ramsey et al., 2016). These issues can undermine mode-neutrality and negatively influence the student learning experience, particularly for online students (Chan et al., 2022; Leijon & Lundgren, 2019; Raes et al., 2020).

While technological challenges and requirements have been well documented for lecture-based HyFlex classrooms, limited research has been conducted on technical requirement challenges in non-lecture-based HyFlex courses and whether these issues dissipate over time. It is conceivable that the planning and implementation of interactive HyFlex classrooms might magnify the scope and frequency of technological issues (Beatty, 2019; Chen & Lai, 2024).

Pedagogical Strategies

Planning, designing, and implementing HyFlex learning demands a significant shift in pedagogical strategies to adeptly navigate and negotiate online and in-person environments simultaneously (Bower et al., 2015; Raes et al., 2020; Zydney et al., 2018). These strategies need to address equity and alignment among online and in-person students in at least five areas: effective communication and interaction (Howell et al., 2023; Kolli et al., 2022), community building (Cheng, 2023; Cumming et al., 2024b), managing attention and social presence (Cumming et al., 2024b; Wong et al., 2023), providing adequate scaffolding and support, particularly for online students (Chen & Lai, 2024; Wong et al., 2023), and engagement (Cheng, 2023; Wong et al., 2023). Engagement is potentially difficult when an instructor uses interactive learning strategies requiring collaboration and discussion (Chen & Lai, 2024; Cumming et al., 2024b; Howell et al., 2023).

Researchers have suggested co-teaching as a viable approach to reduce the challenges of implementing these pedagogical strategies (Bower et al., 2015; Ramsey et al., 2016). In this approach, one instructor facilitates online while the other leads in-class. Divided attention is the common barrier to community-building, effective scaffolding, discussion, and increased engagement (Cumming et al., 2024b). To date, the impact of a second person on student learning has not been studied. To our

knowledge, research on pedagogical approaches and how they evolve over time in non-lecture-based HyFlex classrooms has not been studied.

Support for Instructors and Students

Instructors new to HyFlex often face high cognitive load maintaining mode neutrality, using advanced technology, and implementing new pedagogical strategies (Chan et al., 2022; Chen & Lai, 2024; Cumming et al., 2024b; Detyna et al., 2022). This extensive workload underscores the need for institutional support, professional development, and technological resources to address extensive cognitive demands (Beatty, 2019; Lightner & Lightner-Laws, 2024; Raes et al., 2020).

Institutions need to communicate precise technological requirements and expectations for HyFlex classrooms for both students and faculty (Ørngreen et al., 2015; Zydney et al., 2018). In addition, faculty training must provide dedicated resources to support pedagogical adjustments in course design, evaluation needs, and engagement strategies (Beatty, 2019; Heilporn & Lakhal, 2021; Wong et al., 2023). Finally, teaching assistants could provide critical support in HyFlex classroom implementation (Romero-Hall & Ripine, 2021; Wang et al., 2018). The role and impact of institutional support, faculty professional development, and teaching assistants have not been critically examined in non-lecture-based HyFlex classrooms.

Theoretical Framework

Previous research concerning the theory guiding HyFlex learning is limited (Howell et al., 2023). A theoretical framework for HyFlex classes must address both in-person and online formats. The Community of Inquiry (CoI) framework, developed by Garrison et al. (1999), has been widely used for analyzing asynchronous and synchronous learning and has in-person setting applications as well (Chen, 2022; Karaoglan-Yılmaz et al., 2023). The CoI consists of three interconnected elements: social presence, cognitive presence, and teaching presence (Garrison, 2016, 2024; Garrison et al., 1999).

Social presence enables participants to present themselves authentically, fostering emotional expression, open communication, and group cohesion (Garrison, 2016, 2024; Garrison et al., 1999). Cognitive presence involves constructing meaning through communication, supported by indicators such as problem recognition, exploration, integration, and resolution. Teaching presence encompasses designing and facilitating the learning experience, including content selection, activity design, and assessment. Key aspects include managing instruction, fostering understanding, and providing direct guidance on pacing, discussion, and addressing misconceptions. The CoI framework informed the design of our HyFlex classes and was used to analyze the data and discuss the findings.

Research Questions

Two research questions were addressed:

1. What affordances does a HyFlex format offer in a non-lecture learning environment using the Community of Inquiry (CoI) framework?

2. What challenges arise when implementing a HyFlex format in a non-lecture learning environment using the Community of Inquiry (CoI) framework?

Methodology

Research Design

This study followed a PAR approach, a collaborative method involving participants in all research stages to address real-world issues (Kemmis & McTaggart, 2005; McIntyre, 2008; Reason & Bradbury, 2008). The team designed, developed, and implemented a HyFlex structure for two undergraduate courses in Educational Studies spanning two semesters. Team activities included attending each other's classes, taking notes, providing technical help, and debriefing after each session to assess the format effectiveness. Before the 2023 fall term, we discussed anticipated challenges and promising practices from the literature we wanted to incorporate.

In addition to PAR, a design-based research (DBR) approach was used. This is an iterative, naturalistic research method involving an intervention (Barab & Squire, 2004). In our case, the intervention involved implementing the HyFlex structure. The collaborative and adaptive nature of DBR suited our undergraduate HyFlex classroom setting (McKenney & Reeves, 2018), and enabled us to observe the affordances and challenges of HyFlex classes over time. This offered a deeper understanding of their impact on teaching and learning.

Design-Based Research Procedure

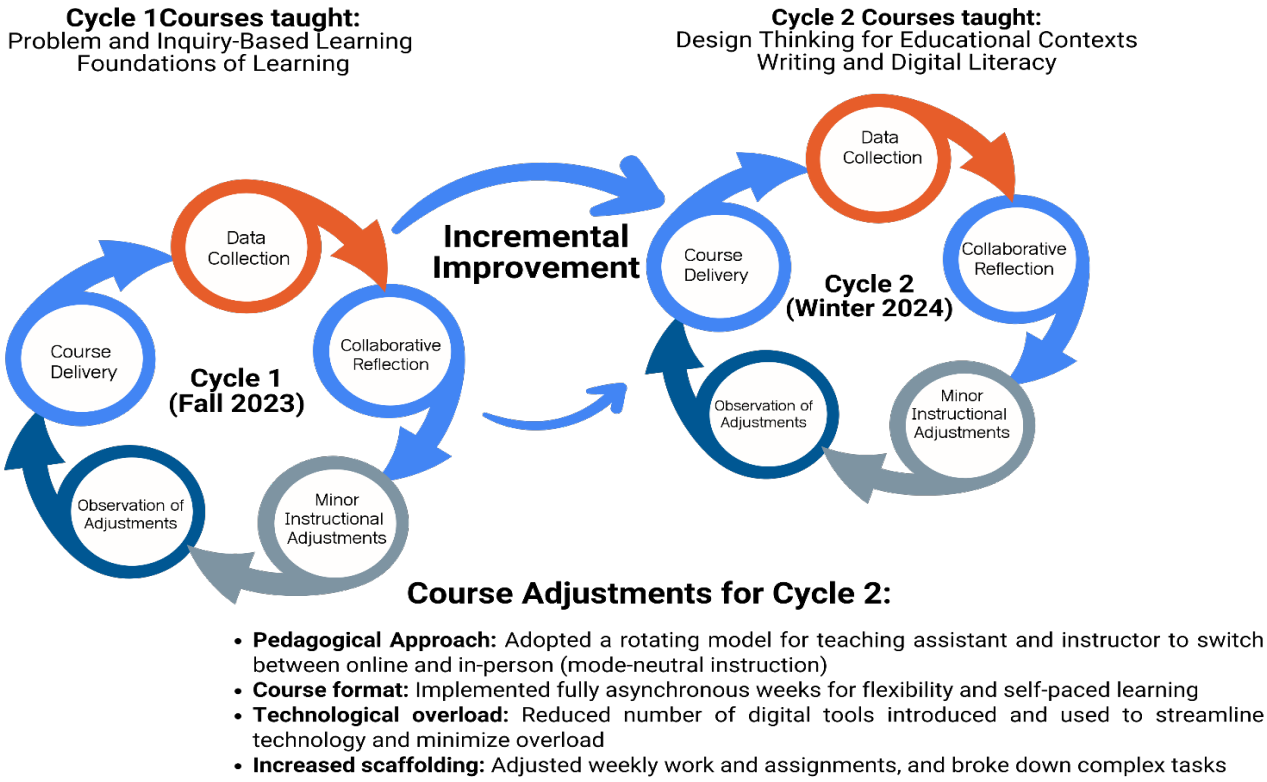
In fall 2023, the first research cycle with two required undergraduate Educational Studies courses was conducted. Enrollment ranged from 80 to 120 students. Throughout the semester, data were gathered and the team made small adjustments to the course structure, tools, and facilitation to meet classroom realities and student needs. For example, different audio input/output design options for lecture-based courses, were considered. The classroom background noise needed to be minimized and speech clarity and volume maximized to ensure that both in-person and online students could hear. We also experimented with fully separate (online and in-person) and mixed (online and in-person) student groups to encourage student engagement and community-building. We used different activities, such as chat waterfalls, inquiry-based activities, and gamification tools, to improve mode-neutrality and support collaborative knowledge-building and the three CoI presences (Garrison, 2016, 2024; Garrison et al., 1999). At the end of cycle one, the persistent issues were technological in nature, like ineffective two-way audio and insufficient video coverage of the in-person classroom, students, and instructor. These issues impacted mode-neutrality, especially for online students, which affected collaboration and community-building across modes and the development of the three CoI presences.

In winter 2024, a second cycle launched to implement changes based on challenges identified in our analysis from fall 2023. Improvements were made to move toward a mode-neutral learning environment and increase reliance on university technical support to reduce tech issues. Audio and video issues were targeted so students could easily collaborate on synchronous class activities. Also, in-person

instruction alternated between the instructor and teaching assistant (TA) each month. This change responded to online student feedback regarding reduced connection to the course instructor during synchronous sessions (teaching presence), and fully online and fully asynchronous weeks were added for broader insights connected to student engagement and cognitive presence. To support student engagement and learning (teaching and cognitive presences), technology tools were streamlined to reduce cognitive load and enhance scaffolding for weekly tasks and assignments.

Figure 1

Research Design Overview: Design-Based Research Component—Cycles 1 & 2



Course Design and Support

While most HyFlex courses use a lecture-based approach with minimal student interaction (Raes et al., 2020; Wong et al., 2023), this study employed a constructivist model. Courses were designed using a flipped classroom approach where students completed readings and self-paced activities asynchronously. Synchronous class time was used for group discussions and applied activities where students experienced teaching presence via the design and facilitation of asynchronous and synchronous learning activities. Social presence could be experienced through group activities (student groups were kept consistent) and cognitive presence experienced in both asynchronous activities, which required critical thinking, and synchronous activities, which required negotiation of ideas, critical thinking, and

knowledge application. Synchronous sessions were dedicated to collaborative activities (50%), reading reviews, and group discussion.

Previous research indicated a need for additional support in HyFlex classrooms (Beatty, 2019; Romero-Hall & Ripine, 2021). In this study, instructors received support from teaching assistants who helped facilitate and troubleshoot unexpected technical issues. Instructors also received support from our team through debriefing sessions focused on improving activities and materials. Technical support was available to manage persistent audio issues.

Participants

Participants included four students and four instructor-researchers who designed, taught, and studied the HyFlex courses. Student consent was obtained via a consent letter. Demographic data for the student (Table 1) and instructor-researcher (Table 2) participants were collected.

Table 1

Demographic Characteristics of Student Participants

Gender	Age range	Semester	Prior online educational experience
Female	Early 20s	Fall 2023	High school online courses from grades 10–12 (mix of fully online, blended, fully asynchronous and synchronous)
Female	Early 30s	Fall 2023	Two college diplomas (one completed online with a work-integrated learning model)
Male	Early 30s	Winter 2024	Online paramedic certification courses and 4 months of online undergraduate courses
Female	Late 30s	Fall 2023	Online undergraduate courses (16 months, 4 consecutive semesters)

Table 2

Demographic Characteristics of Instructor Participants

Gender	Age range	Prior teaching experience	
		In-person	Online
Female	Early 40s	12 years	10 years
Female	Early 50s	26 years	16 years
Female	Early 60s	27 years	8 years
Male	Early 60s	33 years	8 years

Data Collection and Analysis

Data were gathered from instructor-researcher field notes and debriefs throughout the semester and end-of-semester student interviews. Debriefs (10) and interviews (4) were conducted and transcribed via Zoom. Although the courses included first-year and advanced-entry students, only those with online learning experience participated in the interviews (Table 1) which were conducted by research team members not teaching the HyFlex courses that semester.

Data analysis involved qualitative deductive and inductive coding and thematic analysis (Miles et al., 2018). Focusing on HyFlex affordances and constraints, initial codes were deductive, while sub-codes emerged through multiple readings and were refined iteratively. To ensure multiple perspectives were considered and to ensure the reliability and accuracy of the findings, the key trends identified were based on themes that appear in the data across all formats and from multiple participants, i.e., debriefs, verbatim transcripts, and field notes from students and instructors. Findings and the data analysis process were based on direct quotes to support data interpretations and enable transferability. Key trends aligned with the literature included flexibility, technical issues, and pedagogical issues, e.g., disconnection, classroom support, instructor cognitive load, and mode neutrality. The final coding yielded two main themes: affordances (flexibility) and challenges (audio/video issues, mode neutrality, and classroom support).

Results and Discussion

Data analysis revealed two key themes: (a) flexibility as an affordance of HyFlex and (b) both technological and pedagogical challenges. Results are presented holistically and organized thematically without separation into iteration. Despite revising our approach between iterations, i.e., additional IT support and having the TA and instructor switch between online and in-person, similar challenges were experienced across semesters.

HyFlex Affordances

Flexibility

Flexibility is a key benefit of the HyFlex model (Beatty, 2019; Raes et al., 2020; Wong et al., 2023) and the results of this study align with the literature. In a debrief, one instructor-researcher observed that when students got sick, most opted to join online, and some expressed that “they actually like it.” Later, another instructor-researcher reported that a student attended online to avoid commuting in harsh winter weather. Additionally, an instructor-researcher noted that the flexibility to join online or in-person helped hesitant students gain confidence with online learning, reflecting that “students who were initially hesitant to go online, but who did as a result of being sick or home life commitments developed their confidence learning online and some of their tech skills.”

Student participants echoed this view of flexibility. One student noted that while she lived too far to switch modes, “a couple of … groupmates … switched if they were in the area … so that was pretty cool for them.” Despite mixed attendance, groups collaborated smoothly. Similarly, a student recounted

how a peer could join online: "They weren't able to make it into class physically, but they were able to log in on their computer." This flexibility allowed students to stay engaged and attend class in whatever capacity they were able to, offering students a low-stakes way to experience online learning.

HyFlex Challenges

The HyFlex format included both technological and pedagogical challenges. Technological challenges such as audio and video issues remained consistent in both semesters, regardless of increased IT support. After various testing, challenges with the audio and video system (inconsistent two-way audio with no ambient-noise filter and static video cameras without the ability to follow or focus on the speaker) remained unresolved with no viable solution. Pedagogical challenges included issues related to a mode-neutral student experience and the need for classroom support.

Audio Technical Issues

Audio issues were frequent and disruptive. One instructor-researcher described the situation midway through the semester:

> Back to [facilitating] in-person this week. … When I arrived, there were problems with the tech again—sound in particular. [Another instructor-researcher] and I spent 10 minutes troubleshooting the input/output sound issues and eventually had to settle for the output coming out of my computer.

This workaround proved ineffective as only students near the computer could hear online participants, forcing the instructor to mediate communication. She explained, "It became like teaching two classes at the same time because the tech didn't support a seamless integration. … It was exhausting." With only a 10-minute setup time before class, instructors often had to apply quick fixes, adding to the cognitive load in an already short 50-minute session.

Students also reported audio issues which disrupted class flow and information-sharing (Huang et al., 2017; Wang et al., 2018). Early on, a student noted that "if people would ask questions in class … you couldn't hear [the in-person students] online. … [The instructor] would have to … try to remember to repeat the question." Another student stated that online contributions were stifled: "[The online students speaking] doesn't really happen in the HyFlex … so you're only typing in the big group … [The TA] was the one listening to people [online] and checking the chat." Many audio issues experienced in the first semester could not be resolved by the second semester. One second semester student expressed similar frustration at needing a proxy to participate: "In all the other [fully online] classes, we'd be able to raise our hand and actually talk. … But in this [HyFlex class], we would have to just type our question. And then the TA would read our question for us." This student found the disconnect especially challenging during "question periods," though communication was smoother in online breakout rooms.

These technological challenges were consistent with, but more nuanced and prominent than, the issues identified in previous research into lecture-based HyFlex classrooms (Chan et al., 2022; Gillis & Krull, 2020; Raes et al., 2020). More frequent interactions among faculty and students in a non-lecture-

based classroom appeared to be exacerbated by technological challenges. Audio issues disrupted communication and formation of a sense of community between in-person and online students, forcing instructors and TAs to act as intermediaries which added to instructor cognitive load, consumed class time, and hindered a cohesive learning environment.

Video Technical Issues

Video technology issues disrupted both student learning experiences and instructor pedagogical practices. A student noted that the camera angle weakened her connection with the instructor:

> I did suggest to the instructor having the camera on the face because previously, it was like at the back, and they were this little—I couldn't see their face. I couldn't see their expression, so that was a challenge. They tried to move it up a little bit. I still didn't—I didn't feel it to be as personal like this [student referenced the fully online Zoom setting of the interview].

Even when adjusted, the camera setup limited how connected online students felt to both the instructor and the classroom environment, an issue less prominent in fully online environments.

An instructor-researcher shared:

> I kept moving away from the podium every time I wanted to explain something in detail to the [in-person] class. I can only imagine this is really disengaging for the online folks who periodically just see a blank screen when I move out of the frame. I find it difficult being in two places at once. Today, with the sound issues, I just opted to give instructions to the two groups separately so that I could be fully with one group and then fully with the other. For example, I first gave the online group instructions [ignoring the in-person students] at the beginning of class and left [the TA] to help them and then shifted attention to the in-person people and felt free to walk around the room while giving instructions.

Due to technology constraints, the instructor taught each group separately, which was exhausting and disruptive, hindering both community-building and the ability to establish teaching, social, and cognitive presences (Detyna et al., 2022; Garrison et al., 1999). A student described a limited view of the classroom:

> Something I actually always wondered in that class was, how big is this classroom? Because the [one] camera was always just up on the podium facing the professor. So, I don't know how difficult it might be, but like, even if there was a … any sort of TV that shows the … class and … another little camera that's pointing [at the instructor].

Like audio challenges, the video issues experienced were consistent with those described in previous HyFlex studies (Gillis & Krull, 2020; Leijon & Lundgren, 2019; Raes et al., 2020) and the technology configuration limited active learning approaches. Maintaining teaching and social presence was challenging because the camera could either zoom in on the instructor or show the whole class from the back (students appearing small and only visible from behind). These issues could be less problematic in lecture-based classes where instructors stayed at the front of the classroom and video was unidirectional from the instructor to students.

Pedagogical Issues: Mode-Neutrality

Although previous research (Howell, 2022; Mahande et al., 2024; Reed et al., 2008) suggests that achieving mode-neutrality can be challenging, limited detail has been offered regarding the dynamics of equality in the learning experience. Our results offer more detailed insight into the difficulties involved in achieving mode-neutrality in a non-lecture-based setting.

A student reported feeling a weak connection to the class and the instructor, especially due to the initial camera angle:

> [The course] started off at first like not feeling as personable. And then midway through the semester, [the instructor] changed the camera angle. So instead of having it like showing the entire class, [it showed her]. ... She changed it so that it was like right in front of the podium. So, I was like, ok, this is a lot better. I can, I know who she is. I got to see her face. Like I can see her expressions. So that was a lot better… [and] more helpful for me.

In this case, the video was limited in several ways, which restricted the goal of mode-neutrality. Unfortunately, switching the camera angle also impacted the instructor's pedagogical practice (i.e., she had to remain behind the podium), which the student recognized:

> I know [the instructor] is like pretty, actually stuck to the podium. So that was pretty hard for her to move around in the course. And which I think is difficult for her because I think she is one who likes to be animated and … you can't really do that [in a HyFlex setting].

The instructor's attempt to foster community by using a wide camera angle was ineffective, as online students could only see the backs of heads, reducing their sense of connection (Garrison et al., 1999; Garrison, 2024). Adjusting the camera to focus on the instructor at the podium improved teaching presence for some online students but restricted the instructor's movement and added cognitive strain (Detyna et al., 2022).

One instructor-researcher noted in her teaching evaluations, "When I was facilitating in the in-person setting, feedback reflected that the online students did not feel prioritized and vice versa when I was facilitating from the online setting." During two fully online weeks, feedback from instructor-researchers and students indicated these sessions were smoother, with increased engagement and learning. This may have been due to the undivided attention of the instructor, clear instructions, and combined support from both the instructor and TA. As one instructor-researcher reflected:

> When you're teaching [fully] online [and] you see something happening, you can give that hint right there, [and] when you're teaching in [the HyFlex format] ... you don't necessarily see all the things going on [in] the chat and you have to sort of think about—I got people [in-person], do I—what do I mention to the whole class?

One online student felt the imbalance, observing that the professor mainly supported in-person students while the TA became a proxy instructor for online students:

> The TA would be talking to us, and the professor would be talking to the class. That always made us seem kind of separate. And even when we're doing the exercises together, at the same time, it was like the TA was dealing with us, and the professor was dealing with [them].

This student also noted a limited online community in HyFlex compared to other online classes, saying:

> I actually feel like out of all the online classes I've taken, the online community aspect of it in the HyFlex was probably the least of them all. … That's probably just because [the professor is] trying to engage students that are right in front of them.

Overall, instructor cognitive strain combined with requiring the TA to act as proxy between the online and in-person delivery introduced challenges, despite changes made to bridge gaps, i.e., changing camera angles, instructors and TA trading off in-person and online. Students observed a divide between online and in-person delivery, and consequently experienced feelings of deprioritization and disconnectedness. However, feedback from two fully online weeks indicated that being together in one space led to a smoother, more engaging experience.

Pedagogical Issues: Classroom Support

In this study, support for instructors and students was a key focus. The instructor-researcher team facilitated debriefing sessions and provided moral support by helping with troubleshooting and planning after classes, with an aim to improving session design and course materials. Additionally, IT provided technical support with the sound system which had not been tested for large group discussion-based activities.

Teaching assistant support in the classroom was critical for students. They provided immediate technical support with the LMS (Canvas), Zoom, and Google tools as well as support to navigate group sign-ups, breakout rooms, and activity instructions, while instructors focused on in-person students. One student shared that TA assistance helped "not break the flow of the class. … [The instructor] wasn't bogged down by all these little interruptions, especially since the classes are so short." Another student remarked:

> I think the TAs were a godsend. [The TA] was so quick every time. If there was a question, she answered it right away. I actually got to know [the TA] quite well because I always—I'd get her to come in a breakout room [for clarification] ... And that was an important part—having that extra set of hands to kind of—cause the chat goes and sometimes you can easily miss something but [the TA] was on everything, every single time.

Educational Implications

This study aimed to address five gaps in previous research on HyFlex learning: (a) pedagogical strategies for learning, (b) technological challenges, (c) understanding social dimensions (connectedness to peers, instructors, and the learning space), (d) the absence of ongoing assessment, and (e) examining the value of technical and teaching support. Ongoing assessment and feedback offered the opportunity to address these challenges and uncover preliminary promising practices for a non-lecture-based HyFlex

classroom. Multiple interactive strategies used in a collaborative classroom appeared to magnify the challenges experienced by instructors and students. Audio and video challenges, for example, impacted social, teaching, and cognitive presences.

While it would be premature to offer unequivocal advice based on this study alone, future HyFlex educators should consider several preliminary implications. First, non-lecture-based HyFlex classrooms are viable but require extensive planning and support. Essential technology must effectively support the HyFlex environment to help maintain teaching, social, and cognitive presences. Dedicated teaching and technology support is also highly recommended to help maintain flow.

Limitations

This study has several limitations. First, the small sample size limits the generalizability of results. Second, the demographic homogeneity of participants may not reflect the unique challenges faced by more diverse students. Third, the reliance on self-reported data may be biased as participants' reflections could be influenced by memory recall or social desirability. Finally, this study focused on instructor and student perceptions but did not assess the actual impact of HyFlex on learning outcomes.

Future Research

Based on the results and limitations of the study, the following suggestions for future research are offered: (a) continue to use longitudinal, collaborative research, but expand the sample size to include a more diverse population; (b) expand the measurement of HyFlex impact to include specific learning strategies and outcomes; (c) modify and improve the quality of support for HyFlex classrooms to reduce the impact of technological issues; (d) explore the social development and connectedness of students more deeply; and (e) investigate equity and access issues related to HyFlex learning environments.

Conclusion

As global events and technological advancements continue to reshape educational landscapes, there is an ongoing need for adaptable and research-informed pedagogical practices. This study provides insights into the opportunities and challenges of undergraduate, non-lecture-based HyFlex learning, contributing to a growing body of innovative research on flexible learning environments. Our findings suggest that a collaborative learning environment is possible in a HyFlex structure, but that careful attention is needed on design and implementation in order to support social, teaching, and cognitive presences (Garrison, 2024; Garrison et al., 1999). Our recommendations for future research support the evolution of innovative learning in higher education to ensure higher education remains flexible and responsive to change.

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Authors

Laura Morrison is an Assistant Professor in Learning Sciences at Ontario Tech University in Canada. Her research explores innovative education, AI literacy and ethics, digital literacies, and inclusive maker pedagogies. Laura has published widely, presented at 30+ conferences, and co-edits the *Journal of Digital Life and Learning*. *Email:* laura.morrison@ontariotechu.ca *ORCiD:* https://orcid.org/0000-0001-6538-7902

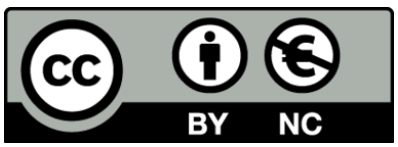
Robin Kay is a full Professor at Ontario Tech University's Faculty of Education in Canada, and has over 30 years' experience teaching computer science, mathematics, and educational technology. Author of 200+ publications, his research explores AI in education, e-learning, blended learning, video podcasts, and the emotional impact of technology on learning. *Email:* robin.kay@ontariotechu.ca *ORCiD:* https://orcid.org/0000-0003-0416-5980

Alison Mann is an Associate Teaching Professor and B.Ed. Program Director at Ontario Tech University in Canada. She specializes in online and blended learning, AI in education, and equity-driven design, with research on HyFlex and flipped classrooms. Her work bridges technology, pedagogy, and creative approaches to teacher education. *Email*: alison.mann@ontariotechu.ca *ORCiD*: https://orcid.org/0000-0003-4253-1822

Diane Tepylo is an Associate Teaching Professor at Ontario Tech University in Canada. Diane's research explores innovative education, especially inclusive teaching in mathematics and coding. An important part of this research is supporting teachers and preservice teachers to change their beliefs and practices. *Email:* diane.tepylo@ontariotechu.ca *ORCiD:* https://orcid.org/0000-0003-3289-4857

Hannah Atkinson is the Educational Technology Analyst at Ontario Tech University in Canada, and a Registered Early Childhood Educator. Hannah holds a B.A. (Hons) and an M.Ed., focusing on education and digital technology. Her research interests include digital play, HyFlex and online learning, non-disposable and alternative assessment, and educational technology.
Email: hannah.atkinson@ontariotechu.ca *ORCiD:* https://orcid.org/0009-0006-7266-4158

Iain Brodie is an Academic Associate at Ontario Tech University in Canada, and a Certified Teacher with 35 years' experience in classrooms at the elementary, postsecondary, and graduate levels. Intensely curious about learning and technology, Iain is always looking for ways to help students become lifelong and successful learners. *Email:* iain.brodie@ontariotechu.ca



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Applying the POUR Model to Enhance Digital Accessibility in HyFlex Learning Environments

Application du modèle PUCR pour améliorer l'accessibilité numérique dans les environnements d'apprentissage comodaux

Natalie Nussli, University of Teacher Education FHNW, Switzerland
Kevin Oh, University of San Francisco, USA

Abstract

The purpose of this study is to advance the accessibility of a hybrid-flexible (HyFlex) learning environment by applying the four attributes of the POUR model (WCAG 2.1, 2018), namely, *perceivable, operable, understandable,* and *robust,* to make digital learning content more accessible to all learners. The connections between the POUR principles and the principles of four frameworks instrumental to digital accessibility—Universal Design, Universal Design for Learning, Mobile Seamless Learning, and HyFlex—are discussed. The study describes one educator's journey to learn the core skills of making learning resources more accessible to undergraduate students at a teaching university in Switzerland. Qualitative data was obtained from a focus group involving three students, as well as from an external evaluator who conducted a digital accessibility check based on commonly used accessibility criteria. This revealed that the criteria were implemented with varying effectiveness. Findings from the focus group suggest that the instructor's efforts to increase digital accessibility were noticeable. Obstacles were mainly related to navigation issues and the different participation modalities integral to HyFlex. The study offers practical advice for instructors who wish to increase digital accessibility and adaptability in their courses.

Keywords: digital accessibility, digital learning, equitable learning opportunities, HyFlex, mobile seamless learning, POUR model, Universal Design for Learning

Résumé

L'objectif de cette étude est de faire avancer l'accessibilité d'un environnement d'apprentissage hybride flexible (comodal) en appliquant les quatre attributs du modèle PUCR (WCAG 2.1, 2018), c'est-à-dire, perceptible, utilisable, compréhensible et robuste afin de rendre le contenu numérique

d'apprentissage plus accessible à toutes les étudiantes et étudiants. Les liens entre les principes PUCR et les principes de quatre cadres théoriques essentiels pour l'accessibilité numérique sont examinés, à savoir la conception universelle, la conception universelle de l'apprentissage, l'apprentissage mobile sans interruption et le comodal. L'étude décrit le parcours d'une personne enseignante dans un contexte d'enseignement supérieur qui développe les compétences essentielles pour rendre les ressources d'apprentissage plus accessibles aux étudiantes et étudiants de premier cycle dans une université suisse. Les données qualitatives proviennent d'un groupe de discussion mené avec trois étudiantes et étudiants et d'un rapport d'une personne évaluatrice externe ayant effectué un test d'accessibilité numérique sur la base de critères d'accessibilité couramment utilisés. Le test d'accessibilité numérique a révélé une efficacité variable dans la mise en œuvre des critères d'accessibilité. Les conclusions du groupe de discussion indiquent que les efforts déployés par la personne enseignante pour améliorer l'accessibilité numérique ont été remarqués. Les obstacles étaient principalement liés à des problèmes de navigation et aux différentes modalités de participation inhérentes à de la formule comodale. L'étude offre des conseils pratiques aux enseignantes et enseignants qui souhaitent améliorer l'accessibilité numérique et l'adaptabilité de leurs cours.

Mots-clés : accessibilité numérique, apprentissage mobile sans interruption, apprentissage numérique, comodal, conception universelle de l'apprentissage, égalité de chances d'apprentissage, modèle PUCR

Introduction

Hybrid education environments offer numerous benefits for traditionally underserved students due to a lack of accessibility. Learners who lack access to technology or have other barriers to participation benefit from flexible access to educational resources, opportunities for interaction and collaboration, and alternative modes of participation in hybrid environments (Cumming et al., 2024). Although technology can be both an enabler and a barrier to effective instruction (Cumming et al., 2024), the increasing digitalization of learning also brings challenges for learners with diverse abilities. Examples include digital and sound or navigation elements that compete for attention on the screen, e.g., moving objects, and have been associated with cognitive overload (Marcus-Quinn & Hourigan, 2022). Similarly, poorly crafted digital materials that ignore accessibility standards limit learner engagement capacity.

Educators need to acquire new skills in designing their instruction to help reduce digital barriers and increase digital accessibility for all learners. Sanderson et al. (2022) grouped digital barriers into four main categories, i.e., perceiving; operating; understanding and language; and other barriers. Auditory and visual barriers prevent learners from hearing or seeing lectures, instructions, learning materials, and the learning environment itself. Operating barriers prevent learners from operating equipment, software, and devices. Understanding and language involve barriers to processing content, tasks, materials, and spoken or written language. Other barriers include different software, formats and devices as well as incompatibility with assistive technology (National Center on Accessible Educational Materials, 2022).

The field of online and hybrid learning would benefit from more research in instructional design that specifically addresses the unique needs of individuals with diverse abilities and that considers a broad range of learning styles and disability types during all phases of content design (Burgstahler, 2021). Familiarization with the principles and practices of web accessibility and Universal Design for Learning is critical to the effective design of accessible and inclusive digital learning environments.

Literature Review

The literature review provides a brief overview of five frameworks instrumental to digital accessibility, (1) POUR (WCAG 2.1, 2018), (2) Universal Design (Center for Universal Design, 1997), (3) Mobile-Assisted Seamless Learning (Wong & Looi, 2011), (4) Universal Design for Learning (CAST, 2024), and (5) HyFlex (Beatty, 2019). These frameworks emphasize accessibility and adaptability, highlighting the importance of inclusivity to ensure effective learner engagement. The frameworks have been researched in isolation rather than in dynamic interaction with other frameworks, with some exceptions. For example, how POUR fits into Universal Design for Learning (UDL) and Universal Design (UD) is well established (Burgstahler, 2021; Nes Begnum & Foss-Pedersen, 2017). Similarly, HyFlex is solidly anchored in UDL (Cumming et al., 2024). The Mobile-Assisted Seamless Learning (MSL) framework was chosen as an additional framework due to its focus on ubiquitous access and adaptability. Nevertheless, the research on the synergies among the five frameworks still appears to be fragmentary.

Each framework is discussed and similarities across the frameworks are mapped out. Special attention is given to digital barriers and ways to avoid them.

POUR

POUR, framed by the Web Content Accessibility Guidelines (WCAG 2.1, 2018), builds on four dimensions, 12 guidelines, and 61 success criteria. All content units, activities, supporting materials, and assignments need to be *perceivable*, *operable*, *understandable,* and *robust.* Specifically, the goal is for all learners to be able to perceive the content. It must also be operable, enabling all learners to navigate the information independently using their preferred tools. For example, the interface needs to be easily navigable using only a keyboard so that learners are not forced to "tab through a whole list of menus until they can get to the correct link" (Sanderson et al., 2022, p. 360). Content must be understandable to support comprehension through a consistent and predictable design. Content must be robust enough to work on a range of current and future technologies, including assistive technologies (National Center on Accessible Educational Materials, 2022). A working draft of WCAG 3 (2024) was published in December 2024 with similar accessibility requirements as WCAG 2 but with a different structure and broader scope.

Common barriers to accessibility are reported in Sanderson et al. (2022) whose investigation of faculty members' understanding of UD and web accessibility indicates a lack of awareness of legislation and familiarity with UD guidelines (Center for Universal Design, 1997). The 35 respondents were unfamiliar with the seven UD principles, and only one participant had knowledge of accessibility

regulations. The most observed barriers, as reported in Sanderson et al. (2022), are related to the first attribute of POUR (WCAG 2.1, 2018), namely, perceivable. Reported visual barriers include inaccessibility to learning materials, such as PDF documents, lecture slides, videos, and images in presentations, small font size, and foreground and background colours. Auditory barriers include students not being able to hear lectures, instructions, and explanations given while writing on the blackboard, sound in videos (e.g., no captions), or difficulties arising from people talking too fast (Sanderson et al., 2022). Table 1 provides an overview of POUR, its goals, and examples.

Table 1

POUR (WCAG 2.1, 2018)

Attribute	Goal	Examples
Perceivable	Perceive the content, regardless of the device or configuration.	The design communicates necessary information effectively to the user. Example of a barrier: inaccessible files or links.
Operable	Operate the controls, buttons, sliders, and menus.	Examples of barriers: unable to operate equipment, software, and devices; interface difficult to navigate using a keyboard, without a mouse or track pad; font (avoid serif-font).
Understandable	Understand the content and interface.	Design (e.g., LMS course) makes it easy and intuitive to read. Easy and predictable structure. Example of a barrier: navigation inconsistent and unpredictable.
Robust	Usable across devices, browsers, and assistive technologies.	Examples of barriers: different software, formats, and devices; lack of compatibility; unable to open content in different tools, mobiles, tablets, etc.

Note. Learning Management System (LMS)

The POUR principles are also reflected in UD as they both highlight a shared commitment to perceptible information, flexibility, and inclusivity.

Universal Design

The seven principles of UD include equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort as well as size and space for approach and use (Center for Universal Design, 1997). University students' recommendations for making online courses more accessible in alignment with UD principles include offering multiple ways to gain knowledge, such as through videos paired with printed materials, captioned videos, and text descriptions for all visuals (Burgstahler, 2021). Regarding online discussions, recommendations include defining a specific focus to each discussion question; providing guidance in how to answer the question, engaging in and guiding the discussion; and summarizing responses (University of Washington, 2019). Teachers' recommendations include content presentation using:

1. a consistent layout.
2. sans serif fonts.
3. uncluttered pages with plain backgrounds of high contrast.
4. accessible colour combinations.
5. structured headings.
6. lists using style features.
7. descriptive wording for hyperlinked text even without context.
8. avoidance of PDFs unless designed using accessibility standards.

(Burgstahler, 2021; CAST, 2024; Center for Universal Design, 1997).

Educators' knowledge of these design principles contributes to creating equitable learning opportunities (Nes Begnum & Foss-Pedersen, 2017; Sanderson et al., 2022). Some UD principles are also reflected in MSL. They both highlight ubiquitous, intuitive, and flexible knowledge access.

Mobile-Assisted Seamless Learning

Mobile-assisted seamless learning is an offshoot of mobile pedagogy and is anchored in the idea that learning should be possible anytime from anywhere and on any device. Wong and Looi (2011) have defined 10 widely cited dimensions of MSL with wireless, mobile, and ubiquitous technologies in education. The 10D-MSL encompass formal and informal learning (MSL1), personalized and social learning (MSL2), learning across time (MSL3), learning across locations (MSL4), ubiquitous knowledge access (MSL5), integration of physical and digital worlds (MSL6), combined use of multiple device types (MSL7), seamless switching between multiple learning tasks (MSL8), knowledge synthesis (MSL9), and incorporation of multiple pedagogical or learning activity models (MSL10) (p. 2367). From among the 10 dimensions, MSL3 to 5 as well as 7 and 8 are relevant to the present study. While MSL highlights ubiquitous knowledge access across time, space, and devices, UDL reinforces the importance of designing inclusive educational practices and learning experiences that cater to all learners, including those with diverse abilities.

Universal Design For Learning

Universal design for learning provides a theoretical and practical framework for designing physical and virtual learning spaces that emphasize individual strengths and challenges. The three main principles of UDL, as indicated by CAST 3.0 (2024), should be observed to remove barriers and provide equitable access to all learners. These principles entail providing multiple means of *representation, engagement, action,* and *expression*. Each principle consists of nine guidelines and checkpoints within each guideline. A total of 31 checkpoints provides specific scaffolding strategies and ideas to help educators make content and activities more comprehensible and engaging for all learners.

Many frameworks overlap with POUR (WCAG 2.1, 2018). For example, perceivable aligns with UDL's representation principle by ensuring that content is presented in multiple formats, thus catering to various sensory needs (Choi & Seo, 2024). Both principles advocate providing options for perception and ensuring that key information is equally accessible to all learners through different modalities and adjustable formats (e.g., zooming features, colour contrasts, sound amplifier to filter or augment sound, and video speed controller). Web content should include text alternatives for non-text content, similar to UDL's representation principle which advocates for diverse representation of information to cater to different learning styles (Burgstahler, 2002). Understandable (POUR) connects with UDL's engagement principle. Both strive for clear navigation and content, and predictable interfaces to create a supportive learning atmosphere that encourages participation and meaningful engagement. This atmosphere fosters learner motivation and reduces cognitive load (Choi & Seo, 2024; Cumming et al., 2024).

POUR's understandable principle overlaps with UDL's action and expression principle. Both principles call for comprehension options by designing and presenting information that scaffolds learners' access to knowledge. For example, learners with dyslexia might benefit from text-to-speech software as a compensatory tool. It has been shown that text-to-speech software helps improve reading speed, fluency, and content retention, which, in turn, increases students' self-efficacy in reading abilities, motivation, and autonomous learning (Raffoul & Jaber, 2023). The UDL action and expression principle also corresponds with the operable (POUR) principle, emphasizing flexible learner options to demonstrate their knowledge in various ways, including assistive technology (Burgstahler, 2002). Similar to UDL, HyFlex is anchored in pedagogical flexibility. Both frameworks complement each other to enhance inclusivity, accessibility, and adaptability.

HyFlex

Beatty (2019) is credited for the popular HyFlex course design approach. *Hybrid* refers to multimodal courses delivered synchronously to online and on-site students. *Flexible* refers to students' choice of participation mode. HyFlex is anchored in four principles, i.e., accessibility, learner choice, equivalency, and reusability. *Accessibility* means that students must have equitable access to all resources and activities to ensure that everyone can interact with the content, their peers, and the tutor. *Learner choice* means that students may choose between participation modes (i.e., on-site, remote synchronous, asynchronous, or offline) for any one session. *Equivalency* means that the learning activities in all participation modes should lead to equivalent learning. *Reusability* means capturing learning artifacts produced by all students, regardless of their participation mode. HyFlex requires that all content, activities, and supporting materials be prepared for multiple participation modes.

Accessibility Principles and Connections

There are clear overlaps between these frameworks. However, there is a lack of systematic research mapping the principles of the five frameworks against each other. Figure 1 provides an overview of accessibility principles. Colours indicate related principles.

Figure 1

Accessibility Principles and Frameworks

POUR (WACG 2.1, 2018)	UD (Center for UD in Education, 1997)	MSL (Wong & Looi, 2011)	UDL (CAST, 2024)	HyFlex (Beatty, 2019)
Perceivable	Equitable use	Learning across time (MSL3)	Multiple means of representation	Learner choice
Operable	Flexibility in use	Learning across locations (MSL4)	Multiple means of action & expression	Accessibility
Understandable	Simple & intuitive use	Ubiquitous knowledge access (MSL5)	Multiple means of engagement	Reusability
Robust	Perceptible information	Combined use of multiple device types (MSL7)		Equivalence
	Tolerance for error Low physical effort Size and space for approach & use	Seamless switching between multiple learning tasks (MSL8)		

Note. Light grey shading indicates all perception-related principles. Dark grey indicates compatibility-related principles. Darker blue refers to flexibility-related principles. Light blue refers to principles related to understanding and usability. UD=Universal Design, MSL=Mobile Assisted Seamless Learning, UDL=Universal Design for Learning, HyFlex=Hybrid-Flexible.

Several principles and guidelines are related to *perception.* Perceivable (POUR) overlaps with perceptible information (UD) and multiple means of representation (UDL). It also connects with MSL8 because seamless switching is only feasible if the transitions among tasks are perceivable or if activities are properly linked. Several principles and guidelines are related to *accessibility across devices* and *tools.* MSL7 overlaps with operable (POUR) in that users must be able to operate equipment, software, and devices to access content, and it corresponds to robust (POUR) in that content must be usable across devices, browsers, and assistive technologies. Several principles and guidelines are related to *flexibility* and *choice,* namely, flexibility in use (UD) and accessibility (HyFlex). These overlap in that the content must be available and accessible for all learners regardless of their participation mode, location, and time. Flexibility in use (UD) overlaps with UDL's action and expression as well as engagement principles. Finally, two principles refer to *understanding* and usability, namely, understandable (POUR) and simple and intuitive use (UD).

Increased awareness of these principles and synergies across the five frameworks supports educators in the intentional design of accessible and adaptable learning environments. Familiarity with these principles also helps to avoid common accessibility errors.

Common Accessibility Errors

McCann and Peacock (2021) report accessibility errors found on the academic library websites of 122 universities. The most overwhelmingly common errors were contrast errors, i.e., the lack of contrast between the text and background colours. The next most common errors were (a) empty links, i.e., links or linked images without associated clickable text; (b) empty headings and missing alternative text; and (c) HTML heading tags without text caused by users trying to insert extra space. According to warnings detected by the Web Accessibility Evaluation Tool (WAVE, 2024), redundant links were the most common accessibility errors, followed by redundant titles, small text, broken same-page links, and underlined text. Links are redundant when two or more adjacent links go to the same location, thus creating extraneous repetition. If both the website image and the following text caption are hyperlinked, they are redundant. Underlined text should only be used for hyperlinks. If text is underlined without a link, WAVE will generate a warning. McCann and Peacock (2021) recommend seeking user input, such as focus groups, on a regular basis to establish institutional best practices.

The reviewed frameworks, along with their principles and guidelines, provide the basis for the implementation of accessible and inclusive practices. Understanding the various principles of web and design enables educators to reduce digital barriers and support inclusive education.

Purpose

The study is framed by the following research question: What are students' perceptions of the digital accessibility of one specific course?

Methodology

Context

With the advent of hybrid teaching, instructional design processes have become more complex. Increasing accessibility during the design process goes beyond "meeting minimum requirements and adding additional functionality for learners with disabilities" (Choi et al., 2024, p. 8). Particularly in HyFlex, each participation mode needs to be considered individually, with students' diverse needs and capacities in mind (Marcus-Quinn & Hourigan, 2022).

Participants

In line with the recommendation by McCann and Peacock (2021) to seek user input through a focus group, the instructor posted a call for participation in a focus group called "Increasing Digital Accessibility & Removing Barriers", including pre-service primary education teachers. The call informed them about the purpose and the type of questions that they were going to discuss:

- How would you evaluate the digital accessibility of our course?
- How would you evaluate the usability of the content and activities?
- Were there any barriers to accessibility, and what kind of issues did you experience?

Three undergraduate student volunteers (1 female and 2 male) in their third and fourth year, respectively, participated in the focus group.

Procedures

The Moodle course materials were reviewed and revised prior to the semester. Table 2 shows the instructor's implemented changes making the content more *perceivable,* with a few changes regarding the POUR attributes *understandable* and *operable*, and no changes regarding *robust.*

Table 2

Adjustments to Course Materials for POUR Attributes

Area	Changes	POUR
Headings	Consistent heading formats (e.g., heading 1, font increased from 16 to 20; heading 2, font increased from 13 to 16).	Perceivable Understandable
Font	Increase font size from 11 to 12.	Perceivable
	Change font from serif to sans serif.	Operable
	Remove all italics.	
URLs	Change font colour of URLs to blue and use underline.	Perceivable
	Add QR code for video links.	Operable
Images	Add ALT text to each picture and figure.	Perceivable
	Increase size of all pictures and figures.	Perceivable
	Hyperlink each key visual for download via the Microsoft Teams folder.	Operable
	Redesign visuals from scratch.	Perceivable
	Remove grey background shading.	Perceivable
Colours	Replace pastel colours, orange, green, and light blue with contrast-rich colours.	Perceivable
	Replace multi-colour visuals with white, dark blue, black, white, and bold font.	Perceivable
Videos	Create videos with captions.	Perceivable
	Record 5-minute video introductions for each research article.	Understandable
PDFs	Avoid PDFs.	Perceivable
	Convert content from PDF and WORD files into Moodle *Page* format to provide flexible zooming options.	Perceivable
	Replace PDFs by WORD files.	Perceivable

Several changes were informed by the principles of graphic design (Reyna et al., 2018). The following features were activated in Moodle. The *mark as done* button was enabled for mandatory deliverables to help students track their activity and progress. The instructor demonstrated the collapse and expanded view function during class. In the expanded view, the large number of files and activities could overwhelm students, potentially leading to disengagement due to the chaotic presentation (Reyna et al., 2018). To address this, the instructor applied the concept of proximity by grouping related activities and materials, helping students perceive them as connected (Reyna et al., 2018). Additionally, the instructor enhanced comprehension by adding purposeful visuals and removing those that failed to serve a specific purpose (Reyna et al., 2018).

Infographics and posters (e.g., Visme) were created to bundle information coupled with visuals and zooming features. Figure 2 shows a Visme example with purposefully selected colours, colour contrasts, zooming features, a timing tool, and presenter pointer options.

Figure 2

Example of a Visualization in Visme

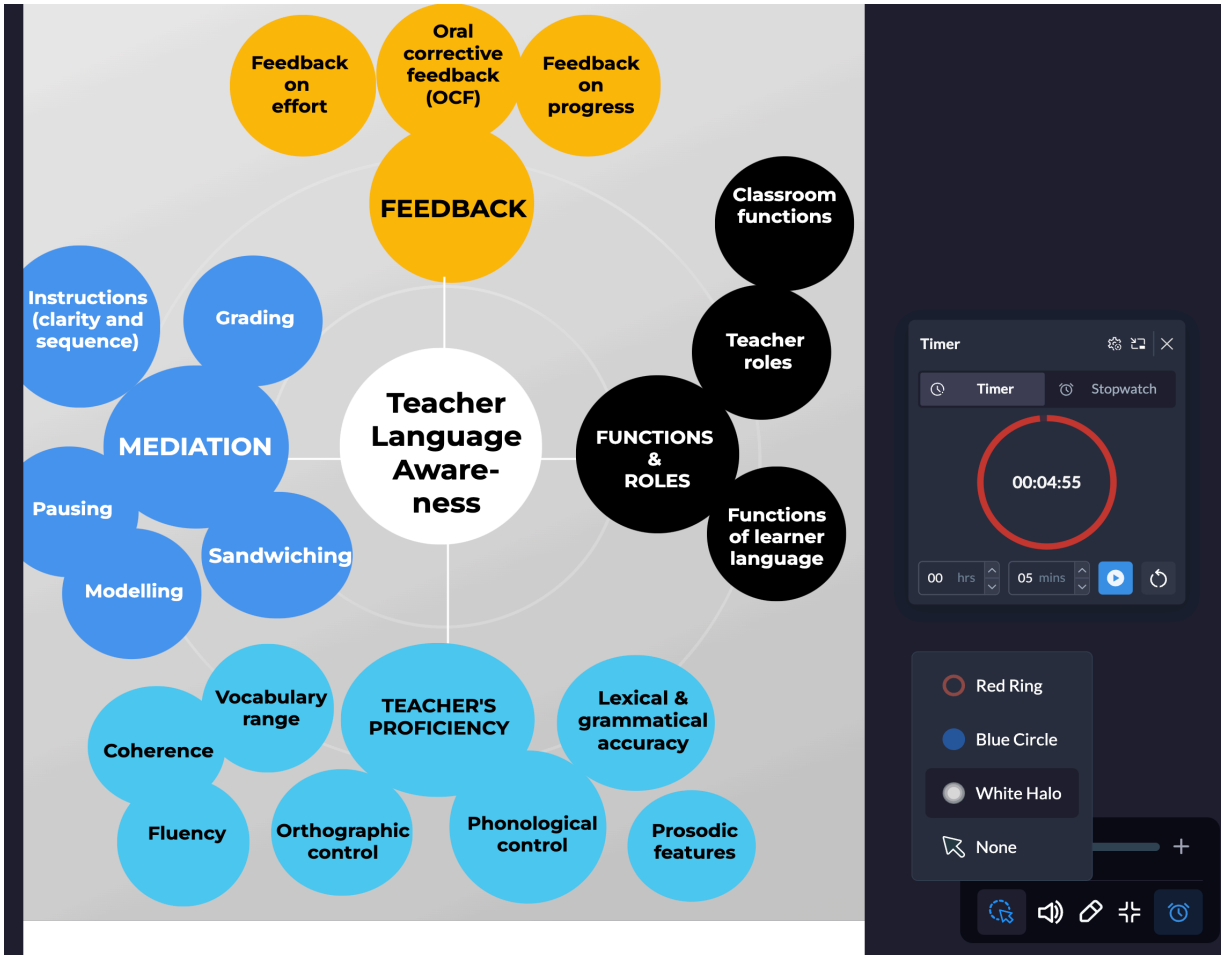


Figure 3 displays an example of grouping activities and materials in Moodle. A folder with eight storybooks, a zoomable and downloadable visual, and two video URLs along with written instructions were placed into a single Moodle activity block with the purpose of avoiding cluttered files and to clarify the relationship among these items (Reyna et al., 2018).

Finally, a symmetrical and clean layout was chosen to create a sense of balance and stability (Reyna et al., 2018), supporting consistency and predictability in line with the understandable principle of POUR.

Figure 3

Example of a Visualization in Moodle

Data Collection

Qualitative data were gathered through a digital accessibility check and a focus group interview.

Digital Accessibility Check

In the first phase, data were gathered through a digital accessibility check of the course contents. A research assistant, serving as the external evaluator, reviewed all learning materials in the Moodle

course. In preparation for this task, the assistant was asked to read previous research (Chodock & Dolinger, 2009; Sanderson et al., 2022) to become familiar with the four POUR attributes (WCAG 2.1, 2018) and the seven UD principles (Center for Universal Design, 1997). The assistant was then introduced to and asked to complete a 13-item evaluation matrix, adopted from an existing checklist (Microassist, 2017) and supplemented by other sources (Akinyemi, 2022; Bureau for Internet Accessibility, 2022; Burgstahler, 2023). The evaluation resulted in a 6,402 word, 26-page report with 21 figures.

Focus Group

In the second phase, a focus group with three undergraduate students was conducted. The focus group prompts were grounded in theory and informed by instructional modifications made prior to the semester. Findings from phase one's digital accessibility check resulted in a revision of these prompts. Next, the instructor and research assistant welcomed the participants. Nine posters with highly visual information about designing for accessibility (UK Home Office, 2023) were posted to a flipchart next to their desks. These posters explained how services can be made for different accessibility needs. Specifically, they provide a list of dos and don'ts when designing for users with low vision, screen readers, dyslexia, hearing impairment, or anxiety, as well as users with physical, mental, or motor disabilities. For example, for users with dyslexia, text should be aligned to the left and the layout consistent. Underlining words, using italics, or writing in capitals should be avoided. Further, materials should be produced in multiple formats and frequent reminders and prompts should be provided. The three participants read the posters prior to the start of the focus group. The focus group interview lasted 46 minutes and was audio-recorded in Audacity. The audio file was transcribed in Otter.ai (2023) and resulted in 7,227 words. After the focus group, 42 screenshots of Moodle components were inserted into the transcript to illustrate the issues that were brought up during the discussion.

Data Analysis

The data were analyzed in two phases. In the first phase, the analysis of the completed evaluation was read multiple times. The evaluator's report revealed major barriers which prompted an in-depth review of the evaluator's recommendations. The key issues were determined based on their severity and frequency. This analysis informed the formulation of the focus group prompts. In the second phase, after the focus group interview, the focus group transcript was reread multiple times and supplemented with 42 figures to enhance understanding. Using the interview transcripts, connections between the key issues identified by the participants and those highlighted in the evaluator's report were identified.

Results

The results reflect the digital accessibility check using 12 criteria from the evaluation matrix, along with insights from the focus group interview with three undergraduate students.

Digital Accessibility Check

The criteria that were effectively achieved include content structure, text, images, documents and other files, adaptability, clear and specific instructions as well as a clean layout with minimal distractions. The criteria that were implemented rather ineffectively include navigation and multimedia. Depending on the course view in Moodle, with the index open or closed (i.e., in the left panel), effectiveness varied dramatically and affected navigation, hyperlinks, and predictability. Table 3 displays a summary of the evaluation matrix (Akinyemi, 2022; Bureau for Internet Accessibility, 2022; Burgstahler, 2021; Microassist, 2017) and shows how well the criteria were implemented (i.e., 2=effectively, 1=partially effectively, 0=ineffectively), including future actions to address the identified issues.

Table 3

Results of Digital Accessibility Check

Criterion	Effectiveness of implementation	Rating	Future action to address issues
Navigation	**Ineffective.** Hyperlinks and files shown differently in open index view.	0	Redesign Moodle course with index open. Add topics to weekly sections or use tile view. Shorten headers.
Content structure	**Effective,** except for a few inconsistencies regarding titles and headings.	2	Make headers more distinct. Replace bullet-point lists with numbered lists when order matters.
Hyperlinks	**Ineffective** in open index view. **Effective** with open index closed.	0 2	Make hyperlinks perceivable in open index view. Add descriptions as to what can be done with the linked file and what file type it is. Remove underscores, special symbols, dashes, parentheses, hash tags, numbers, and abbreviations in file names. Make linked images visually identifiable. Delete redundant links.
Text	**Partially effective.** Font size effective and adjustable, but issues with colour and contrast.	1	Improve colour contrast. Eliminate different shades of black and grey. Avoid pastel colours. Use white background instead of coloured background.
Images	**Partially effective.** Most images with ALT text, but ALT text fails to convey enough relevance.	1	Consistently add ALT text. Provide more precise image descriptions.

Criterion	Effectiveness of implementation	Rating	Future action to address issues
Documents and other files	**Partially effective.** WORD files logically navigable with formatted headings, proper structure, and clear hyperlinks but without image descriptions.	1	Add image descriptions in WORD files. QR codes in WORD files not paired with instructions (i.e., what to do with the code) and where it leads.
Multimedia	**Ineffective.** Several videos without captions.	0	Use videos with higher resolution and consistently provide captions or transcripts. Add short written summaries of each video.
Adaptability	**Partially effective.** Speed of videos adjustable. Content translates mostly well across devices (laptop, tablet, smartphone). PDF files accessed on smartphone: text did not reshuffle. All text in Moodle scalable.	1	Improve adaptive design and responsiveness.
Predictability	**Effective** for most students. **Ineffective** in open index view.	2 0	Address navigation issues in open index view.
Clear, specific instruction	**Partially effective.**	1	Add instructions to downloadable folders. Use bold print of key words or phrases sparingly. Label importance: mandatory, recommended, or optional.
Clean layout with minimal distraction	**Effective** in Moodle. **Partially effective** in documents.	2 1	Remove decorative images. Show collapse/expand function to students. Reduce clutter, number of files. Use short titles and short file names. Separate folders for on-site presence and synchronous remote attendance in HyFlex courses. Add tables of content in all WORD files.

Note. Rating: 2=effectively, 1=partially effectively, 0=ineffectively.

Focus Group

The students identified features that they found helpful or confusing and formulated recommendations. The most valued features included predictable features, such as using similar structures for each weekly session, highlighting the current weekly section in Moodle, and keeping navigation simple. The students valued tools that supported their workflow, such as checklist features, the mark-as-done button, blacked out bubbles for completed activities, and due dates automatically

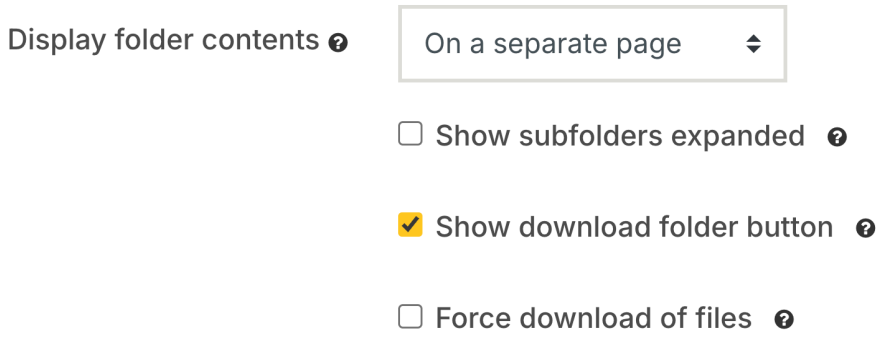
being synced with the calendar. Clear communication and precise labeling, such as *mandatory*, *recommended*, or *optional* were appreciated. These tools were particularly helpful for learners with a strong need for predictability.

The *most confusing* aspect for students was that different teachers used different Moodle designs. This took valuable time to familiarise with and potentially increased anxiety and stress levels. Therefore, focus group participants recommended a more unified, institution-wide approach to LMS course design to benefit learners experiencing stress or anxiety. A major issue was caused by the *open index* view, where most resources and information are presented differently. For example, URLs are not clearly perceivable in this view, which also prevents seamless switching between learning tasks (MSL8). Further, students mentioned feeling overwhelmed with long and multi-part task descriptions and preferred brief video instructions to supplement written instructions. On the other hand, detailed instructions with clearly formulated expectations are beneficial for all learners.

Folders containing multiple files were problematic because their purpose was unclear and the distinction between mandatory and optional tasks was not made sufficiently clear. Similarly, the purpose of several visuals was not clearly communicated, making them seem disconnected from the task. *Forced download* mode within folders was unpopular; students preferred to make download decisions themselves (Figure 4).

Figure 4

Download of Files Not Enforced



The HyFlex course format provides all content, activities, and supporting materials for multiple participation modes. However, this complicated efforts to increase digital accessibility, creating new barriers that impaired the learning experience of some on-site students. As a result, the focus group participants recommended creating three separate folders for students accessing the course: 1) onsite, 2) synchronous, and 3) asynchronous. The students expressed a desire for certain accommodations but were unaware that Moodle already offers these accessibility features. Some students, for example, may prefer to access reading materials aurally, which requires enabling the Moodle-integrated text-to-speech plug-in to be enabled.

Discussion

The focus group liked the Moodle course design and felt that digital accessibility was satisfactory and superior to other Moodle courses they had experienced. The instructor's efforts to observe basic graphic design principles (Reyna et al., 2018) had been noticed. The students were satisfied with the clean layout of the Moodle course, its clear structure, the precise and detailed instructions for each session, and the visuals if they supported meaning (Reyna et al., 2018). In contrast to the findings of Sanderson et al. (2022), the most frequently observed barrier types in the present study were not related to perceivable or understandable (POUR) issues. Instead, issues relating to poorly organised content that affected the learners' ability to engage with it echoed a finding by Marcus-Quinn and Hourigan (2022).

Other issues were related to and caused by increased flexibility. Although hybrid environments can reduce barriers by allowing flexible participation to accommodate diverse needs, the HyFlex approach of this course created new issues instead of reducing them, as Cumming et al. (2024) also found. The instructor provided access for multiple participation modalities. Additional files and activities were developed to support synchronous remote participation and bridge the physical-virtual divide during class sessions. However, this led to a significant increase in the number of files, which ultimately undermined the goal of keeping Moodle pages uncluttered (Burgstahler, 2021). The multitude of files overwhelmed the focus group participants and resulted in their disengagement. The risk of cognitive overload caused by digital elements competing for attention on the screen has been mentioned in previous research (Marcus-Quinn & Hourigan, 2022). Further, some files were only useful to the synchronous remote students resulting in confusion for on-site participants. Content presentation in hybrid learning environments needs to be carefully considered to promote universal usability across all participation modes (Beatty, 2019) without creating new barriers. Although the instructor's initial efforts to enhance digital accessibility were partially successful, more advanced training in web and design accessibility is needed.

Conclusion

The study illustrates an educator's efforts to learn the basics of digital accessibility, experience the application of the POUR principles in a HyFlex course, remove digital barriers that students with diverse abilities might encounter, and evaluate the course's digital accessibility and adaptability in collaboration with an external evaluator and three undergraduate students. It presents key elements from POUR (WCAG 2.1, 2018), UD (Center for Universal Design, 1997), MSL (Wong & Looi, 2011), UDL (CAST, 2024), and HyFlex (Beatty, 2019). Many principles are interrelated in terms of how they impact accessibility and adaptability; yet, they all offer a distinctive perspective on accessibility.

The core skills to implement the four POUR attributes can be learned in a relatively short time if the tutorial or self-paced course aligns with the instructor's technical skill level. The perceivable principle is straightforward and relatively easy to implement, especially because one can visually see how well the features have been implemented. Operable appears to be more difficult to apply because it

needs a series of test-runs on multiple devices and browsers and, most importantly, feedback from users (i.e., students, teacher colleagues). Similarly, understandable is more challenging than perceivable to implement because the instructor needs to know learners' individual needs to make pedagogically sensible adjustments. Educators need to carefully consider which accommodations are appropriate for some learners and which might benefit all learners. This requires a familiarization with POUR, as well as an understanding of how these four attributes intertwine with the principles of other frameworks that help advance digital accessibility. In addition, hybrid learning environment educators need to be aware of the HyFlex principles (Beatty, 2019) and how they can be implemented in concert with POUR.

Recommendations

It is recommended that instructors ask students in the first session about any individual learner preferences or needs to maximize their learning experience so that LMS features can be appropriately selected and learning resources adjusted, activated, or disabled. As Marcus-Quinn and Hourigan (2022) state, "accessibility, inclusion, and UDL cannot be treated as add-ons. They must be factored from the very beginning of the design process" (p. 165). For example, only learners with a visual impairment would benefit from viewing an alternate image if the original image provided is difficult for them to process. Another example would be that some students are allowed to see audio files attached to a resource (e.g., in an exam situation), whereas other learners are prevented from viewing them. Learners who experience reading and comprehension challenges may benefit from a feature that converts text to speech (Raffoul & Jaber, 2023). Educators also need to be aware that the robust principle (POUR) needs a time-consuming digital accessibility check across multiple devices to ensure the combined use of various device types (Wong & Looi, 2011). Preferably someone other than the instructor conducts the check to provide a different perspective.

Training is needed for students and educators in how to remove digital barriers and and make use of accessibility features offered by an LMS. Raffoul and Jaber (2023) highlight that the use of accommodations and assistive technology, such as text-to-speech software, demonstrates to students that there are different approaches to learning the same content (CAST, 2024). There are areas where educators can apply quick fixes, such as headings, links, ALT text, tables, colour contrast, lists, video (e.g., speed control, closed captions), audio (i.e., text-to-speech), and accessible PowerPoint slides. Mastering these core skills helps address LMS accessibility issues, with impactful quick tutorials and self-paced modules (e.g., Concordia, 2023; ETH Zurich, 2023; Northwestern, 2023) offering practical guidance. Although tools like the Brickfield Accessibility Toolkit support content checks and alternative formats in Moodle, they cannot replace human evaluation (Brickfield Education Labs, 2024). Students should be given an opportunity to share their experiences and insights on how the accessibility of a course can be improved (McCann & Peacock, 2021).

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Authors

Natalie Nussli, Ed.D., is a lecturer in English Didactics and educational researcher at the University of Teacher Education FHNW, Switzerland. With extensive experience in teacher education, her expertise encompasses digital pedagogy and culturally responsive instruction. Her research focuses on HyFlex learning environments, digital accessibility, and the intentional design of inclusive, technology-enhanced learning spaces for diverse student populations. *Email:* natalie.nussli@fhnw.ch
ORCiD: https://orcid.org/0000-0002-2411-0023

Kevin Oh is a Professor and Chair of the Learning and Instruction Department at the University of San Francisco, USA. He received his doctorate in Special Education at the University of Virginia, USA. Kevin emphasizes culturally responsive teaching and effective technology integration for in-service teachers. His work focuses on preparing educators to support high-need students with disabilities in urban schools through thoughtful curriculum design and instructional strategies. *Email:* koh2@usfca.edu
ORCiD: https://orcid.org/0000-0002-7764-5347

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Student Motivation Using Virtual Reality in Human Anatomy and Physiology Courses

Anatomie de la réalité virtuelle dans l'enseignement supérieur : Efficacité, motivation d'apprentissage et adoption institutionnelle

Avinash Thadani, *Georgian College, Canada*
Isabelle Deschamps, *Georgian College, Canada*
James Doran, *Georgian College, Canada*
Cassandra Forlani, *Georgian College, Canada*
Rob Theriault, *Georgian College, Canada*
Sean Madorin, *Georgian College, Canada*

Abstract

This study investigates student motivation using virtual reality (VR) technologies in anatomy and physiology courses. Over a two-year period, 21 college students from nursing, paramedic, and biotechnology-health programs were recruited for this study. The participants were randomly assigned to either a group using immersive VR on Quest 2 headsets or a group using desktop-based VR on personal computers. Both groups utilized VR on the health education platform 3D-Organon. The study compares the intrinsic motivation between these two groups. Four subscales of the *Intrinsic Motivation Inventory* were employed for this study. The immersive VR group was statistically significantly higher on the interest/enjoyment and perceived competence subscales. There was no significant difference between the two groups on the pressure/tension and perceived choice subscales. This study demonstrates VR's potential in boosting student motivation in human anatomy and physiology courses. Due to limited participation in pre- and post-assessment tools, content-based learning gains could not be compared. This highlights challenges in conducting VR studies in postsecondary institutions, including volunteer bias, curriculum integration barriers, student recruitment, and survey fatigue. These insights are critical for administrators and pedagogical designers when evaluating wider VR adoption in health and science education.

Keywords: 3D-Organon, human anatomy and physiology courses, motivation, nursing, technology-enhanced learning, virtual reality

Résumé

Cette étude se penche sur la perception des étudiantes et étudiants sur l'utilisation des technologies de réalité virtuelle (RV) dans des cours d'anatomie et physiologie. 21 étudiantes et étudiants issus de programmes d'études en soins infirmiers, soins paramédicaux et en biotechnologie santé ont été recrutés sur une période de deux ans pour cette étude. Les participantes et participants ont été répartis de manière aléatoire dans deux groupes : l'un utilisant la RV immersive sur des casques Quest 2, l'autre utilisant la RV sur des ordinateurs personnels. Les deux groupes ont utilisé la RV sur la plateforme d'éducation à la santé 3D-Organon. L'étude compare la motivation intrinsèque entre ces deux groupes. Quatre sous-échelles de l'Inventaire de motivation intrinsèque ont été utilisés pour cette étude. Le groupe de VR immersif a obtenu des scores statistiquement significatifs plus élevés sur les sous-échelles intérêt/ plaisir et compétence perçue. Il n'y avait pas de différence significative entre les deux groupes sur les sous-échelles pression/tension et choix perçu. Cette étude démontre le potentiel de la RV pour stimuler la motivation des étudiantes et étudiants dans les cours d'anatomie et physiologie humaines. En raison de la participation limitée en lien avec les outils d'évaluation pré et post-test, les gains d'apprentissage basés sur le contenu n'ont pas pu être comparés. Cela met en évidence les défis liés à la réalisation d'études sur la RV dans les établissements d'enseignement supérieur, notamment le biais des volontaires, les obstacles à l'intégration dans les programmes d'études, le recrutement des étudiantes et étudiants et la fatigue liée aux sondages. Ces informations sont essentielles pour les administratrices et administrateurs et les conceptrices et concepteurs pédagogiques lorsqu'ils évaluent l'adoption de la RV à plus grande échelle dans l'enseignement des sciences et de la santé.

Mots-clés: 3D-Organon, cours d'anatomie et de physiologie humaines, motivation, soins infirmiers, apprentissage assisté par la technologie, réalité virtuelle

Introduction

Virtual reality (VR) tools are revolutionizing education by offering immersive, experiential learning for students and introducing novel teaching methods for faculty. This study explores the two forms of virtual reality. *Immersive* VR uses headsets to create an immersive computer-generated simulation that enables users to engage with and explore a virtual world while disconnecting from physical reality (Lessick & Kraft, 2017). This is distinct from *desktop-based* VR, which uses a flat computer screen to display 3D objects or worlds. Both forms of VR offer students an immersive sense of presence, context, and control over their learning environment. Realistic and engaging virtual environments, such as life sciences labs, allow students to interact with and examine life-sized anatomical models, providing unique and visceral learning experiences. While the experiential learning afforded by VR can be effective, its implementation costs and efforts must be balanced against its educational benefits.

Generally, technology-enhanced learning describes the application of technology to support learning whether on campus or remotely (Sen & Leong, 2020). Technology-enhanced learning tools include learning management systems, artificial intelligence, mobile applications, social networking

applications, information visualizing tools, virtual reality, augmented reality, podcasts, gamification systems, and cloud services (Daniela et al., 2018). In recent years, due to advances in digital quality, device mobility, and the proliferation of devices and applications, immersive technologies have become particularly appealing to higher education institutions (Adnan et al., 2025; García-Robles et al., 2024; Odogwu et al., 2025).

At the participating Canadian college in Central Ontario, the integration of VR has been primarily faculty-driven, though it is now beginning to attract the attention of administrators. This cautious institutional approach reflects widespread hesitancy within large organizations toward adopting new learning modalities like VR, due to administrative reluctance, high deployment costs, and swift obsolescence of devices (Hamilton et al., 2021). Despite these challenges, the appeal of VR use in higher education is growing, attributed to its immersive learning experience, enhanced graphics, falling device costs, and utility in remote education (Angel-Urdinola et al., 2021; Cicek et al., 2021). Currently, this college has implemented VR in approximately 20 programs, focusing on cases where traditional learning experiences would be otherwise dangerous, impossible, counterproductive, or expensive, which is aligned with Bailenson's (2018) D.I.C.E. framework (as cited in Bailenson et al., 2025). The expanding use of VR in educational settings has sparked research interest.

An increasing number of studies document positive benefits of learning with VR, using a wide variation in research methods, participant demographics, subject areas, and study durations, making it difficult to state definitely how and why VR can improve learning (Hamilton et al., 2021). One factor contributing to the difficulty in assessing the impact of VR on learning is the challenge of conducting controlled studies in postsecondary educational settings, as assigning students in the same program to different treatment groups is often not feasible (Hamilton et al., 2021). Consequently, educational VR studies are often voluntary, short-term, single-exposure, and involve participants from diverse educational backgrounds (Adnan et al., 2025; García-Robles et al., 2024; Odogwu et al., 2025) and are further complicated by rapidly evolving VR technologies that can render past studies less useful for comparisons. Studies focusing on specific applications also make it challenging to distinguish between the effects of the application itself and the efficacy of the VR medium (Hamilton et al., 2021). Furthermore, ensuring consistent completion of assessment tools in VR research is difficult, affected by factors such as, lack of incentives and varying priorities of the participants. Measuring long-term knowledge retention is also challenging due to high student turnover and time constraints (Hamilton et al., 2021).

Despite research challenges, studies suggest VR enhances student enjoyment and motivation, leading to positive learning experiences (Abundez Toledo et al., 2024; Makransky & Lilleholt, 2018; Niu et al., 2025). It is important to recognize that these favourable outcomes are specific to the experiences studied and not statistically generalizable. Virtual reality has been shown to be effective for procedural training where learners must perform tasks in a specific sequence, such as in safety training, mechanical assembly, and repair procedures (Allcoat & von Mühlenen, 2018; Blumstein et al., 2020; Hamilton et al., 2021; Rainford et al., 2023). For instance, Blumstein and colleagues (2020) found that students trained in VR correctly performed 63% of fracture nailing surgical steps, compared to 25% for

those taught through a standard guide traditional methods (p. 971). In addition, some studies suggest that VR learning experiences may also increase short-term memory retention (Allcoat & von Mühlenen, 2018; Hamilton et al., 2021; Huang et al., 2019; Krokos et al., 2019). A review of the literature for this study found an absence of longitudinal studies.

Of particular interest to the current study is the fact that VR has proven useful for teaching content where students must comprehend the 3D spatial arrangements of objects (Jensen & Konradsen, 2018), especially when this is difficult to depict in two dimensions. This is highly relevant human anatomy and physiology training (Gloy et al., 2021; Liou & Chang, 2018; Maresky et al., 2019; Odogwu et al., 2025; Reymus et al., 2020; Salimi et al., 2024; Schloss et al., 2021; Zinchenko et al., 2020). Indeed, recent systematic reviews (Adnan et al., 2025; García-Robles et al., 2024; Minouei et al., 2024; Odogwu et al., 2025; Salimi et al., 2024) and empirical studies (Al-Hor et al., 2024; Hammouda et al., 2025) have documented the effectiveness of using VR in anatomy education, particularly for enhancing spatial understanding and engaging learners. For example, Niu et al. (2025) documented an increase in pre-class assessment scores for students assigned to a continuous VR group compared to a control group using traditional learning methods of 2D images and textual descriptions (p. 2). Those students using VR also reported a higher level of satisfaction.

The current study draws from the growing body of evidence supporting the potential of VR for enhancing learning and applies it to the learning of human anatomy and physiology which requires spatial understanding and medical procedural accuracy. Several related studies have investigated students' learning experiences by comparing VR with non-VR instruction in neuroanatomy (Schloss et al., 2021), human anatomy (Gloy et al., 2021), heart anatomy (Zinchenko et al., 2020), physiotherapy (Cikajlo & Potisk, 2019), root canal anatomy (Reymus et al., 2020), and biomedical instruction (Fabris et al., 2019). Previous studies have focused on various metrics, including efficacy, motivation, engagement, content retention, and learning outcomes (Adnan et al., 2025; Odogwu et al., 2025). The context for the current study was higher education instruction of human anatomy and physiology, and set out to explore how VR might enhance the learning. The goal was to compare experiences of students using immersive VR to students using desktop-based VR. The following three hypotheses were generated:

1) Students using immersive VR will report a higher level of motivation compared to students using the desktop-based VR.
2) Students using immersive VR will demonstrate a higher level of engagement compared to students using the desktop-based VR.
3) Students using immersive VR will have increased learning gains compared to students using the desktop-based VR.

Method

Participants

From January 2022 to April 2023, the study recruited 21 students enrolled in the Honours Bachelor of Science Nursing (HBSN) degree, the Primary Care Paramedic (PCP) diploma, or the Biotechnology-Health (BH) diploma programs at the participating Canadian college in Central Ontario. Among the 21 students, 17 (81%) were female and 4 (19%) were male, and their ages ranged from 18 to 44 years. To avoid coercion, students were recruited via in-class announcements from a member of the research team who did not teach in the programs. The college's research ethics board approved the study. None of the participants in the immersive VR group reported motion sickness or other adverse events (e.g., eye strain and fatigue) when returning their VR headsets following its use.

Materials

VR System and Software

The health education platform 3D-Organon VR Anatomy (Medis Media) was used as it offers both an immersive VR-headset version and a desktop-based VR version (which is in 2D). For the immersive VR group, the study software was installed on stand-alone VR headsets, called the Meta Quest 2, and each student assigned to this group took one headset home for the entire semester. Students assigned to the desktop-based VR group installed the software on their personal devices.

Research Instruments

Pre-Assessments and Post-Assessments. Two professors from the HBSN and PCP programs at the college developed a pre-assessment instrument (i.e., diagnostic quiz) focused on anatomy content in their courses. This assessment was conducted in a "Virtual Lab" within the Blackboard learning management system (LMS). These labs provide interactive lessons with instructions, learning activities, resources, and assessment tools, all accessible online. A set of course resources was created containing all research materials, including the study consent form, as well as the anatomy-focused content. The post-assessment instrument was designed to evaluate students based on their respective anatomy and physiology course final exam grades.

Mental Rotation Test. Research shows a positive link between mental rotation skills and success in anatomy learning in non-VR settings (Guillot et al., 2007: Hoyek et al., 2009). Building upon this research, Bogomolova et al. (2020) investigated that link using an interactive model of human anatomy represented in augmented reality. To control for variations in learning anatomy that might be unrelated to the primary variables of the current study (immersive and desktop-based VR formats), an online 3D mental rotation test was developed. This test was designed and hosted using the PsychoJS platform, available on Pavlovia (https://pavlovia.org/). The format of the mental rotation test was derived from Ganis and Kievit's (2015) 3D adaptation of the Shepard and Metzler objects and their experimental approach.

Intrinsic Motivation Inventory. The *Intrinsic Motivation Inventory* (IMI) is a multidimensional questionnaire intended to assess self-reported motivation and self-regulation by asking participants to use a 7-point Likert scale to respond to 45 statements, which are divided into 7 subscales (interest/enjoyment, perceived competence, effort/importance, pressure/tension, perceived choice, value/usefulness, and relatedness; Center for Self-Determination Theory [CSDT], n.d.). The Likert scale used ranged in responses from 1 (not true at all) to 7 (very true), with 4 being somewhat true. To fit a research purpose, the IMI can be modified to use a selection of subscales and alter the wording of statements (Choi et al., 2010; CSDT, n.d.; Gibbens, 2019). Various IMI subscales have been used to quantify participants' subjective experience of virtual environments (Du et al., 2020; Lloréns et al., 2015; Rivera-Flor et al., 2019; Sattar et al., 2020).

Four subscales were selected for the current study: interest/enjoyment, perceived competence, pressure/tension, and perceived choice. While the subscales of effort/importance and value/usefulness contribute to students' motivation, one assesses task relevance (i.e., effort/importance) which is not the focus of this study. The other (i.e., value/usefulness) uses fill-in-the-blanks and Likert-scale items and does not follow the same scoring procedure. The developers of the IMI attribute the following uses for these four subscales: the interest/enjoyment subscale is a self-report measure of intrinsic motivation; the subscales perceived competence and perceived choice are considered to be positive predictors of behavioural measures of intrinsic motivation; the pressure/tension subscale is a negative predictor of intrinsic motivation (CSDT, n.d., para. 1).

Students' Thoughts on Virtual Reality Questionnaire (STVRQ). The STVRQ questionnaire was developed to capture students' thoughts and opinions on VR and the implementation of VR technologies in higher education (Cicek et al., 2021). The questionnaire is composed of 27 items scored on a 5-point Likert scale intended to assess three subscales. The Likert scale used ranged in responses from 1 (not true at all) to 5 (very true) with 3 being somewhat true. The first subscale examines students perceived preference to use VR over a 2D display. The second subscale captures whether students think that VR systems can increase interest in teaching content. The third subscale captures students' opinions regarding the belief that VR in education can improve learning outcomes.

Student Engagement Log. As a measure of engagement, students were asked to complete a journal activity log to track the number of hours they spent using 3D-Organon.

Study Procedure

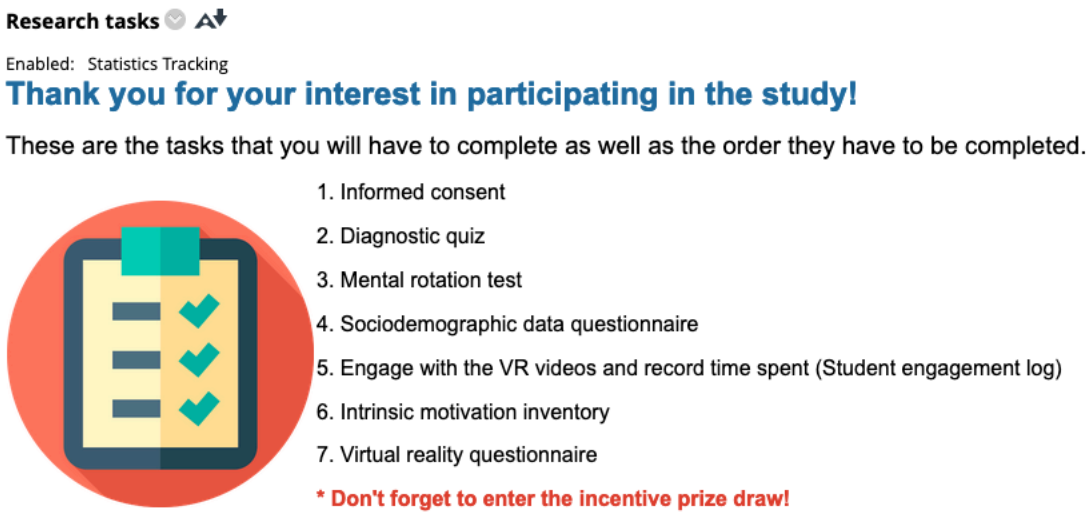
Lacking a true control group, this study employed a quasi-experimental design to compare student perceptions of immersive VR and desktop-based VR using content from 3D-Organon to learn anatomy and physiology. Students were randomly assigned to either the immersive VR or desktop-based VR group using a randomization procedure implemented in Microsoft Excel (using the =RAND() function). Ten students (n=10) were assigned to the immersive VR group, and eleven (n=11) were assigned to the desktop-based VR group. A Virtual Lab on the Blackboard LMS hosted course content and research instruments, including the consent form, the pre-assessment (i.e., diagnostic quiz), the

mental rotation test, the sociodemographic data questionnaire, the IMI, the STVRQ, and the student engagement log.

Figure 1 shows the ordered tasks that the students were asked to complete. The students were asked to complete the informed consent form, the sociodemographic data questionnaire, pre-assessment (i.e., diagnostic quiz), and the mental rotation test before engaging with 3D-Organon. At their own pace, students accessed the Virtual Lab to explore anatomy modules and then used their assigned format (either immersive or desktop-based VR) via the 3D-Organon platform. Students were asked to track their 3D-Organon usage time as an indicator of engagement. At the end of the study, they were asked to fill out the IMI questionnaire and the STVRQ. As an incentive, participants could enter a draw each semester for a new Meta QUEST 2 headset.

Figure 1

Screenshot of Virtual Lab



Results

Pre-Assessment and Mental Rotation Test

Due to the extremely low participation rates in the pre-assessment quiz (6 of 21), the mental rotation test (0 of 21), and the student engagement log (1 of 21), these three measures were excluded from all subsequent analyses. As a result, it was not possible to test the hypotheses related to engagement (hypothesis 2) and learning gains (hypothesis 3); therefore, the revised hypothesis is: Students using immersive VR will report a higher level of motivation compared to students using the desktop-based VR.

Intrinsic Motivation Inventory

To evaluate differences in motivation between the desktop-based VR and immersive VR groups, the study used Mann-Whitney U tests to analyze four IMI subscales: interest/enjoyment, perceived competence, pressure/tension, and perceived choice. In this test, medians are reported when the distributions for the immersive VR and desktop-based VR groups are similar in shape, whereas the mean rank is reported when the distributions are not similar in shape. The Mann-Whitney U tests were conducted on a final sample of 19 participants, as two participants did not complete the IMI.

Interest/Enjoyment Subscale

The distributions of scores were dissimilar between desktop-based VR and immersive VR groups. A Mann-Whitney U test indicated that interest/enjoyment was significantly higher for participants in the immersive VR group (mean rank = 12.78) than for those in the desktop-based VR group (mean rank = 7.50), with $U = 20$, z = -2.049, $p = .043$.

Perceived Competence Subscale

Again, the distributions were dissimilar. Perceived competence was significantly higher for participants in the immersive VR group (mean rank = 13.67) than for those in the desktop-based VR group (mean rank = 6.70), with $U = 12$, z = -2.704, $p = .006$.

Pressure/Tension Subscale

The distributions were dissimilar, but no significant difference was observed in IMI scores between immersive VR group (mean rank = 9.83) and desktop-based VR group (mean rank = 10.15), with $U = 46.5$, z = 0.123, $p = .905$.

Perceived Choice Subscale

The distributions of scores were similar. No significant difference was found between the median scores between the immersive VR group (mean rank = 5.60) and desktop-based VR group (mean rank = 6.00), with $U = 50.50$, z = .454, $p = .661$.

Students' Thoughts on Virtual Reality Questionnaire

To assess for variations in student perceptions of immersive VR and desktop-based VR experiences, the study compared responses using Mann-Whitney U tests across three subscales of student perceptions: preference between immersive VR and desktop-based VR, interest in teacher content, and improved learning outcomes. The Mann-Whitney U tests were conducted on a final sample of 20 participants, since one participant did not complete the questionnaire. Missing responses on a given item were automatically excluded from the analyses. Initially, no statistical differences were found between the immersive and desktop-based VR groups in each of the three subscales.

Subsequent Cronbach alpha reliability tests revealed varying levels of internal consistency. The immersive VR versus desktop-based VR subscale, comprised six statements and showed low internal consistency with a Cronbach's alpha of 0.368. The interest in teacher content subscale consisted of 10 statements and demonstrated good internal consistency with a Cronbach's alpha of 0.777. The improved

learning outcomes subscale used 11 statements, and showed low internal consistency, indicated by a Cronbach's alpha of 0.112.

The findings suggest that while the interest in teacher content subscale was reliable, the other two may require revision for improved consistency in measuring student perceptions.

In response to initial findings, a Categorical Principal Component Analysis (CATPCA) was conducted on the 27-statement questionnaire assessing student thoughts on VR. This process aimed to refine the questionnaire to provide more reliable insights into students' perceptions of VR in education. Pre-analysis checks confirmed CATPCA suitability, with the correlation matrix showing variables having at least one coefficient above 0.3. CATPCA identified four components (i.e., subscales) with eigenvalues over one, explaining 28.05% (subscale 1: immersive learning perceptions), 14.47% (subscale 2: experiential learning), 13.16% (subscale 3: learning environment), and 11.12% (subscale 4: thoughts on learning) of the total variance, cumulatively accounting for 66.8% of the variance.

Subsequently, Cronbach's alpha tests were conducted for the four new subscales: immersive learning perceptions, experiential learning, learning environment, and thoughts on learning. The immersive learning perceptions subscale, consisting of 12 statements, exhibited a high internal consistency (Cronbach's alpha = 0.889). The experiential learning subscale, comprised of five statements, showed a low consistency (Cronbach's alpha = 0.278). The learning environment subscale, initially designed with five statements showing a very low consistency (Cronbach's alpha = -0.377), was revised to be three statements with two statements being removed i.e., statement #4 "The classical evaluation system in education (e.g., exams) does not reflect the real knowledge of the respondents" and statement #9 "Through the learning process, it's necessary to apply theoretical knowledge to practical examples in order to master a new skill". The revised subscale showed a low consistency (Cronbach's alpha = 0.483). The thoughts on learning subscale consisted of five statements and showed a low consistency (Cronbach's alpha = 0.417).

Spearman's correlation was used to validate correlations within each new subscale. This analysis led to the removal of one statement from the experiential learning subscale (statement 20 with r_s =0.174, p = 0.463) and two from the thoughts on learning subscale (statement 21 with r_s = 0.360, p = 0.118; and statement 26 with r_s = 0.355, p = .125) due to a lack of significant correlation with their respective subscales. Descriptive statistics for each subscale are detailed in Tables 1—4. Each table represents one new subscale and reports the number of responses (n), along with the mode, median, and mean for each statement included in each respective subscale. While the full sample (N=20) was included in the CATPCA analysis, individual item-level data had some missing responses, resulting in a range of 19 to 20 responses per statement.

Table 1

Descriptive Statistics of STVRQ Statements that Measured Immersive Learning Perceptions

No.	Statement	*n*	Mode	Median	Mean
2	The visual stimuli provided by VR systems are fascinating to the users.	20	5	4	4.28
3	Stimulation of multiple senses leads to a better understanding of educational content (positive stimulation to the senses consequently leads to more impactful experiences and understanding of educational content).	20	4	4	4.13
7	Time passes faster for me while I consume content via VR system compared to consuming content via regular 2D displays.	20	3	3	3.18
8	Introducing VR into the classrooms turns learning into entertainment.	20	5	4	4.08
10	Due to the simulation and experience provided by VR, students will continue to explore and research the educational content.	20	5	4	4.03
11	Virtual reality develops students' creativity.	20	5	4	3.95
17	With VR, I'm not limited to passively consuming information and images displayed on the screen.	20	5	4	4.10
18	Being able to see and experience the various locations around the world within the classroom provided by VR can inspire and intrigue students.	19	5	5	4.47
23	It's difficult for me to understand abstract contents and concepts (e.g., cranial nerves) without a visual representation of the same.	20	5	4.75	4.18
24	Evaluation tailored to the individual, where certain parameters of the respondents are monitored with the help of a VR system, represents a better evaluation system.	20	4	4	3.55
25	I think that my interest in courses and educational content would be higher if interactive content and VR systems were used.	20	5	4	4.05
27	While using VR systems, students can actively learn and participate instead of passively looking at 2D displays.	20	5	4	4.08

Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 2

Descriptive Statistics of STVRQ Statements that Measured Experiential Learning

No.	Statement	*n*	Mode	Median	Mean
5	People learn better through interaction.	20	5	5	4.48
12	Unlike VR, which can provide an interactive experience, classical learning boils down to providing facts only.	20	3	3	2.65
16	With the help of VR, a student can learn how to react in certain (unknown, dangerous) situations.	20	3	4	3.80
19	Virtual environment models teach and train with the same efficiency as reality.	20	3	3	3.18

Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 3

Descriptive Statistics of STVRQ Statements that Measured Learning Environment

No.	Statement	*n*	Mode	Median	Mean
13*	While I use a VR system, I am always aware that I'm in a virtual world and that none of it is real.	20	1	2	2.05
14	The group's shared experiences in a shared environment are important.	20	4	4	4.08
15	The classical evaluation system in education (e.g., exams) reflects the real knowledge of the respondents.	20	2	3	2.73

Note. *Negatively formulated statement. Values were calculated using inverse data. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Table 4

Descriptive Statistics of STVRQ Statements that Measured Students Thoughts on Learning

No.	Statement	*n*	Mode	Median	Mean
1*	Interaction with the real people in the real world, whether they are lecturers or students, is necessary.	20	1	1	1.45
6*	Complete immersion in the virtual world frightens me.	20	5	4	3.83

No.	Statement	*n*	Mode	Median	Mean
22	In the classrooms, there should be mostly interaction between students (the professor only serves as a "guide" to the conversation).	19	3	3	2.53

Note. *Negatively formulated statement. Values were calculated using inverse data. Students' thoughts on virtual reality questionnaire (STVRQ).

The Mann-Whitney U test was conducted on the four new subscales (engagement, experiential learning, learning environment, thoughts on learning) of the STVRQ statements. Each subscale showed a dissimilar distribution of scores between the immersive VR group and the desktop-based VR group. Because of this, mean ranks were used regardless of the null hypothesis outcome. Differences between the mean ranks were determined using the exact sampling distribution for U as per Dinneen and Blakesley (1973). Each subscale showed no significant difference. The engagement subscale used an immersive VR mean rank of 11.35 and a desktop-based VR mean rank of 9.65 to generate the results $U = 41.5$, z = -0.644, $p = 0.529$. The experiential learning scale used an immersive VR mean rank of 10.45 and desktop-based VR mean rank of 10.55 to create results $U = 50.50$, z = 0.038, $p = 1.00$. The learning environment subscale used an immersive VR mean rank of 9.85 and a desktop-based VR mean rank of 11.15 to show the results of $U = 56.50$, z = 0.498, $p = 0.631$. The thoughts on learning subscale used an immersive VR mean rank of 11.30 and a desktop-based VR mean rank of 9.70 to produce the results of $U = 42.00$, z = -0.612, $p = 0.579$. These analyses were conducted on the four subscales tailored for this study using results from 22 of the 27 STVRQ statements documented in Tables 1 through 4. For completeness of reporting on the use of the STVRQ, Table 5 shows the descriptive statistics for the five excluded statements.

Table 5

Descriptive Statistics of STVRQ Statements Excluded From the Four New Subscale Analyses

No.	Statement	*n*	Mode	Median	Mean
4*	The classical evaluation system in education (e.g., exams) does not reflect the real knowledge of the respondents.	19	3	3	2.63
9	Through the learning process, it's necessary to apply theoretical knowledge to practical examples in order to master a new skill.	19	3	4	4.05
20	While I use a VR system, I feel like I am present in a virtual world.	20	4	4	3.75
21*	Using a VR system would distract students from the educational content.	20	5	4	4.03

26*	In classrooms, the professor should lead the keynote, i.e., the professor is the main source of information and interaction.	20	2	2	2.45

Note. Virtual reality (VR). Students' thoughts on virtual reality questionnaire (STVRQ).

Discussion

This study investigated students' perceptions of using VR in human anatomy and physiology education. Based on the varying completion rates of instrument use, the primary focus narrowed from three hypotheses to one hypothesis. This study tested the hypothesis that students using immersive VR will report a higher level of motivation compared to students using desktop-based VR. Students completed the IMI and STVRQ self-reporting instruments. From the results of the IMI there were two subscales of motivation that showed a statistically significant difference between the two study groups. Students in the immersive VR group reported higher levels of motivation as measured by the interest/enjoyment subscale. This result is consistent with findings from studies across various disciplines including neuroanatomy (Schloss et al., 2021), human anatomy (Gloy et al., 2021), heart anatomy (Zinchenko et al., 2020), physiotherapy instruction (Cikajlo & Potisk, 2019), root canal anatomy (Reymus et al., 2020), and biomedical instruction (Fabris et al., 2019). Students in the immersive VR group also reported higher levels of motivation as measured by the perceived competence subscale. This finding aligns with a study by Sattar et al. (2019) that documented a greater increase in both motivation and perceived competence for students in an immersive VR group. We found no significant difference in pressure/tension or perceived choice subscales between students in the immersive VR and desktop-based VR groups, indicating that students in both groups felt in control of their learning activities and did not feel pressured to use the assigned technology. Together, these results suggest that students using immersive VR found more interest and enjoyment in learning and felt more competent in their academic performance than their counterparts using desktop-based VR, which are key behavioural predictors of intrinsic motivation (CSDT, n.d., para. 1). The findings of this study align with previous research on the use of VR in anatomy education, suggesting that VR may be a useful tool to support student learning (Adnan et al., 2025; Gloy et al., 2021; Odogwu et al., 2025; Scholoss et al., 2021).

In contrast to the IMI results, the STVRQ results showed no significant differences between the immersive VR and desktop-based VR groups across its subscales. The psychometric properties of the STVRQ and the general nature of its statements require careful consideration when interpreting these null results. The survey's initial three-subscale structure proved to have a low internal reliability, necessitating a restructuring into four new subscales (engagement, experiential learning, learning environment, and thoughts on learning). While this improved the reliability for the engagement subscale ($\alpha = 0.889$), the other subscales' reliability remained low to moderate (experiential learning, $\alpha = 0.278$; learning environment, $\alpha = 0.483$; thoughts on learning, $\alpha = 0.417$) suggesting that these results should be interpreted with caution.

Additionally, the survey's statements generally asked about students' broad opinions or beliefs about VR in education, rather than the specific experiences in this study of using immersive VR or desktop VR in a human anatomy or physiology course. Given that several students likely have some familiarity with VR from non-educational contexts like gaming, it is perhaps unsurprising that no differences were found between groups based on these general attitude questions. Nevertheless, based on the overall high median scores on many items, the results do show that both groups of students reported favourable beliefs that VR can assist with learning.

Limitations

Several limitations should be considered when interpreting the findings of this study, particularly those related to sample size, data completeness, and the reliability and validity of certain research instruments. Conducting a controlled study with emerging technologies, such as VR, in a live academic setting presents numerous practical and methodological challenges, many of which were encountered in this project.

Volunteer Bias

This study relied on volunteers from demanding health science programs. Students who chose to participate may have already had a keen interest in VR or a positive bias towards new technologies, while non-volunteers during classroom visits cited the additional stress of participation as a deterrent. This self-selection process may skew the sample towards students predisposed to having a positive experience.

Participant Compliance

Ensuring participants completed all study components proved difficult. Most critically, the low completion rate for the pre-assessment, mental rotation, and engagement log instruments prevented any analysis of learning gains or engagement levels, meaning two of the three primary hypotheses could not be evaluated. Efforts to incentivize completion, such as classroom visits and a prize draw for a Meta Quest 2 headset, were only mildly successful.

Instrument Validity

The STVRQ has not been validated prior to this study. This study showed the STVRQ has mixed internal consistency even after modification based on statistical tests. The internal consistency of this instrument undermines the validity of the findings related to student perceptions on VR. Future studies should employ or develop more robustly validated instruments to assess these constructs.

Generalizability

The study is not generalizable because it employed a small sample size. While this is a limitation, it is aligned with previous research exploring the use of VR for learning anatomy (Abundez Toledo et al., 2024; Alturkustani et al., 2025; Kim et al., 2023; Li et al., 2024; Wu et al., 2023) and contributes to the knowledge development in this area.

Technological and Human Factors

This study did not assess potential shortcomings of the 3D-Organon software itself. The specific design, usability, and features of the application could have influenced student motivation and is an aspect that warrants further investigation. Finally, the study did not systematically collect data on the potential negative side effects of VR use, such as cybersickness (e.g., dizziness or nausea), having only been informally asked when returning the VR headsets. Such factors may impact a student's experience and willingness to engage with the technology and represent an important variable for future research to consider.

Conclusion

Prior to this study, VR had been explored independently by faculty at the college, with anecdotal reports of its benefits sparking grassroots adoption and attracting the attention of institutional decision-makers. Our research aimed to rigorously investigate student perceptions of the use of VR in human anatomy and physiology courses within the college's existing semester structure. The study's primary finding is that the immersive VR group reported significantly higher intrinsic motivation, as measured by interest/enjoyment, and perceived competence compared to the desktop-based VR group over a full semester. This motivation suggests that VR has the potential to enhance nursing and paramedicine student learning experiences. These findings contribute to the growing research on implementing immersive VR in postsecondary education and may be valuable in supporting student learning experiences in health and science programs.

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Authors

Avinash Thadani obtained his PhD from the University of Toronto and is currently a professor in the Baccalaureate Nursing program at Georgian College in Ontario, Canada. His research has resulted in nearly 20 peer-reviewed scientific articles, including publications in Nature and PNAS. He is also an inventor with five USA and Canadian published patents. *Email*: Avinash.Thadani@GeorgianCollege.ca *ORCiD*: https://orcid.org/0009-0003-4067-7665

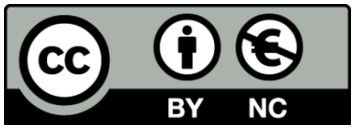
Isabelle Deschamps received her PhD from McGill University and is currently a professor in the Honours Degree in Counselling Psychology at Georgian College in Ontario, Canada. Her research bridges neuroscience with multiple applied domains, using insights into brain mechanisms of cognition and perception to better understand human behaviour. *Email*: Isabelle.Deschamps@GeorgianCollege.ca *ORCiD*: https://orcid.org/0000-0003-2128-0083

James Doran is an independent research and innovation consultant who supports private and academic organizations with project development, management, and reporting. He specializes in grant writing, community engagement, and strategic planning, helping clients secure funding and advance new ideas. His work bridges research and practice to create meaningful outcomes. *ORCiD*: https://orcid.org/0009-0008-9069-7951

Cassandra Forlani has contributed to a wide range of research initiatives, including studies on police mental health, advancing inclusion, and academic integrity. Her dedication to helping others, combined with her passion for teamwork, drives her pursuit of shaping a more promising future within her current role as a research analyst. *Email*: Cassandra.Forlani@GeorgianCollege.ca

Rob Theriault is the Immersive Technology Manager for Georgian College in Ontario, Canada, and leads the exploration and integration of XR and AI. Rob has a Master of Educational Technology from the University of British Columbia and is the recipient of the Virtual World Society's Nextant Educator Prize for global leadership in XR. *Email*: Rob.Theriault@GeorgianCollege.ca *ORCiD*: https://orcid.org/0009-0004-4029-4821

Sean Madorin is a professor at Georgian College in Ontario, Canada, with expertise in anatomy and physiology. Sean developed physiology courses that utilise data acquisition systems to provide students with rich lab-based learning experiences. Sean has developed an interest in using augmented reality tools to teach anatomy in Georgian's Biotechnology program and is eager to apply these tools along with AI to support student learning in anatomy and physiology courses. *Email*: Sean.Madorin@GeorgianCollege.ca *ORCiD*: https://orcid.org/0009-0007-2031-4129



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Community Building Through Social Annotation: Building Academic Literacies at a Distance

Création d'une communauté par le biais de l'annotation sociale : développer des compétences universitaires à distance

Jennifer Walsh Marr, *University of British Columbia, Canada*
Shihua Tan, *University of British Columbia, Canada*

Abstract

Student readiness for university study cannot be assumed; the progression to become a successful student requires support. Highlighting the implementation of purposeful, accessible, and inclusive pedagogical design, this case study explores emergent academic literacies and community building using social annotation in the context of remote teaching and learning. This study analyses first year international students' annotations in academic texts for indicators of learning and community in their asynchronous interactions with one another. Findings indicate that students were able to discern relevant aspects of meaning-making within their texts, pointing to developing academic literacies. Student threaded annotations, group work, and peer review demonstrated individual and shared learning developed over sustained engagement with one another. The study provides support for a curriculum that facilitates and supports novice scholar participation in university communities and discourses.

Keywords: academic literacies, community of inquiry, online learning, principles of inclusive pedagogy, social annotation

Résumé

On ne peut pas présumer que les étudiantes et étudiants sont prêts pour réussir ses études universitaires; leur progression pour devenir des étudiantes et étudiants performants nécessite du soutien. Cette étude de cas met en avant la mise en œuvre d'une conception pédagogique accessible et inclusive, et explore les nouvelles compétences universitaires émergentes et le développement de communauté en utilisant l'annotation sociale dans le contexte de l'enseignement et l'apprentissage à distance. Cette étude analyse les annotations d'étudiantes et étudiants internationaux de première année dans des textes universitaires afin d'identifier des indicateurs d'apprentissage et de communauté dans

leurs interactions asynchrones les uns avec les autres. Les résultats indiquent que les étudiantes et étudiants étaient capables de discerner les aspects pertinents de la création de sens dans leurs textes, ce qui indique le développement des compétences universitaires. Leurs annotations, leurs travaux de groupe et l'évaluation par les pairs ont démontré un apprentissage individuel et partagé développé grâce à un engagement soutenu les uns envers les autres. L'étude apporte un appui aux programmes d'études qui facilitent et soutiennent la participation des chercheurs débutants aux communautés et aux discours universitaires.

Mots-clés : compétences universitaires, communauté d'enquête, enseignement en ligne, principes de la pédagogie inclusive, annotation sociale

Introduction

When students begin university studies, they may need to navigate many new factors of academic life such as where to find information, how best to get through and make sense of readings, and how to engage in class discussions. These are challenges faced by students when they move from high school to university, where they study and work in their native language. These challenges are amplified for students who study in a new country and language. The shift to remote online teaching during the COVID-19 pandemic only exacerbated the difficulty for first year students to establish familiarity with academic conventions and their sense of belonging at university (van Heerden & Bharuthram, 2023). In addition to language barriers, international university students faced other challenges, such as different time zones and cultural expectations. Particularly in this context, these challenges were intensified by a lack of face-to-face interaction for acquiring cultural norms and discriminatory practices, despite the increased financial cost (Tavares, 2024).

The course described and studied is a discipline-specific language tutorial and is part of a first-year program for international students at a Canadian university. This cohort program is specifically designed for students who have gained academic entry to the university but have not achieved its English language proficiency standards for direct entry (Zappa-Hollman & Fox, 2021). This cohort of international students is separate from those first-year students who enter the university directly. They complete their year of university studies with a full course load, including an introductory academic writing course and the discipline-specific language analysis course discussed here.

In this program, course instructors draw from readings, lectures, and assessments from students' disciplinary courses to situate analyses of language in texts and tasks authentic to their studies. For example, students on the science program study how English is used in calculus, physics, earth and ocean science, and computer science. Meanwhile, students on the arts program study how English is used in subjects such as sociology, history, political science, human geography, and psychology.

The curriculum design was influenced by principles of academic literacies to make the disciplinary features of students' concomitant arts courses more visible and accessible (Lea & Street, 1998; Lillis, 2006; Nallaya et al., 2022; Wingate & Tribble, 2012). This course drew from authentic disciplinary texts to make the connections and applications explicit.

This case study investigates how an online course supported first year, multilingual, international university students by enacting Lowenthal et al.'s (2020) three principles of inclusive and accessible online teaching. Work in academic literacies (Maldoni, 2018; Nallaya et al., 2022; Wingate & Tribble, 2012) was prioritized for the course's language focus and rationale, and student social annotation of course texts is highlighted here as evidence of their academic and social engagement (Clinton-Lisell, 2023; Kalir & Garcia, 2021; Morales et al., 2022). As a sense of community and belonging are integral to student engagement and success (Walton & Cohen, 2007), ways to mitigate isolation endemic to online learning (Choo et al., 2020; Tavares, 2024), exacerbated by pandemic protocols, were investigated. The research question asks: How did social annotation and stable student groups help students develop their academic literacies and foster community in a remote teaching and learning environment?

This study uses social annotation for both pedagogy and evidence of student interactions. The course design used social annotation to have students engage in individual learning and in small groups, critically examining the meaning behind different disciplinary language and texts. For this paper, we highlight how students' annotations across the course exemplify their engagement with their nascent academic literacies and with one another.

Academic Literacies

Literacies are the means of comprehending and engaging in valued ways, varying from context to context. This acknowledges that literacy is not a monolithic concept. Specific to academia, pluralizing academic literacies further acknowledges that different disciplines have different practices indicative of knowledge bases, participants, and power differentials (Lea & Street, 1998; Nallaya et al., 2022; Wingate & Tribble, 2012). While typically represented through language, particularly in academia, multiliteracies are inclusive of other modes of meaning-making, such as sound and imagery, that are also informed by context (Kalantzis et al., 2016). The primacy of context is important, as academic literacies are firmly situated within the social construction of knowledge, gained through exposure, engagement, and participation in literacy practices. When first encountering discipline-specific practices, everyone is a novice, as each discipline has its own configuration of creating and presenting knowledge (Basset & Macnaught, 2024; Wingate & Tribble, 2012). Some proponents of academic literacies advocate for "making language visible" by specifically attending to it (Lillis, 2006, p. 34 as cited in Wingate & Tribble, 2012). This focused attention on language recognizes that mere exposure is insufficient; the ways in which language is used to make disciplinary meaning can seem opaque to novice scholars (Bond, 2020).

A focus on academic literacies emerged in response to the broadening of postsecondary enrolment (Nallaya et al., 2022; Wingate & Tribble, 2012) which was a shift away from the enrolment of mainly the elite white male traditional student who had been groomed for university throughout his schooling (Klinger & Murray, 2012). University enrolment has now expanded to include women, domestic students from different socioeconomic backgrounds, and international students. Each new cohort has different experiences and levels of knowledge and may not have had the same access to the

dominant literacy patterns of academia as traditional students. Many multilingual international students require further support to develop English language proficiency (Maldoni, 2018; Nallaya et al., 2022). However, academic literacies are not solely language based, as

> learning to write in an academic discipline is not a purely linguistic matter that can be fixed outside the discipline, but involves an understanding of how knowledge in the discipline is presented, debated and constructed. The second issue is that reading, reasoning and writing in a specific discipline is difficult for native and non-native speakers, or, in other terms, home and international students alike. (Wingate & Tribble, 2012, p. 481)

Academic literacies are fostered through social contact and the negotiation of meaning with others. This process can be facilitated through careful design and sustained practice within a learning community that provides a rich, supportive context for novice scholars to navigate disciplinary practices and establish themselves as active participants (Maldoni, 2018; Nallaya et al., 2022). This learning community benefits from accessible and inclusive teaching.

Principles of Accessible and Inclusive Teaching

In addition to developing academic literacies, a sense of belonging or "seeing oneself as socially connected" is an important component of navigating new academic contexts successfully (Walton & Cohen, 2007, p. 82). Particularly for non-traditional students, this can be fostered in learning environments that prioritize safety and respect, which engage the whole and authentic selves of participants and that establish a strong community (van Heerden & Bharuthram, 2023; Walton & Cohen, 2007). Studies show that community building can help develop problem-solving skills, communication skills, interdisciplinary learning, and critical thinking, as well as improve academic success and student retention rates (Beers et al., 2021; Nye, 2015; Smith et al., 2009). Community building in higher education is characterized by a student-centred approach that prioritizes collaborative work and active learning online or face-to-face, with benefits to students' wellbeing, belonging, and academic success (Walton & Cohen, 2007).

Lowenthal et al. (2020) foster belonging and community through inclusive and accessible teaching design manifest through three principles: (1) useable courses and content, (2) inclusive pedagogy and course design, and (3) accessible and inclusive teaching. Originally situated to compliance with the Americans with Disabilities Act, Lowenthal et al. take a bold, more inclusive stance advocating for the support of *all* learners. Furthermore, they expand this alignment with academic literacies to claim, "making learning opportunities accessible to all is not just a legal issue but ultimately an ethical issue" (2020, p. 2).

In expanding upon their first principle of usable courses and content, Lowenthal et al. (2020) argue that the learning management system must be navigable and their content accessible. In describing the second principle of inclusive pedagogy and course design, they adopt the tenets of universal design for learning (UDL): multiple means of engagement, multiple means of representation, and multiple means of action and expression (Centre for Applied Special Technology [CAST], 2018). In essence, this means providing options for learners to choose which aspects of course content to engage with (multiple

means of engagement), choice in how they engage (multiple means of representation), and flexibility in how they demonstrate their learning (multiple means of action & expression). Finally, the third principle of accessible and inclusive teaching stresses the importance of establishing instructors' teaching presence and social presence as described in the community of inquiry (CoI) framework.

The CoI framework is composed of three interconnected and interdependent presences: the social, cognitive, and teaching presences (Arbaugh et al., 2008; Choo et al., 2020; Shea & Bidjerano, 2010). Social presence refers to how members of a learning community are able to "project their personal characteristics into the community" (Garrison, 2011, p. 5, as cited in Lower, 2022, p. 511). Components of social presence include students' sense of belonging, participation in a trusting environment, and personal and affective relationships (Choo et al., 2020; Lower, 2022). Online courses can present challenges for social presence due to isolation from the instructor and other students, and a lack of meaningful social interaction (Choo et al., 2020; Tavares, 2024). An online community that fosters a sense of belonging among students helps decrease social isolation (Choo et al., 2020). Cognitive presence is seen in the ability of CoI participants to co-construct knowledge and meaning through ongoing engagement with one another (Garrison et al. 2001). This presence is closely related to the process and outcomes of critical thinking (Garrison et al. 2001; Lower, 2022). In this study, we readily acknowledge we are merely making connections to these principles in the course design and uptake, not formally measuring them with tested CoI measurement tools (Arbaugh et al., 2008).

Similar to UDL and Lowenthal et al.'s (2020) inclusive teaching principles, teaching presence is the design and facilitation of learning that is both personally and academically relevant to students (Anderson et al., 2001). Components of teaching presence include setting the curriculum, establishing group norms, and facilitating productive discourse to sustain learner engagement by encouraging and acknowledging student contributions (Shea et al., 2006). In their study, Shea et al. (2006) demonstrate that students are more likely to report higher levels of learning and a sense of community when they perceive a salient teaching presence on the part of their instructors. Teaching presence is often shared among instructor, teaching assistants (TA), and students. The instructor and TA design the course modules, assignments, and activities, to provide learning experiences that enhance the cognitive and social presence of students (Choo et al., 2020; Lower, 2022). It is also essential for students to assume teaching presence to increase self-directed learning and self-efficacy (Lower, 2022). In this way, teaching presence is connected to and can support learning presence, which is composed of the motivational, metacognitive, and behavioural traits and characteristics of online learners (Shea & Bidjerano, 2010). Learners' self-efficacy and self-regulation are central to learning presence. In other words, learners' mental states and perception of their ability to improve despite failures, accomplish tasks and achieve desired outcomes in a course affects the learning presence (Shea & Bidjerano, 2010). If the learner feels motivated to improve despite challenges and failures, this can lead to higher levels of cognitive presence. Effective teaching presence and social presence can improve self-efficacy of learners and positively impact learning presence; this is particularly relevant in the context of a remotely delivered course for first year international students.

Access and Inclusion Through Social Annotation

Annotation is the process of adding notes to texts, enabling people to comment on and engage with texts and other readers (Kalir & Garcia, 2021; Morales et al., 2022). Digital annotation tools in education can help students to annotate online texts and engage in dialogue with peers (Morales et al., 2022). One type of learning technology is social annotation which provides an online social platform for students to annotate digital texts and resources, share information and ideas, and co-construct knowledge (Clinton-Lisell, 2023; Kalir et al., 2020).

Research shows that social annotation technology improves students' critical thinking, reading comprehension, and cognitive skills and enhances student motivation, collaboration, peer review, and community building in undergraduate and graduate classes (Kalir et al., 2020; Morales et al., 2022). Furthermore, Clinton-Lisell (2023) found that social annotation facilitated students' self-expression in their ability to relate personally to the text. In the context of the internationalisation of higher education, students come from a variety of backgrounds, including students who have been historically underserved by traditional educational systems (Clinton-Lisell, 2023). Social annotation is an opportunity for representational justice, as these historically-underrepresented students are able to insert themselves into the text. This increases students' sense of belonging by weaving in their voices as they interact with a text, and is more effective than individual notetaking (Clinton-Lisell, 2023). This collaborative dialogue attempts to compensate for face-to-face opportunities international students value as they "employ language in creative and dynamic ways to respond to their peers' comments and questions" (Tavares, 2024, p. 218). Social annotation can be conceptualised as multilayered writing where students engage with and build upon one another's comments and queries to build community, co-construct knowledge, and strengthen engagement in the learning. Annotation threads become "a generative space to theorize, enhance, complicate, and question our thinking as [we] navigate the claims [we] make" (Sterner & Fisher, 2020, p. 68). We feel attending to language features through collaborative discussion threads are steps toward abstracted reflection and metacognition, an important part of developing critical language awareness.

Another aspect of social annotation is peer review. Students engage with each other's comments and queries, helping one another by offering corrections, revisions, and recommendations for further resources. Peer review helps to improve student learning and enhance mutual investment in the learning community through both teaching and learning presences (Shea & Bidjerano, 2020). Research shows that students who provide feedback to other students help to improve their own work (Cho & Cho, 2011; Li et al., 2010). There is a significant relationship between the quality of feedback that students provide and the quality of their own work (Guasch et al., 2013; Li et al., 2010).

Methodology

Research Design

This case study of academic literacy instruction employed inclusive pedagogical design principles and social annotation in two sections of student work from an online course conducted during

the COVID-19 pandemic. As a case study, its scope is naturally limited, but it allows us to focus on authentic examples of teaching and learning during the widespread shift to remote teaching. As such, it demonstrates "engagement with the complexities of classrooms, schools and other learning contexts" (Hamilton, 2024, p. 195). Its complexities include the range of emergent academic literacies that are typical of first-year students and are amplified by their diverse academic backgrounds and the remote nature of pandemic study. The differing time zones, varying Internet bandwidth, and the lack of a contained classroom environment necessitated an accessible means of engagement that would suit a tailored pedagogic approach best (Tavares, 2024), and is representative of customized pedagogic and research support provided by some universities' teaching and learning centres (Sharif et al., 2024). This case study focuses on students' engagement with both the course content and one another through their writing, analysing a collection of annotations in the margins of assigned texts and a personal reflection on learning.

Case Description

Deployed in the 2020–2021 academic year, a revised 26-week course spanned two semesters and was offered to students concomitantly enrolled in human geography, history, and psychology courses for their first year of remote study in Canada. The authors served as the instructor and teaching assistant for both sections of the course offering with 21 and 25 students, respectively.

A concerted effort to make the course design streamlined and explicit to students was made, as "creating a high-quality online learning experience begins and ends with the design of the course" (Lowenthal et al., 2020, p. 12). The course began with two weeks of introductory activities which aimed to establish the purpose, structure, and expected standards of the course, as well as the means of engagement for individual and group activities. Students were assigned to a group to choose a disciplinary text from their concomitant courses to annotate over the course of the unit. The course closed with individual student reflections on their learning. The scope and sequence of the units and activities are outlined in Table 1.

Using the language feature or academic literacy device covered in that week's lesson, students were asked to find and/or query examples within their chosen group text. They were also asked to support their group's learning through comments, questions, responses, and additional explanations. Annotations were graded individually. As a pedagogic activity, annotating was intended to focus students' attention on the language features used by the author(s) in writing the text, thereby aiding their comprehension and encouraging them to deploy these features in their own writing. In line with accessibility and student needs, Sareen and Mandal advocate for incorporating a behaviourist-constructivist pedagogical approach for online and blended courses, combining elements of behaviourist and constructivist frameworks. Behaviourist refers to instructivist or traditional approaches that focus on instructor lectures, knowledge transmission, and clearly defined course objectives, whereas constructivist frameworks for learning are situated in organic, collaborative, emergent, and developmental planning (2025, p. 3). In the absence of behaviourist pedagogies, where much control is left to the students to co-construct and facilitate their own learning, there is the challenge of assumed learning, which may not lead to effective teaching and learning (Sareen & Mandal, 2025). When

designing this course, the authors implemented a behaviourist-constructivist framework (Sareen & Mandal, 2025), emphasizing the need for both lecture-based content, knowledge transmission, and collaborative knowledge construction through student group work and discussions.

Table 1

Scope and Sequence of the Course

	Unit 1: Clause constituents	Unit 2: Texture of texts	Unit 3: Evaluation	Unit 4: Argumentation	Final task: Course reflection
Lecture and practice activities	Individual and group activities (practice quizzes, discussion boards, uploads of additional examples from disciplinary texts, etc.).				Individual reflection on learning about language feature, academic literacy, or working in a group.
Text choice	Process and rationale for the selection of the text to annotate for the unit. Written and assessed as a group.				
Annotations	Individually written and assessed within shared group text in CLAS.				
Feature analysis	Synthesis of the unit's annotations within the shared group text connecting language features to meaning making of the text. Written and assessed as a group.				
Peer evaluation	Individual scores and feedback to group members' contributions to group learning through annotations and group writes.				

Note. Collaborative Learning Annotation Software (CLAS).

Teaching presence (Shea et al., 2006) was developed through active engagement between the instructor and TA with students, e.g., through purposeful and supportive messaging. This set the course norm of a welcoming and supportive space, which can be important to international students who are studying remotely and building an online community (Tavares, 2024). Lectures referred to foundational concepts that had been previously introduced, encouraging students to revisit these archived resources as needed. Teaching presence was also established through instructor and TA explanations and feedback. Challenges and triumphs were acknowledged in lectures, instructions, assignment feedback, and announcements. Designing meaningful and sustained communicative and collaborative activities for online courses was part of the teaching presence. For example, the course's introductory activity was a still life selfie, in which each student shared a photo of artefacts representing themselves and explained their choices. This gave everyone the opportunity to curate their presentation to the cohort without revealing too much about themselves too soon.

Community building continued in the form of sustained group work, during which students provided and engaged with peer feedback, and reflected on their group work. In these instances of shared teaching presence, students took on the responsibility of teaching and learning from one another, in addition to incorporating instructor and TA feedback. The instructor and TA served as the bridge between students and the professional and academic community, modeling scholarly engagement and

providing opportunities for students to teach each other. This knowledge exchange between instructors and students demonstrated that knowledge is co-constructed (Lower, 2022). At the end of each unit, student groups synthesized what they had learned about disciplinary meaning-making within their shared text and annotations through a jointly constructed essay. They graded one another's contributions to the group's learning through an online peer assessment tool. The innovative peer review took place at the point of engagement and inquiry, during the social annotations and through the process of reading. It was embedded throughout the process as students navigated the texts and constructed meaning. In contrast, a more typical peer review involves checking a draft assignment once most of the thinking, organising, and writing has been completed. Also, typical peer review often serves as a function for grade improvement ("Can you check this to ensure I haven't made mistakes/help me get a better mark?") rather than genuine inquiry for comprehension.

Each unit was similarly organised, giving students the opportunity to improve their proficiency and performance as the course progressed. The consistent module design, chunking of course content, and referring to connections between previous and new material align with Lowenthal et al.'s (2020) principles of accessible and inclusive pedagogy and course design. Students engaged in a series of group and individual learning tasks, organised into four units over the 26 weeks. The focus of each unit aligned with the three interacting metafunctions of language, as informed by functional grammar. This approach moved from the smaller pieces of language to how they interact to shape texts, and then to how texts, authors, and audiences interact with each other to shape and be shaped by context.

Data Collection

The pedagogic use of social annotation aligns with Morales et al.'s (2022) purpose of enabling knowledge construction, shared meaning-making, and collaborative learning. Social annotation also serves as a means of collecting data for this study, providing a stable representation of students' engagement with their texts (and therefore their emerging academic literacies), as well as their engagement with one another. Common social annotation platforms include Hypothesis.is and Perusall.com. For this pedagogic project and study, the Collaborative Learning Annotation Software (CLAS) platform, which was developed by our university and adhered to the province's Freedom of Information and Protection of Privacy Act, was used. This meant that all data were stored on Canadian Internet servers, which was important for protecting students' data privacy, particularly when they were engaging in potentially politically sensitive topics in their history, human geography, and psychology courses. Further, this approach aligned with the university's statement on protecting students, which acknowledged that some course content (i.e., geopolitics, human rights, sexual orientation, etc.) might be considered controversial or even banned in some countries.

To utilize the social annotation platform, student groups uploaded their chosen text into a group assignment created in the CLAS settings. Once uploaded to the group folder, students could access and annotate the text asynchronously over each multi-week unit. The shared platform embedded with the course's learning management system aligned with Lowenthal et al.'s first principle of "accessible and usable course and content" (2020, p. 8).

Ethics approval from the institution to collect and analyse student work was obtained before the course began. A university colleague who was not involved in the course managed which students opted in or opted out of having their data included. This information was shared with the instructor upon completion of the course and submission of final grades, to ensure that the instruction and interaction between instructors and students did not differ based on whether students opted in or out of the study. Additionally, any identifying characteristics within student annotations were deleted.

Results

Over the 26-weeks, the 46 students generated more than 3,000 annotations (or responses to peers' annotations) across their four units of study. Groups of four to five students averaged 78.5 annotations per shared text, with the lowest number of annotations (22) on the first unit and the highest number of annotations (144) on the fourth and final unit. Groups consistently wrote more in the margins of their shared texts as the course progressed, suggesting cumulative knowledge building, as they were encouraged to revisit and annotate features of earlier lesson foci as useful, and confidence in engaging with one another.

Table 2

Annotation Assessment Criteria

Criteria	Assessment
Quantity of comments	Did students annotate enough?
Tagging	Did students tag annotations correctly and from the various lessons in the unit?
Accuracy	Did students' annotations match the text excerpts they had chosen? Did students ask/give the correct details?
Relevance	Did students' annotations focus on important information and/or excerpts?
Collaborative discussion	Did students engage their group members through annotation?

The example annotation in Figure 1 shows a student-initiated thread engaging with the focus of a unit on the building blocks of academic language. It highlights the main ideas of the excerpt manifest in the head nouns "facts" and "documents" within the paragraph's topic sentence. Subsequent comments, by both the instructor and classmates, discuss the noun groups' roles and premodifiers, contributing to enhanced academic literacy.

Figure 1

Students' Social Annotations on Collaborative Learning Annotation Software

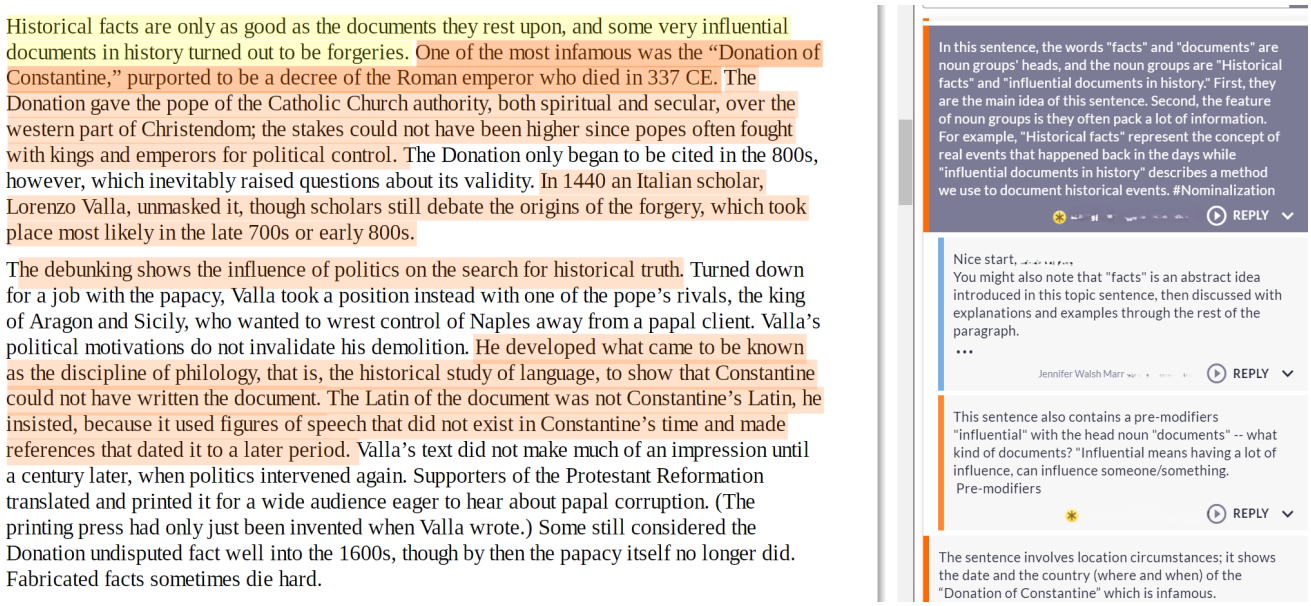
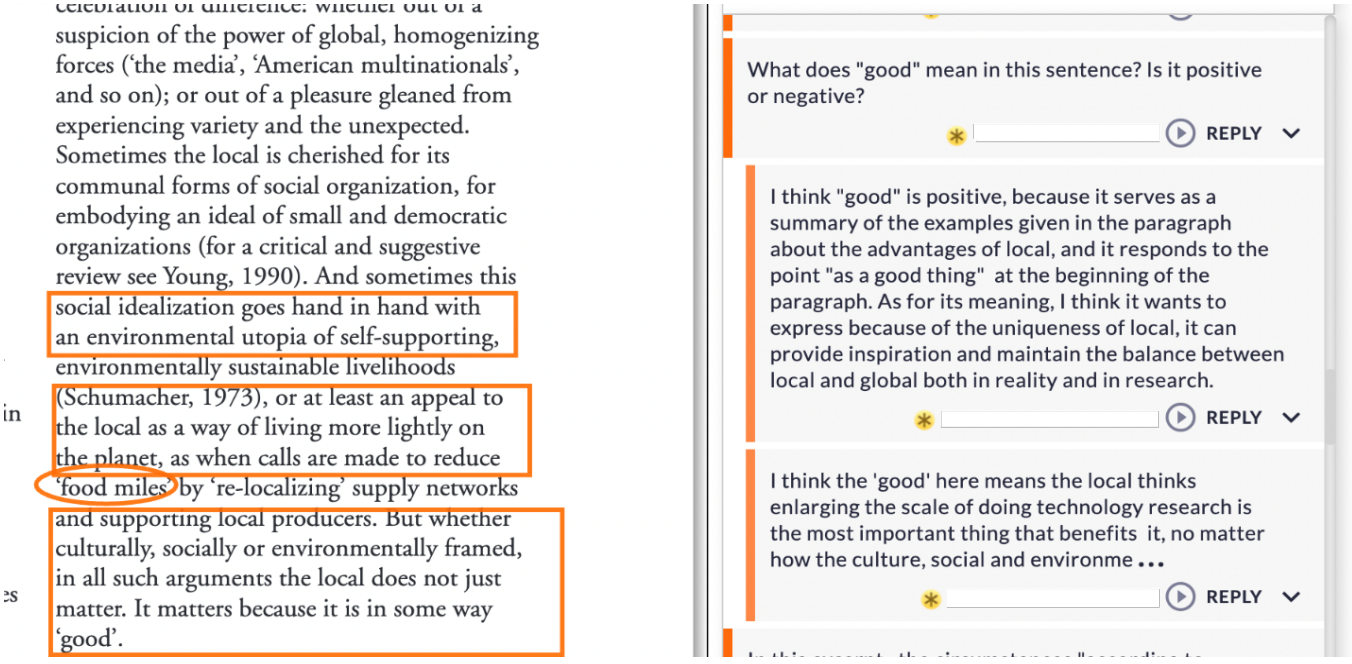


Figure 2 is an example of the students critically engaging with the connotation of the word "good" (in quotation marks in the original) in the closing sentence. The first student asks if its meaning is positive or negative and two students follow up with their response and rationale.

Figure 2

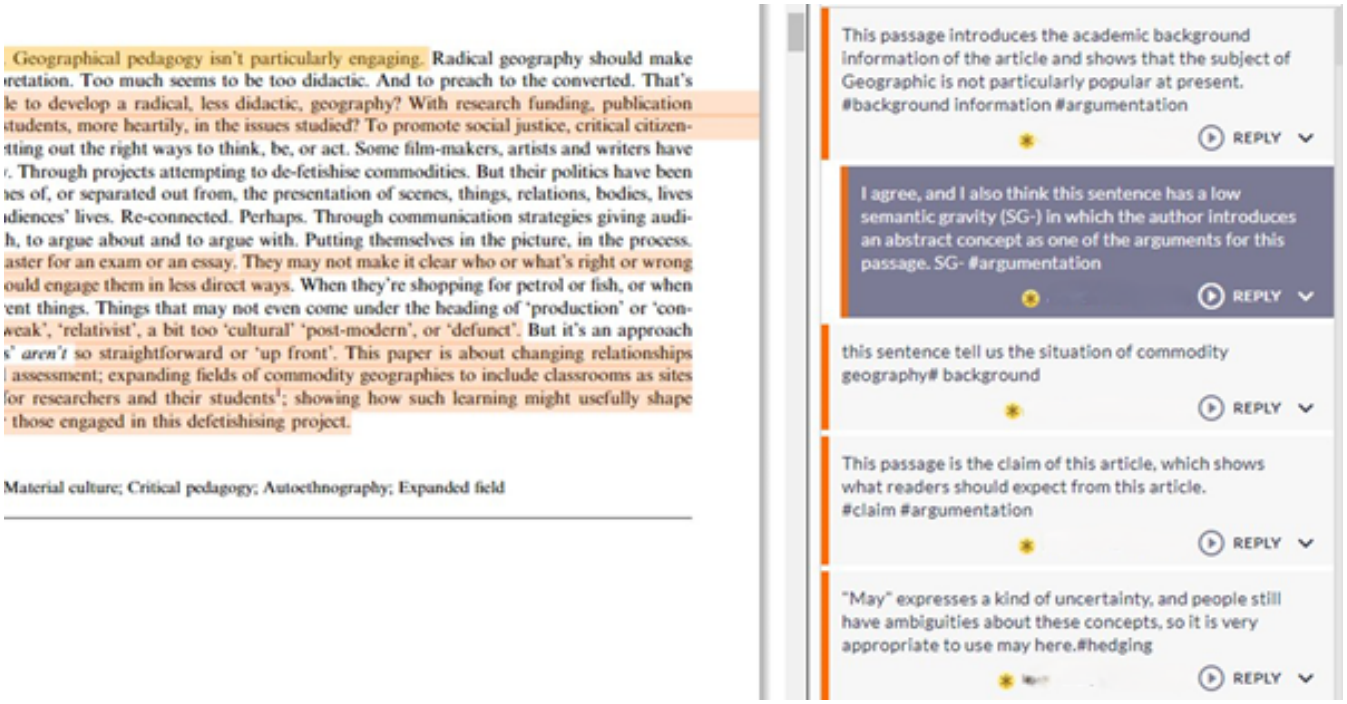
A Snippet of Students' Social Annotations and Interaction



In Figure 3, one student builds upon a classmate's annotation and expands its relevance beyond the original scope. They acknowledge the unit's focus on argumentation and revisit previous lessons on semantic gravity, representing cumulative learning and connections across units.

Figure 3

Snippet of Expanded Discussion



The Figure 4 snippet of a partial thread begins with an unequivocally friendly salutation and shifts to Student 1's query regarding the article's claim/thesis. Support is offered, then some hashtags to reiterate the major themes of the post (satisfying the tagging criterion). The first response continues to foster engagement by addressing the initial poster by name, giving their opinion, then returning to sociality by stating, "I'm not sure. What do you think?" The initial poster responds with more social gestures (greeting Student 2 by name, reduced, friendly forms of language) with some teaching content inserted between the friendliness. Two more students join the discussion, picking up the first two students' teaching content, albeit without the same friendliness. The annotations are directly related to the course content and satisfy the rubric's criteria for relevance, accuracy, and collaborative discussion.

S1: Hello, my wonderful groupmate! Is this sentence a claim/thesis of the article?

I think this sentence foreshadowed the content of the following article.

#Argumentation #Stages #Claim/Thesis #Foreshadowing

S2: Hi [Student 1], I think this is still a part of the introduction where the author is providing the context of the claim. I'm not sure. What do you think?

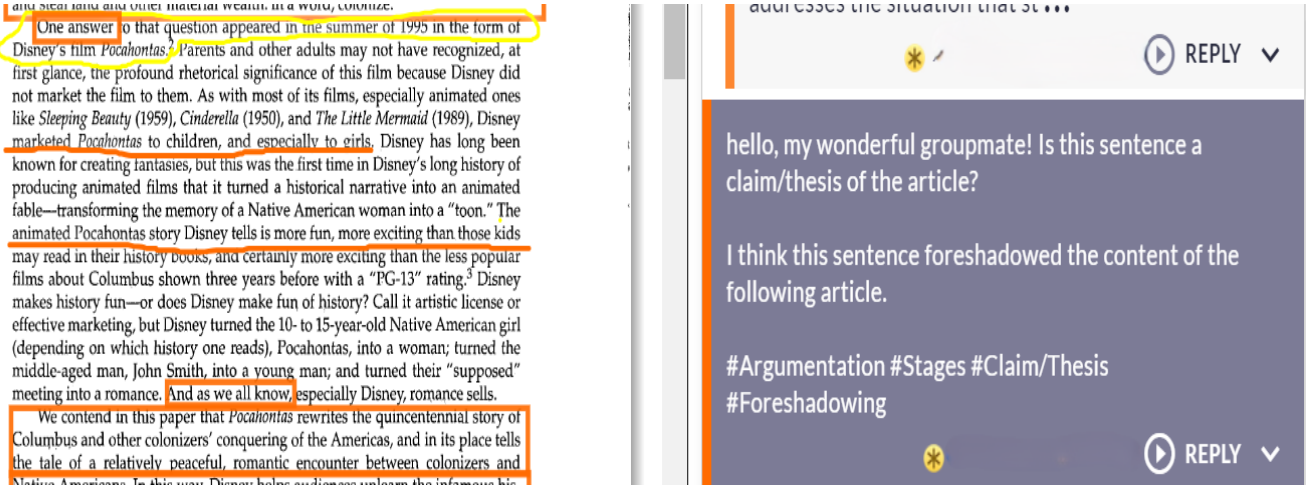
S1: Hi [Student 2], ya ~ I agree with u this is still a part of the introduction. But in somehow, i feel like it has foreshadowed the rest of the content of the following article, and i think it is also what does the author want the reader to accept ... im not sure either. that's why it is good to be discuss and thank u for ur idea!!!!

S3: Yea. I also agree it is still the introduction. The reason is that it continues to develop the content from the beginning, and you can see the main theme here does not change. Even though it looks so long, and it is still part of the introduction. The most important thing is about content, and how content develops.

S4: In my opinion, it is probably too short to be the thesis for this article. Moreover, it doesn't have the major points and claims that are showing the article's significance.

Figure 4

A Student's Friendly Annotation



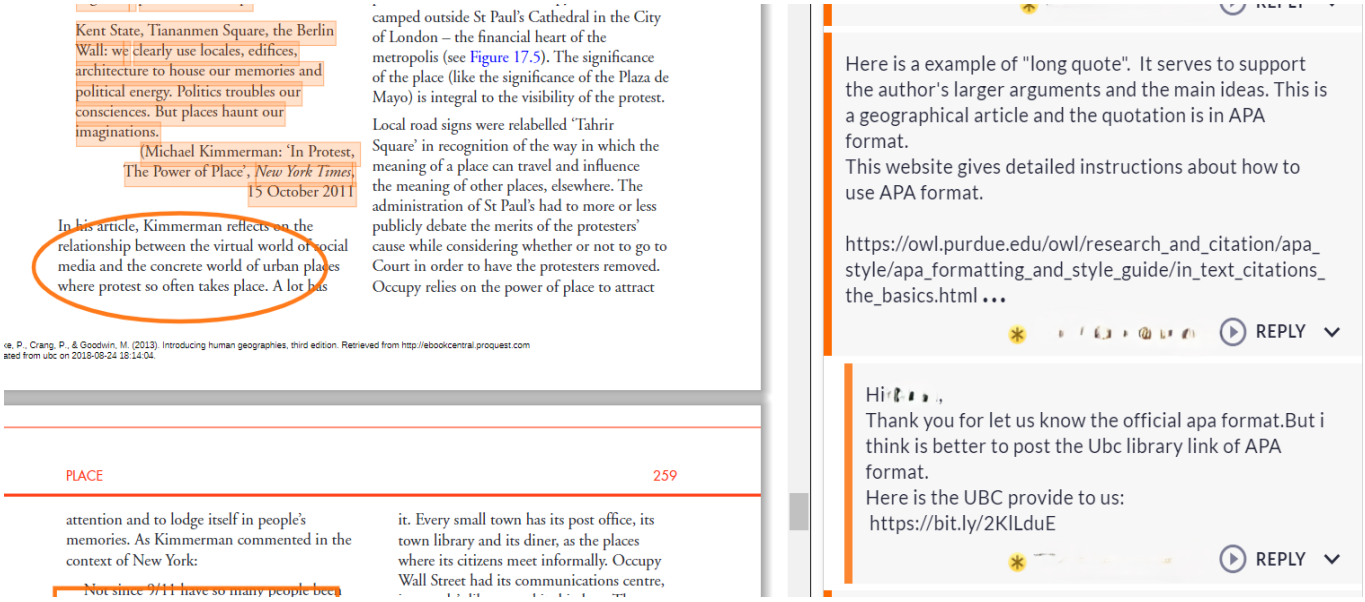
The Figure 5 snippet also includes some niceties toward the peer group ("Thank you for let[ting] us know...") as well as co-constructing knowledge, as the two students supply the group with external resources to support their APA citation practices. The first student identifies the excerpt as a long quote and highlights its purpose in supporting the author's ideas, then provides a hyperlink to the Purdue University online writing lab (OWL) instructions. The second student acknowledges this but suggests using the web-based resources developed in house by the university library. In the excerpted student assignment, a group describes their concern about establishing consensus, their process for collecting input, and their satisfaction with the result:

> "...after our further discussion, we made a full agreement on choosing this article. We all believe that the analysis of this text, as mentioned above, is also of great value to us. Before we wrote this paragraph, we were concerned about how we could sum up our diverse ideas. So we decided to write everyone's ideas under each question, just like last time, and then summarize them. Before we submitted this assignment, this paragraph was also sent to our group chat, and it was submitted after each of us agreed. During the process, everyone was free to express his or her

> own opinions and modify the paragraph with the permission of others. ... They support the purposes that we want to learn from each other, enrich our understanding, and develop the use of language through group cooperation. The process of cooperation is very enjoyable. It allows each of us to express our own ideas freely and understand the different perspectives of others. Like this paragraph, it is made up of everyone's cooperation, and we believe that our friendly cooperation and the way we cooperate respectfully express the ideas of each participant."

Figure 5

Students Sharing Resources in Their Social Annotation



In keeping with UDL principles of meaningful options to engage with course content, the final course task was an individual reflection assignment (CAST, 2018; Lowenthal et al., 2020). Students were prompted to do the following:

> Think about the group work you completed through the course and what worked well, was a challenge and/or you learned. What have been some of the various factors of your success, challenges & learning, and how might you apply these lessons to your future studies and career? Write 2-3 paragraphs.

The excerpt from a student focuses on the challenges and successes of group work, embodying the engagement and community students were able to foster over the year:

> "Working with others has never been easy for me… Throughout spending two terms with my group members in this course, I have learned something that might help me continue the efficient learning and socializing…First, I learned that knowing how to communicate is necessary to succeed in this course. From choosing the texts to writing their analysis, other group members and I always needed conversations to arrange each other's annotation plan. For instance, some of the assignments got excellent grades when we had thoughtful discussions, and others are relatively lower because we did

> not properly discuss the topic. Although I did my part pretty well on the assigned group writing in Unit 1, other members and I didn't get the grade we expected. [Our instructor] pointed out that we need to connect and build relationships in each part of the writing. After that, others and I soon realized the problem and corrected it on time to get a better grade next time."

This student discussed how they had learnt the importance of communication and building relationships through group work. It is through dialogue and relationship-building in group work that a sense of belonging to an academic institution is fostered, leading to efficient learning, excellent grades, and academic success (Lower, 2022).

Social annotation is seen as both means and evidence of students' academic literacy development and community building. Students were able to access teaching and learning resources within and beyond the course. Further, reflections highlight learning and teaching presence, and speak to the role of CoI in students' sense of inclusion and belonging.

Discussion

The examples in the Results section represent the categories of relevance and collaborative discussion, highlighting how students engaged with their disciplinary texts, the language within, and one another, "construct[ing] meaning through sustained communication" (Garrison et al., 2001, p. 89). The relevance of annotations is particularly tied to academic literacies, as the students highlight features of texts' language, organisation, and connections between ideas within the context of disciplinary meaning-making. The examples demonstrate how students situate their emerging knowledge in relation to the course content by tagging lecture concepts and showing thought processes within the task structure.

The snippet and subsequent transcript of the annotation thread in Figure 4 represents students' relationship and rapport with one another, indicating a burgeoning community and mutual investment in one another's understanding of the course content.

The final snippet in Figure 5, represents *learning presence* (Shea & Bidjerano, 2010) explicitly through individual students' contextualized engagement with the course content *and* peers in the margin of course readings. Through purposeful task design, direct instruction and feedback, *teaching presence "*articulate[d] the specific behaviours likely to result in a productive community of inquiry" (Shea & Bidjerano, 2010, p. 1722). That community was fostered through the group tasks and instructional support that were present throughout each unit. This began with the selection of a disciplinary text, which group members had to annotate, before explaining the process and rationale in a group text.

The iterative process to seek peer input to improve understanding of a text indicates positive emotions related to learning and group work, and an investment in the group as a whole. It also points to *social presence* within a community of inquiry which "promotes positive affect, interaction and cohesion ... that support a functional collaborative environment" (Shea & Bidjerano, 2010, p. 1722). Within its consistent modular design, the course incorporated both individual behaviourist learning opportunities (lectures, quizzes) and constructivist learning tasks (shared annotations, group texts, peer review) (Sareen & Mandal, 2025).

The group write on consensus-building suggests significant *co-regulation* (Shea & Bidjerano, 2010) and metacognition within the group. The final individual reflection on learning throughout the course also served to support students' metacognition (Butler et al., 2017), encouraging them to reflect on their own thought processes and learning. It was an individual writing task for which explicit instruction had been provided on the often implicit expectations of reflective writing (Martin & Walsh Marr, 2024; O'Sullivan, 2017). The task also helped students recognize and celebrate all they had accomplished during such an unusual academic year.

This case study was an impromptu response to remote learning during the COVID-19 pandemic and not set up with formal measurement tools to empirically measure and validate teaching, social, and cognitive presences of communities of inquiry (Arbaugh et al., 2008). As such, social annotation was the most appropriate tool for engaging first-year students around the world with academic literacies and for delivering accessible, relevant content in context. Future course designers are encouraged to use these tools to enhance their instructional design.

Conclusion

This innovative instructional design promoted inclusion and accessibility for first-year students through encouraging social annotation and raising awareness of critical language. Attention to academic disciplinary practices helped to facilitate the transition of linguistically and culturally diverse students to a Canadian university by building their academic literacies. Learning about linguistic features within academic texts enabled a wider and more critical scope of student participation and success. Through collaborative annotation and writing, students supported one another's learning and deepened their own learning. They gained insight into *what* disciplinary texts said and *how* those ideas were articulated in the texts. Bespoke teaching materials were based on texts and assignments of students' concomitant disciplinary coursework, highlighting how meaning is constructed and valued in these fields and supporting novice scholars' participation. The curriculum revisited and built upon foundational concepts over two semesters, deepening students' familiarity with, and ability to engage with, increasingly sophisticated disciplinary meaning-making.

Despite course participants being at a significant distance from one another through an international pandemic, learning communities were fostered through social annotation and group tasks. *Teaching presence* was manifest in a clear curricular structure, consistent assessment criteria, and sustained engagement through student learning cycles, including formative feedback. The consistent structure and clarity of expectations created an accessible and inclusive student learning environment (Lowenthal et al., 2020). The use of social annotation over several weeks scaffolded more careful, reflective engagement, due to ongoing interaction within groups. These groups established a strong rapport over the two semesters. Their authentic academic and social engagement with challenging texts and circumstances indicated resilience and self-regulation. Furthermore, social annotation provided critical engagement with texts and knowledge, as well as community building with peers. This shift towards accessible and inclusive pedagogy should benefit learners in any context.

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Authors

Jennifer Walsh Marr is an English for Specific Academic Purposes instructor at Vantage College, University of British Columbia in Canada, and a PhD candidate at the Ontario Institute for Studies in Education at the University of Toronto, Canada. Her praxis foci have included the portrayal of settler-Indigenous histories, genre-informed pedagogy, and linguistically responsive instruction. Her current research focuses on university instructors' language ideologies and pedagogic practices.
Email: jennifer.walshmarr@ubc.ca

Shihua Tan is a PhD student in Educational Studies at the University of British Columbia, Canada. Her research interests include environmental and sustainability education, teacher education, lifelong learning and adult education. She is a graduate teaching assistant who has worked with undergraduate international students and pre-service teachers. *Email:* dtan1907@gmail.com