Using social annotations to support collaborative learning in a Life Sciences module

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We used an online social annotation platform for Life Sciences undergraduates to develop self-efficacy in their own learning and to leverage on collaborative learning while annotating in groups. In particular, we were interested in supporting students in a large-class setting as they learn to read research articles as a means of integrating concepts with critical thinking. Students were tasked to post annotations based on their reading of two research articles. A graded quiz based on each article was administered after each reading. We used content analysis to analyse students' annotations based on the ICAP framework as a proxy measure of cognitive engagement. Students actively participated in the assignment, with most annotations classified as constructive and interactive. However, the percentage of interactive annotations was low, suggesting that students do not perceive the need for interaction to understand the research article. The interactive annotations were further examined for quality of writing using the SOLO taxonomy. The quality of interactive annotations were high, with majority of the annotations at the "Relational" level. We propose that the use of social annotations provided a student-centered environment for individual learning, but scaffolds could be incorporated to foster interactions and collaborative learning among students.

Keywords: online social annotations, interactive, ICAP, SOLO taxonomy

Introduction

The use of research articles in Life Sciences undergraduate modules has been part of our instructional design to introduce students to the practice of scientific investigations. Moreover, using research articles is a good way to integrate concepts with critical thinking among undergraduates. However, in our year-two Cell Biology module, the large class size of more than 200 students normally makes it difficult for instructors to provide immediate feedback to students who are learning to read research articles.

As such, we used an online social annotation tool Perusall as a means to support students as they are able to post annotations including comments, questions and answers on the article as they read and try to understand the research article. The aim was for them to learn to apply the concepts learnt in lectures in the context of research questions in the research articles. As not all undergraduates are familiar with reading research articles, the students were organised into groups to encourage collaborative learning through their annotations and interactions.

Theoretical framework

The theoretical frameworks that underpin our work involve both the ideas of student-centered learning and social constructivism. Student-centered learning that emphasises less-structured environments where students regulate their own learning, (Hannafin, 2012), is especially common in institutions of higher learning. This model is in line with our approach to reduce the level of dogmatic teaching and help students develop a sense of self-efficacy in their own learning (Bandura, 1995) that has been correlated with achievement (Lawson, Banks, & Logvin, 2007).

The idea of collaborative learning has roots in social constructivism (Vygotsky, 1978) that has been proposed to provide higher levels of cognitive engagement based on the ICAP cognitive engagement theory (Chi & Wylie, 2014). Accordingly, the authors had proposed that interactive (I) is greater than constructive (C) which is greater than active (A) which is greater than passive learning (P). This is because interactive learning constitutes generative learning, has elements of co-construction or co-building from one another's ideas.

With the advent of technology, collaborative learning has been an important mode of learning in computer-assisted learning environments such as for peer discussions (Schellens & Valcke, 2006). Hence, we leveraged on the use of an online platform (Miller, Lukoff, King, & Mazur, 2018; Miller, Zyto, Karger, Yoo, & Mazur, 2016) for students to share annotations while reading a research article as a form of collaborative learning when they interact through their annotations. It remains unclear whether student-centered learning environments can indeed support cognitive engagement, given that a substantial level of prior knowledge, experience and metacognition is required (Hannafin, Hill, Land, & Lee, 2014). Hence, we set out to explore the possible benefits of social annotation on student learning.

Research questions

In this exploratory study, we wanted to examine:

1. The engagement behaviour of students when using the social annotation platform Perusall
2. The quality of the annotations generated through interaction among students

Materials and Methods

Module information and recruitment for the study

The elective module was on Cell Biology and spanned 13 weeks. A total of 224 students enrolled in the module. The students were mostly second-year undergraduates from the Life Sciences degree programme. Institutional consent was obtained for this study (IRB S-17-214E). Student volunteers were requested in class and their consent were obtained for the analysis of their annotations. Among students who provided consent, 30 students were randomly chosen for analysis.

Social annotation assignment

Students had to read two research articles to be able to answer two quizzes linked to the articles. We used the social annotation platform Perusall (www.perusall.com). Students were randomly assigned by Perusall into groups of 6. Students were given 2 weeks to read each article using the social annotation platform to help one another understand the articles. For instance, students within a group could post questions and answers related to content in the articles. The support provided by the instructors include a short guide on how to read research articles, background on the research topic, videos and lectures on techniques used in the article, and discussion on misconceptions found in students' annotations. 6% of student's final marks were awarded for 12 best annotations per article. After each article, the students had to take a graded quiz that accounted for 3% of their final marks. For this paper, we analysed the annotations on the second research article.

Examining engagement behaviour using ICAP framework

The engagement behaviour of students was examined using the ICAP framework. We first checked if students annotated on the article to determine the participation rate in the assignment. For the other students who annotated, we classified their annotations as active (A), constructive (C) and interactive (I), with each annotation as the unit of analysis. An overview of the ICAP classification is presented in Table 1. The various categories of annotations are presented using descriptive statistics.

Table 1: Interpreted ICAP descriptors and examples of student's annotations

Classification	Description	Typical characteristics	*Examples of annotations*
Passive	Student did not participate in the assignment.	No annotations observed.	N.A.
Active	Student posted annotations without or with minimal thinking and consideration of contents in the research article.	Simple acknowledgement, simple labelling of materials, reiterating of contents stated in the research article.	*Shows the position of the nucleus.*
Constructive	Student posted annotations with clear thinking and consideration of the contents in the research article. There was no interaction between students.	Questioning, analysing methods and results, providing inferences, explanations and suggestions, making claims. Not interacting with other students.	*How is the localization of Akt to the nucleus related to its phosphorylation in ser-473? Could it be that the phosphorylation occurs at the nucleus?*
Interactive	Student posted annotations with clear thinking and consideration of the contents in the research article. There was interaction between students.	Evaluating other students' annotations. Referencing to students' annotations and building on contents contributed by other students.	*If I understand correctly, you are referring to ... If so, ... Hence, I think p27 may also not be present in non-dividing cells.*

Examining quality of posts using SOLO framework

To further examine students' level of understanding of research topic when interacting among peers, we coded all "I" annotations using SOLO taxonomy (Boulton-Lewis, 1995) with each annotation as the unit of analysis. The annotations were classified according to level of understanding. Table 2 presents the overview of SOLO categorization of annotations. The various categories of annotations are presented using descriptive statistics.

Table 2: SOLO categorization of "Interactive" posts by students in Perusall social annotation assignment

Level of understanding	Description	Typical characteristics	*Examples of annotations*
Pre-structural	Student had no understanding of the concepts in the paper. Information provided was irrelevant.	N.A.	N.A.
Uni-structural	Student dealt with only one aspect/concept of the paper. Information provided was reductive or had low value and significance.	Straight forward response to a peer's question. Short replies which only focused on one main concept with no elaboration.	*I guess it is not very clear if this is implied here but I agree with your statement that the nuclear Akt activity and phosphorylation is not the main focus of this article.*
Multi-structural	Student dealt with multiple aspects/concepts of the paper and was able to make some connections within these aspects. However, overall significance of these aspects was not shown.	Elaborated a concept with accuracy but short of providing any significance. Attempted to link different concepts together but the link might not be entirely accurate.	*Yup, it probably occurs in G1 phase. I think it is possible that phosphorylation occurs in other phases (with whatever p27 is left in the cytoplasm) but it may be too late and not have any effect on the cell cycle.*
Relational	Student dealt with multiple aspects/concepts of the paper and was able to make clear connections. The integration showed	Explained results with conclusion. Interpreted results with some inference on the student's end. Argued	*I think that @ABC answers are very feasible, but I would like to propose a step further and conclude that… When I first read the article, what I noticed was...*

	the understanding of significance of parts, and parts to whole.	their stand in a discussion. Explained cause and effect.	*How I interpreted it was that... But from the bands seen, it seems…*
Extended Abstract	Student was able to generalize what they had learnt to a new area, beyond that of the scope of the research article.	Generalization of ideas.	*To add to the above point… prevent cell cycle progression. The lack of cell division may pose a huge problem in organs where the surfaces experience 'wear and tear'. …stem cells in the gut cannot produce new gut epithelial cells to replace the old worn out cells. As a result, the wall of the gut may be damaged and deteriorate.*

Results and Discussion

Students demonstrated active participation in the assignment

Learning on Perusall revolves around meaning construction and interaction between peers through annotations. Thus, active participation through posting annotations is a prerequisite to learning through the assignment. Among the 30 students selected randomly for our analysis, the participation rate was very high (96.67%), with only one student not posting any annotations. The other 29 students posted a total of 475 annotations, which equated to an average of 16.4 annotations per student who annotated. This number was higher than the minimal 12 annotations set for the assignment. The high participation rate could be attributed to the design of the experiment. The marks awarded for participation and completion of the quiz might act as external motivating factors to push students to participate and understand the contents of the research article thoroughly. Even with external motivating factors, interest in the assignment might also decrease if the perceived difficulty is high (Hom & Maxwell, 1983). Scaffolds provided by instructors might have lowered the perceived difficulty of the assignment. Students were not penalized for any misconceptions, which provided a safe environment that could have encouraged students to post annotations. Overall, the low-risk design of the Perusall assignment, together with formative assessments could have contributed to the active participation in the assignment.

ICAP analysis suggests high levels of cognitive engagement, but low levels of interaction between students

The different modes of engagement behaviour correspond to different knowledge processes, which in turn correlate to different levels of learning (Chi & Wylie, 2014). To study engagement behaviour, we looked at the annotations posted by students, and classified the annotations to the mode of engagement behaviour using the ICAP framework. From these 475 annotations posted, less than 5% of the posts were in the “A” category, with majority of the annotations falling within “C” and “I” categories (Table 3). These results suggest that students were highly engaged in using the platform to generate meaning and understanding of the research article (shown as “C” and “I”). However, interaction between students remained relatively low (16%). Upon reflection, we did not include any assessments on group work. Furthermore, there was no strict enforcement for students to interact with each other through the Perusall platform. Thus, students seemed to work on the annotation exercise individually and did not see the need to interact with other peers. Nonetheless, we concluded that students were highly engaged in the Perusall assignment, but there were low levels of interaction between students.

Table 3: Frequency count of ICAP categorized engagement levels demonstrated by students’ annotations

ICAP classification	Number of annotations (Total: 475)
Active	20 (4.21%)
Constructive	378 (79.58%)
Interactive	77 (16.21%)

Annotations in the “Interactive” category demonstrated higher-order levels of understanding of the topic

Interactive learning is believed to be greater than individual learning as it constitutes generative learning (Chi & Wylie, 2014). To further understand the level of understanding afforded by interaction, we analyzed the quality of the “I” annotations using SOLO taxonomy. Categorization of the 77 “I” posts using SOLO taxonomy showed that a large percentage of annotations achieved knowledge levels of multi-structural and above (> 92%). In particular, 76% of these posts showed relational knowledge level with clear connections between different concepts and meaningful understanding. We also observed an annotation that is classified as extended abstract, the highest level of classification in SOLO taxonomy. These results show that interaction between students generated higher-order levels of understanding of the research topic, with the potential of generalization beyond that of the research topic. As such, collaborative learning through interaction between students might improve the level of understanding of the research topic.

Table 4: Frequency count of the SOLO taxonomy categorized levels of understanding demonstrated by “Interactive” annotations

SOLO Taxonomy	Number of annotations (Total: 77)
Uni-structural	6 (7.79%)
Multi-structural	11 (14.29%)
Relational	59 (76.62%)
Extended Abstract	1 (1.30%)

Conclusion and future directions

In this exploratory study, we report that students were highly engaged in the social annotation assignment using Perusall as the platform. The use of technology was informative in allowing instructors to observe learner-centered behaviours. Annotations on the platform served as student artefacts reflecting levels of cognitive engagement, as well as levels of understanding. Analysis of these observations allow instructors to improve on the design of activity to achieve better student learning outcomes.

One observation from the study was the low interaction levels between students. To foster more collaboration, we could include the element of group accountability in the assessment (Brame and Biel, 2015). One possibility is to grade the groups based on transcripts of their interaction as seen in Perusall. The level of group interdependence could also be increased by adjusting the amount of guidance provided by the instructors (van Leeuwen & Janssen, 2019). For example, misconceptions could be rephrased as prompting questions to facilitate discussion among the students during the period of assignment. These misconceptions could be addressed by the instructors after the assignment is closed should the misconceptions persist. Finally, understanding students’ perspectives of the assignment would allow us to make optimal changes in design of collaborative learning activities.

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