What Draws the Upvotes? Examining Relationships among Performance, Interpersonal Skills, and Learning Behaviors in Online Social Annotation Environments

Abstract: Social annotation has become a transformative pedagogical approach to promote active learning and community-building in online learning. Receiving upvotes serves not only as feedback but also as a source of motivation, social connection, and validation. The current study aimed to examine students' upvoting behaviors and their relationship to students' cognitive engagement, interpersonal skills, and the content of their social annotations. We first identified three distinct clusters based on students' interpersonal skills and then examined the relationship between upvotes and the automated score assessed by Perusall, the number of replies, content similarity, and the posting order. However, we could not identify any statistically significant correlations between these variables, nor statistically significant differences among three clusters.

1. Introduction

Social annotation has become a transformative pedagogical approach to promote active learning and community-building in online learning. Social annotation means that instructors and students work collaboratively on highlighting, commenting, and discussing course reading materials (Novak et al., 2012). Through social annotation tools like Hypothesis, Perusall, and shared Google Docs, instructors create interactive learning spaces for processing domain-specific knowledge, supporting argumentation and inquiry, improving literacy skills, supporting peer assessment, and connecting online learning spaces (Zhu et al., 2020). This method fundamentally shifts learning from passive consumption to active knowledge construction, as learners exchange insights, pose critical questions, and synthesize ideas within a shared online space (Sun et al., 2023). By making thinking visible and creating opportunities for real-time intellectual exchange, social annotation fosters deeper comprehension while increasing reading engagement. As such, social annotation represents both a practical instructional strategy and a powerful solution to key challenges in online learning.

Cognitive presence and social presence may influence students' learning experiences and outcomes in social annotation activities, just like other kinds of online learning (Garrison et al., 2001; Richardson et al., 2017). Teaching presence is not included here as we mainly see students' social annotation as relatively independent collaboration between students without rich facilitation from teachers. Cognitive presence refers to learners' capacity and willingness to understand course content by reflecting and interacting within an online learning context. Social presence describes learners' capacity to express themselves socially and emotionally as authentic individuals within an online community (Garrison et al., 1999). It typically comprises

three dimensions: open communication, group cohesion, and personal/affective projection (Arbaugh et al., 2008). Open communication involves learners' readiness and capability to share their thoughts, perspectives, and constructive feedback. Group cohesion reflects learners' feelings of belonging and interpersonal connection, strengthened by positive engagement and supportive responses. Personal/affective projection captures learners' capacity and behaviors in communicating their emotions, personalities, and identities in online interactions. Social presence may be especially related to students' interpersonal relationships.

Upvoting is a prevalent feature in social annotation platforms, enabling users to express approval and engage with peers' contributions (Li et al., 2024). Upvotes can serve as a powerful social signal that influences content visibility and shape discourse. For example, by analyzing discussion posts on a public platform called Reddit, researchers found that posts receiving upvotes are more deliberate with factual content and structural responses, compared to posts with voting feature disabled (Papakyriakopoulos et al., 2023). In educational settings, scholars have further explored the factors that contribute to upvoting behavior in social annotations. Li and colleagues (2024) found that cognitive presence, such as the number of annotations posted, and social presence, including peer mentions and connections to course context, were associated with upvotes. Similarly, Huang and colleagues (2024) found that annotations conveying positive effects, such as curiosity, enthusiasm, and an encouraging tone, were significantly more likely to receive upvotes. Additionally, annotations demonstrating cognitive depth, including statements indicating causation, insight, tentative reasoning, or strong motivation, such as a desire to learn, achieve, or build social connections, were also more likely to receive upvotes. These results indicate that upvotes in social annotation are associated with both content-related and interpersonal cues (Huang et al., 2024).

Receiving upvotes serves not only as feedback but also as a source of motivation, social connection, and validation (Burrow & Rainone, 2017). Students may feel acknowledged, encouraged, and even more motivated when they receive a high number of upvotes. Accordingly, they may feel confused, disengaged, and even isolated when they do not receive the number of upvotes they expected (Burrow & Rainone, 2017; Li et al., 2025). The current study aimed to examine students' upvoting behaviors and their relationship with students' cognitive engagement, interpersonal skills, and the content of their social annotations. Specifically, we aimed to address the following research question: *What is the relationship between upvotes and the quality of the comment, the posting timestamp order, the number of replies, and students' interpersonal skills?*

2. Study Design

This study was conducted during the Winter 2022 semester (weeks 17 to 13) in an undergraduate learning media course at a North American university. Initially, 97 students (47 female; Mean age = 20.67) were enrolled. The sample was predominantly White (n = 59), with additional representation from Chinese (n = 5), South Asian (n = 3), Southeast Asian (n = 2), Black (n = 1), Filipino (n = 1), Japanese (n = 1), Korean (n = 1), and Latin American (n = 1) students. Three participants identified as other racial backgrounds, and several did not disclose their race. Four students withdrew from the course, yielding a final sample of 93.

Students were assigned to 16 small groups (typically six members per group) and engaged in collaborative reading and discussion activities using Perusall, a digital social annotation platform (https://www.perusall.com/). Perusall allows students to asynchronously annotate course readings by highlighting text, posing questions, and commenting on peers' annotations. The platform also features an automatic scoring system that evaluates each student's contributions based on criteria such as relevance, quality, and engagement, offering a holistic score that includes both original posts and replies. Figure 1 presents an example of the platform and the learning task.

Over the seven-week activity, students were required to annotate ten readings. A total of 7,482 annotations were collected from the platform's log files, including original annotations, replies, upvotes, timestamps, and system-generated scores. These data were used to explore the dynamics of student interaction within groups.

To examine how individual interpersonal competencies may influence annotation behavior, 84 participants completed an adapted interpersonal skills survey based on Riggio's six dimensions (Lee et al., 2015). The survey consists of seven items measuring self-perceived behaviors such as empathy, open-mindedness, communication, conflict resolution, and adaptability, rated on a 7-point Likert scale (1 = Strongly Disagree, 7 = Strongly Agree). A total of 84 participants completed the survey. The results were later used to cluster students into subgroups based on interpersonal skill profiles for further analysis of their annotation behaviors and group interactions.

3. Data Analysis

To address the research question, we first applied hierarchical clustering to identify distinct clusters based on responses to interpersonal skills survey, examined if there is any statistically significant difference in interpersonal skills across three clusters. We also calculated the similarity between the social annotation and the highlighted text, extracted annotation behavioral pattern, and examined the differences among clusters.

Specifically, we applied hierarchical clustering using Ward's linkage with Euclidean distance. Hierarchical clustering is a method that constructs a hierarchy of clusters

(Nielsen, 2016). In general, hierarchical clustering can be categorized into agglomerative clustering (from data points to emerging clusters based on distance, such as Euclidean distance) and divisive clustering (split clusters from one whole cluster). This study adopted agglomerative clustering, to be specific, Ward's method, which iteratively merges clusters by selecting the pair whose union minimally increases total within-cluster variance (Murtagh & Legendre, 2011). This unsupervised clustering procedure revealed meaningful groupings of interpersonal skills profiles, preparing for subsequent correlation analyses of annotation behaviors across clusters.

To measure the alignment between social annotations and the highlighted text, we computed their cosine similarity. First, we used TF-IDF, a widely used method in natural language processing, to convert text into numerical vectors. Then, Cosine similarity was computed for each annotation and highlighted text pair, yielding a score between 0 and 1, with higher scores indicating stronger semantic alignment (Singhal, 2001). Cosine similarity is an appropriate method to discern the alignment of two segments of text. In this study, this metric allowed us to quantitatively assess how closely participants' annotations reflected the meaning of the highlighted text and to explore differences in linguistic engagement across identified clusters.

4. Results

To address the research question, we first applied hierarchical clustering to identify meaningful clusters based on students' interpersonal skills response surveys, then to examine the

4.1. Identifying clusters based on students' interpersonal skills

To identify meaningful interpersonal skill profiles, we used integers from 1 to 7 to represent participants' survey responses, with value 1 for strongly disagree and value 7 for strongly agree. To identify the best cut, we searched for the largest vertical gap between horizontal lines and drew a horizontal cut through the gap. By applying hierarchical clustering, we identified three distinct clusters based on participants' interpersonal skill profiles, see Figure 2. There are 28 students in Cluster 1, 9 in Cluster 2, and 47 in Cluster 3. However, we did not observe a statistically significant difference on the number of upvotes each student received among the three groups.

4.2. Examining the correlations

Based on the literature, we assumed that (1). Social annotations of high quality tend to receive more upvotes; (2). Social annotations of high similarity with the original text are likely to receive more upvotes; (3). Annotations of high upvotes are likely to be those with a higher number of replies; (4). Students sometimes have similar opinions about the same issue, and they may choose to upvote a previous similar comment to express

acknowledgement and agreement. We used the automatic score provided by Perusall to measure the quality of annotations, conducted cosine similarity to assess the similarity between each annotation and its associated highlighted texts, counted the total number of replies each annotation received, calculated the mean score of students' responses to interpersonal skill surveys, and extracted the order of each annotation posting time. These variables of interest are noted as *score, cos similarity, replies,* and *posting order.*

To address the research question, we examined the relationship between the number of upvotes and these variables using Spearman correlation, results are shown in Table 1. However, all correlation coefficients were weak, suggesting none of these variables were influential. In addition, the correlation coefficient for the number of upvotes and posting order was negative. Since we used 1 to represent the first annotation, 2 for the second, and so on, this negative trend is worth further investigation.

5. Conclusion

This work is set to address the research question: what draws upvotes in online social annotation platforms. We collected data from a college course and examined students' social annotation behaviors centering upvotes. We hypothesized that the number of upvotes is related to the quality of the annotation, the similarity between the annotation and its associated original text, the number of replies, the author's interpersonal skills, and the posting time precedence. We identified three distinguishable clusters based on students' interpersonal skill responses yet did not observe a statistically significant difference in the average number of upvotes each student received across three clusters. We examined the relationship between the number of upvote each annotation received and its score, cos similarity, the number of replies, and the posting order. However, none were strongly correlated, suggesting no strong correlation between students' interpersonal skills and the number of upvotes. Future work may continue to explore other potential influential factors, such as the cognitive contribution of the annotation to students' learning. Alternatively, researchers may distribute surveys to understand why and what leads students to give an upvote.

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Figures and Tables

Figure 1. An example of Perusall platform and the learning task

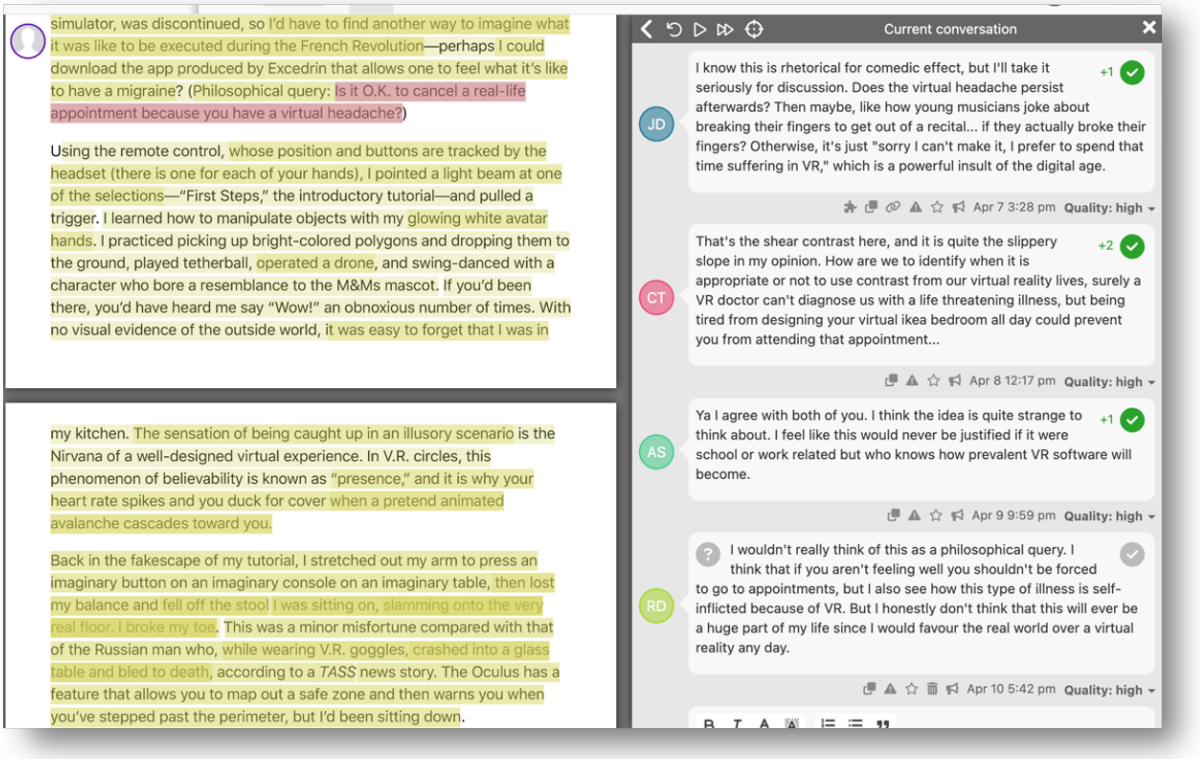

Figure 2. A dendrogram of clustering results

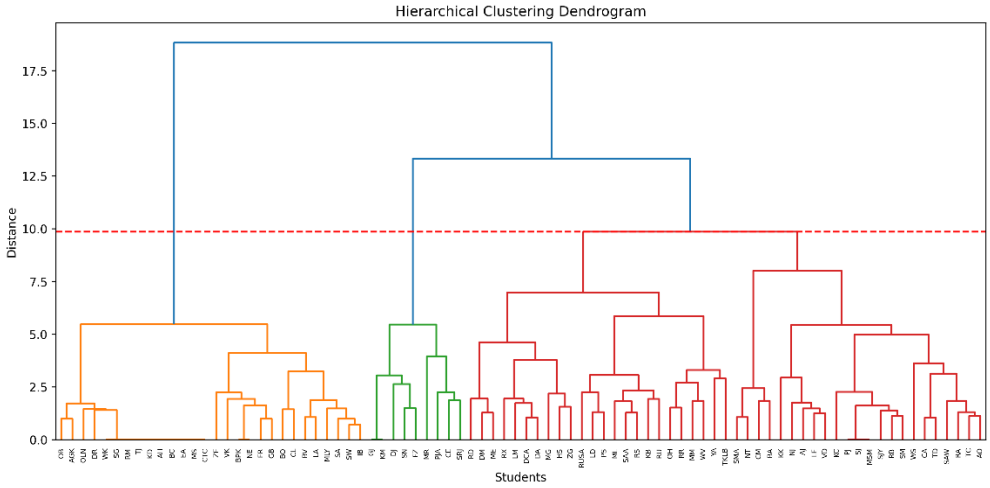

Table 1. The correlation between the number of upvotes and variables of interests

	Score	Cos Similarity	Replies	Posting Order
Upvotes	0.107	0.018	0.159	-0.034