# Nudge for Reflective Mind: Understanding How Accessing Peer Concept Mapping and Commenting Affects Reflection of High-stakes Information

Jingxian Liao
jxliao@ucdavis.edu
University of California, Davis
Davis, CA, USA

Hao-Chuan Wang
hciwang@ucdavis.edu
University of California, Davis
Davis, CA, USA

## ABSTRACT

Deep conceptualization and reflection of online information is essential to people's knowledge acquisition and decision-making in high-stakes domains, such as health. Reflective thinking, however, demands extra cognitive efforts, resources and skills, and therefore could deter people from taking further steps to question information encountered online. In this paper, we proposed a digital nudging tool for supporting critical reflection of video contents based on concept mapping and peer commenting mechanisms. The proposed tool, DeepThinkingMap, aims to promote people's understanding and reflection of video content via interface features that foster the disclosure of personal conceptualization and transparency of personal beliefs about the video. By seeing how peers conceptualize and reflect about the video content, the concepts and comments made available to people could potentially serve as a "thinking nudge," allowing individuals to reap in-depth thoughts about the video otherwise inaccessible to them. Through a proof-of-concept controlled evaluation, we found that seeing peer thoughts through DeepThinkingMap significantly increased content comprehension, and fostered greater efforts for reflection in comparison to the baseline of receiving no nudge. The study contributes to understanding the socio-technical-cognitive mechanisms and the design space of social nudging that may be utilized to support reflection and critical thinking toward high-stakes information.

## CCS CONCEPTS

• **Human-centered computing → Human computer interaction (HCI)**; *Interactive systems and tools.*

## KEYWORDS

Nudging, Reflection, Concept mapping

**ACM Reference Format:**
Jingxian Liao and Hao-Chuan Wang. 2022. Nudge for Reflective Mind: Understanding How Accessing Peer Concept Mapping and Commenting Affects Reflection of High-stakes Information. In *CHI Conference on Human Factors in Computing Systems Extended Abstracts (CHI '22 Extended Abstracts), April 29-May 5, 2022, New Orleans, LA, USA.* ACM, New York, NY, USA, 7 pages. https://doi.org/10.1145/3491101.3519815


*CHI '22 Extended Abstracts, April 29-May 5, 2022, New Orleans, LA, USA*

ACM ISBN 978-1-4503-9156-6/22/04.
https://doi.org/10.1145/3491101.3519815

## 1 INTRODUCTION

In the era of online infodemic, the quality and credibility of online content vary largely as the proliferation of user-generated content and the wide usage of online social platforms. It raises an increasing need to consume information analytically in multiple high-stakes fields, including health, science, politics, and economy [12, 13, 31]. As a recent example, a study reported in March 2020 showed that over 25% of the most viewed YouTube videos on COVID-19 contained misleading information, nevertheless reaching millions of viewers worldwide [29]. Moreover, following news signs more people started to believe these alternative facts rather than sciencific facts and authoritative resources [18]. Biased personal interpretation of content, such as cherry-picking, anchoring bias, cultural and political polarization, may have consequences on individuals and communities. Empowering individuals' deep processing and reflection of online information is critical to individuals' and communities' benefits and safety when consuming online content that's novel, fast-spreading, and often unverified [11, 13].

Cognitively, to conceptualize and deeply reflect on information encountered, individuals have to make efforts to operate on the information at higher-order levels, beyond just remembering and reiterating. It demands significant engagement in higher-order thinking, operated by the reflective mind as suggested by the dual process theory [21]. They are crucial to combat cognitive biases and social influence, and correct erroneous heuristics if necessary. Among types of higher-order thinking, there are two broad categories: reflective and critical thinking [14]. Both are exclusively vital to handle complex information and perform knowledge work like learning, deliberation, and decision-making [14, 27, 28, 44]. For example, critical thinking can aid in processing conflicting information from diverse sources because such cognitive operations will allow individuals to develop a more well-developed mental model to integrate different perspectives [6, 32].

As cognitive and meta-cognitive resources required to perform higher-order thinking in high-stakes domains is not universally available to different individuals and automatically accessible in various circumstances [3], external thinking support to increase the opportunity to think beyond the literal content is much needed. Nudging is a choice-preserving technique that aims at altering people in a predictable way without forbidding any option which preserves all the choices people can have [38]. Nudging as a type of lightweight intervention, often in the form of implicit suggestion to people [8], can also reduce the possibility of backfire and burnout [16] compared to regulations, making it ideal to engage people in reflective and critical thinking. We have seen recent examples of

digital nudges such as balanced positioning of reports [34] and fact-check alerts [41]. More importantly, nudged thinking tends to be cognitively less demanding, compared to unsupported formal thinking activities for reflection such as critical reviewing. Nudged thinking can render reflective thinking less expensive and more accessible to individuals given the availability of guidance.

With the ubiquity of social discussion for content verification and moderation, researchers and practitioners have leveraged general users' efforts and online resources to mitigate the harm of mis- and dis-information [4, 24, 37]. The current approaches that utilize social information include but are not limited to collecting and crowdsourcing dispute warnings from users [24, 37], visualization design for these crowd-based dispute for the community [4, 41], providing the community access to reputable alternative opinion and discussion space [20], redesign the positioning of comments [25]. Though these approaches all aim to provide nudge cues and resources from different angles to mitigate the impact of mis- and dis-information to some extent, few existing approaches attempted to improve people's engagement in deeper, reflective thinking when digesting online information.

In this paper, we take a different route to support online information consumption - sharing peers' thinking activities to nudge for reflective thinking. Seeing how other people process and react to the same piece of information could provide both behavioral cues (e.g., do other people engage in the content?) and cognitive stimulation (e.g., how other people react to the content?), which may consequently promote engagement in reflective thinking. One significant challenge is how to allow people access diverse peer inputs vis-a-vis simultaneous consumption of the content. The original content and additional thoughts shared by peers need to be organized in a way that amplify the conceptual and semantic linkage, so that which comment anchors to which part of the content is visible. Another requirement is to mitigate the influence of recency and popularity of specific opinions in social sharing of thoughts to preserve diversity [25], and thus its ability to nudge more diverse thoughts, across different times of interactions.

To address this challenge to nudge people for engaging in higher-order thinking, our work proposes a nudging interface by engaging people in peer concept mapping and commenting activities as part of online video watching. Our nudge interface, DeepThinkingMap (see the screenshot of Figure 1), comprises two nudge designs to foster social sharing of thoughts in video watching. One is an end-user concept mapping interface that invites individuals to identify and extract concepts appearing in the video, put the identified concepts on an editable canvas and connect inter-related concepts. The concept map represents peers' personal conceptual understanding of online content in a shareable, and accessible graphical representation [26, 33]. Another feature of the interface is a concept-anchored comment space that takes peers' free-text inputs in the form of opinions and/or questions, which invites reflective thinking beyond the original content. They are anchored to the content concept map through related concepts or keywords peers identified, providing a shared semantic organization between comments and content [43]. In an evaluation study, we examined the impact of DeepThinkingMap using a health video-watching task. We manipulated the availability of peer concept mapping and commenting when people were asked to consume and make sense of video in a between-subject controlled experiment. Results showed that the system can trigger participants to better engage in reflection compared to the baseline. We also confirmed that DeepThinkingMap helped users engage in developing a better understanding of video content. Moreover, participants tended to produce more constructive comments, performing further analyses and asking questions. Our findings provide a proof-of-concept, suggesting that system-mediated sharing of understanding and personal thoughts can nudge individuals' understanding and reflection on online content, which may serve as an effective design strategy to resolve infodemic-related issues through collective efforts.

## 2 NUDGE DESIGN FOR REFLECTIVE MIND

To provide non-coercive opportunities for people to engage in higher-order thinking, the proposed design focuses on three thinking processes: understanding, reflective thinking, and critical thinking, and follows the guidance of nudge and cognitive theories to design the interactions. Thinking with reflective mind can be non-trivial for many individuals [21]. In comparison, automatic mind handles about 95% of daily activities, known as unconscious, fast, and instinctive [3]. When consuming online information such as watching videos, it is necessary to motivate people to interact with the content in ways other than passive watching, which may still rely much on intuition and automatic processing [23].

Behavioral transparency that provides observability of behaviors is one common approach to nudge for the performance of similar behaviors [8]. In the context of video watching, we may also install behavioral transparency among peers by making observable how other people process the videos and whether they invest extra efforts to handle the videos consciously and reflectively. Social sharing of personal thoughts on content can serve as a thinking nudge in two ways. First, seeing peers performing analytical and reflective thinking beyond the content can provide a social proof heuristic on how to handle the content appropriately [10]. Even though peer reflection may not necessarily provide valuable insights, it may still encourage individuals to make similar efforts to reflect [9]. Second, seeing conflicting or disagreeable comments from peers about the same content may lower individuals' perception of the quality of content [42]. Piagetian theory of constructivism suggests that cognitive dissonance or incompatibility between the original mental model and the information received is critical in driving critical reflection that leads to learning [30, 35]. With the disclosure of interpretation and comments from others and their own, people will be explicitly presented with information and beliefs that contradict one another. It may nudge individuals to stay open to new ideas and evaluate every possibility, such as re-processing the content to find verdicts or taking a different perspective to reduce the cognitive conflicts experienced [30]. These activities have the potential to substantially nudge people to compare, evaluate and analyze specific parts of the content deliberately.

To guide the assessment of thinking processes, we adopted Geertsen's framework of higher-order thinking in this work. Geertsen categorized higher-order thinking into two broad categories: critical thinking and reflective thinking [14]. Critical thinking focuses

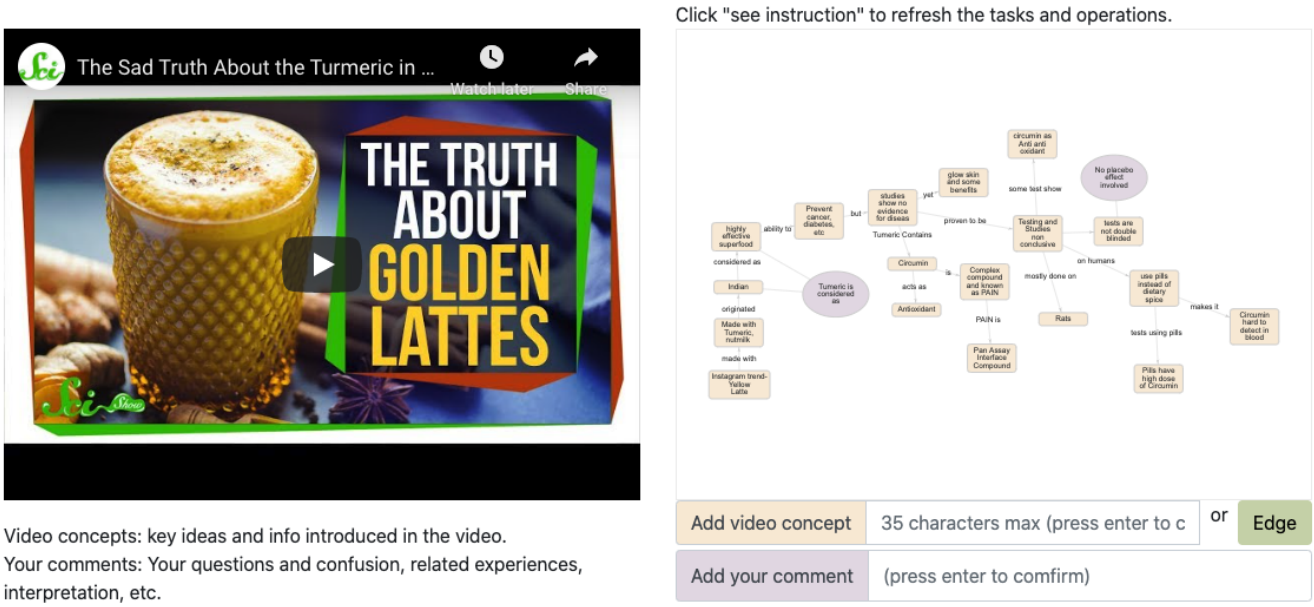


**Figure 1: Screenshot of DeepThinkingMap**

The system integrates a video player and a peer concept mapping canvas. In-video concepts and personal comments are coded with different colors and shapes.

on establishing the credibility or validity of content, including critical judging and self-reflection; and reflective thinking seeks to extend, enlarge, or explore the focus and scope of thinking so that the thoughts are relatively more expansive and contextualizing. Despite these distinctions, both critical and reflective thinking are essential to fully process information received. We are interested in understanding how social sharing of peer thoughts facilitates both types of thinking.

## 3 SYSTEM DESIGN AND PROTOTYPING

### 3.1 DeepThinkingMap Interface

The DeepThinkingMap nudge interface combines a video player and an editable canvas for nudge (Figure 1). For our prototype, the content is queried from YouTube Data API to play task videos [40]. The standard YouTube video player is embedded in the interface which enables common play functions such as play, pause, playback, the same as in YouTube. The nudge and video player are displayed side by side. We implemented D3.js library for concept map visualization and edit [39]. When nudging is available, the nudge canvas will display one hybrid concept map and make peers' previous concept mapping inputs and comments visible. The shape and color of concepts mentioned in the video and their comments are different to indicate different sources: concepts extracted from the videos are visualized as box-shape and light-yellow, while users' comments are shown in violet ellipsoids. The input box colors also changed accordingly. Users can add, edit, and delete components like nodes, links and their labels between concepts, and comments whenever they watch the videos. The links between concepts are directed to show the directionality of relationship in the labels, and the links connected to comments are undirected, representing only the association between concepts and participants' comments. When users hover over the concepts and links, the author name will show up to highlight different contributors. We also designed a button to hide or show comments for users to focus on either concept mapping or commenting.

### 3.2 Nudge Construction

In this prototype, we collected nudging content for two videos respectively. To generalize our findings beyond video content, we selected videos of different topics and types. One video clip introduces the basic knowledge of human immune systems ('Immune System') [1], talking about how human body fights bacteria via multiple lines of defense (video type: theoretical explanation). The other talks about the scientific evidence of a health-related claim that turmeric in golden lattes ('Golden Latte') is beneficial for humans (video type: application) [36]. Both videos are health-related given the public interest around health-related issues nowadays, especially with clear evidence that online searching around health-related questions has seen an increase since the outbreak of the COVID-19 pandemic [15]. The processing of health videos may require users to forge connections between healthcare experiences and background knowledge, engage in content abstraction, reason about the processes and causalities underlying the contents, and reflect on their daily health-related routines. The lengths of the videos are controlled to approximately five minutes for feasibility and consistency in the evaluation.

As our work proposes to nudge thinking with socially shared thinking activities, we invited participants to generate the nudge content to be displayed for participants using the nudge support in a formative evaluation study. After screening people to make sure they are capable to consume health knowledge and make health-related decisions, 24 participants were recruited. One half of

participants watched the video 'Immune system' and constructed the concept maps with personal comments individually. Two individual work was selected from these participants and used as nudge content in the evaluation. The other half people watched video 'Golden Latte' and we chose another two work as nudge content for the study.

As we'll describe in section 4.1 as well, participants were instructed to produce two parts of thoughts when they watched the video offered to them: 1) create a concept map to represent the video content to the extent understandable to them, including extracting keywords, linking the keywords they believe are conceptually related and explicating the meaning of the links, i.e, the semantic relationship between keywords; 2) document their thoughts relevant to the content and topic, which can be interpretations, takeaways, opinions, related experiences, questions around, etc. They also were asked to anchor each of their thoughts to a specific concept that is the most relevant in the current concept map. For those who did not know about concept mapping, we provided a simple example from the biology domain to instruct about how to create concepts, links, and link labels for concept mapping [19]. We recorded a tutorial to instruct participants how to input in the interface. For instance, they need to differentiate concept input and comment input by using different input boxes.

To select work from specific individuals as nudge content from the pool, two researchers screened through the contributions in all concepts maps created by the participants, and labeled the validity and uniqueness of each concept. In total, 28 unique concepts were identified for the 'Immune System' video and 36 concepts for the 'Golden Latte' video. Then we calculated the concept coverage of maps (i.e., #concepts_in_map/#concepts_in_conceptspace) and selected two maps per video whose concept coverage resides in the median as the peer concept mapping example to be used as nudges. Furthermore, we identified original comments created that were not literal copies or paraphrases of the content. The two maps of video 'Immune System' have 0 and 1 original comments respectively, and the maps of video 'Golden Latte' have 1 and 3 original comments respectively. We still kept the literal or paraphrased comments in the maps for nudging as these comments could still inspire other people to attempt making comments.

# 4 EVALUATION

With the design and prototype described above, we investigate the influence of seeing peer thoughts through DeepThinkingMap on the engagement of higher-order thinking of online videos. This initial study was constructed as a "one-way simulation" of social nudging, in which some participants were invited first to produce the nudging cues to be accessed by later participants so that we can evaluate how accessing peer thoughts as nudge impact later participants' thinking activities. We hypothesize that accessing peer thoughts would positively increase the extent of understanding, as a regular thinking activity, and engagement in higher-order thinking activities (i.e., reflective thinking and critical thinking) of the videos. By seeing peer thoughts, the follow-up comments on the videos will also be more expansive and constructive, showing greater reflection and criticism toward the online content.

## 4.1 Participants and Experimental Design

Forty-four college students (gender distribution: 28 female, 14 male, 2 other) were recruited from two university campuses and the surrounding communities in the United States between the ages of 19 and 29. Their self-reported background knowledge (health in this study) was reported median on average (mean=4.92, sd=0.78, on a 7-point scale where 1="novice level" and 7="expert level").

The experiment consists of two conditions: control condition and nudge condition. The evaluation was designed as a between-subject experiment. Twenty participants were assigned to the experimental nudge condition, receiving social nudge cues (seeing other peers' thoughts and comments) while watching the videos, and the other twenty participants were recruited prior to the administration of the nudge condition, and were assigned to the controlled condition without access to these cues. As described in the section 3.2 about nudge construction, concept mapping activities and comments from four participants assigned to the control condition were selected and held out as nudge content for the purpose of prototyping, and thus data from the four participants were excluded from the rest of the analysis. In the nudge condition, participants were randomly assigned to watch one of the two health videos and perform the concept mapping and commenting activities with the support of a partially constructed concept map that displays the thoughts and comments from another peer (the nudge cue). As each video has two partially constructed concept maps available, we randomly selected and assigned a map to each participant in the nudge condition for generalizability.

For the experimental process, participants were introduced to the study and procedure first. Then they were asked to complete a pre-task survey about their demographics and health knowledge proficiency prior to watching the videos. Following a tutorial instructing how to perform concept mapping, participants watched a health video, and worked on concept mapping and commenting. The instruction asked participants to give their best effort on either "creating a concept map of the video" in the control condition, or "improving the partial concept map of the video" in the nudge condition. Participants in the control condition started their work from scratch with an empty concept map canvas. In the nudge condition, people had the freedom to edit the initial concept map by modifying concepts as well as adding their own comments. The comments could be thoughts such as interpretations, opinions, and questions about these videos. The entire task procedure lasted for 20 minutes. At the end of experiment, participants completed a questionnaire measuring their engagements in different levels of thinking activities as well as their holistic experiences and perceptions of the task. Given that the time available for video watching and mapping was controlled, we place our focus of the current analysis on how seeing other people's thoughts and comments on the initial concept map affect their engagement in higher-order thinking, but not on the completeness or productivity of concept mapping.

## 4.2 Measures

We designed pre-experiment and post-experiment surveys to measure engagements. Pre survey collected participants' basic information and background knowledge via self-report, i.e, personal healthcare knowledge (e.g., I am familiar with preventing minor and

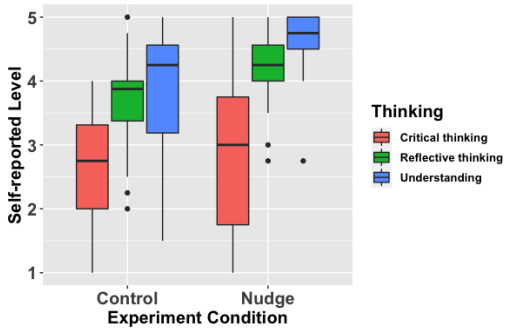


**Figure 2: Boxplot of engagement of comprehension and higher-order thinking in two conditions**

temporary problems such as colds and viruses) through questions in health knowledge dimension modified from [17]. Post-experiment survey reported participants' levels of thinking engagement with modified questionnaires from Kimber et al. [22]. With the 5-Likert questions, we measured engagement of understanding, engagement of reflective thinking (e.g, I reflect on my actions to see whether I could improve on what I did.), and engagement of critical thinking (e.g, It challenges some of my firmly held ideas.)

To analyze comments, two coders were recruited to watch the video clips and code comments independently. Coders first identified the number of real comments, which were not literal copies or rephrase from the video. Then they classified these comments according to the higher-order thinking skills they related, based on Anderson and Krathwohl's revision of Bloom's taxonomy [2, 7] : interpretation, analysis, and evaluation, another approach to categorize higher-order thinking. The two coders achieved a satisfactory coding agreement of Cohen's Kappa higher than 0.9.

## 4.3 Results

**Table 1: Regression coefficients of ANOVA models for understanding and higher-order thinking processes**

| Predictor | Understanding | Reflective Thinking | Critical Thinking |
|---|---|---|---|
| Intercept | $2.57^{***}$ | $2.68^{***}$ | 1.41 |
| Nudge | $0.71^{***}$ | $0.55^{**}$ | 0.23 |
| Background | $0.26^{*}$ | $0.19^{*}$ | 0.29 |

The intercepts represent corresponding engagement in control condition. Significance: $p < 0.01$: ***; $p < 0.05$: **; $p < 0.1$: *.

To test our hypotheses, we used ANOVA models for analysis. The main independent variable is experiment condition. The background knowledge is control variable when videos and nudge contents are treated as variance. We took necessary pre-processing steps to ensure the premises and assumptions for the aforementioned statistical models were met (e.g., normality, homoscedasticity, no multicollinearity). The analysis was conducted by R 3.0.

***Engagement of Understanding*** ANOVA reported significant positive effect of nudge on engagement in understanding combined with health background as control variables (nudge condition: $F(1, 37) = 8.038$, $p = 0.007$, background: $F(1, 37) = 3.937$, $p = 0.05$) shown in Table 1. Participants in the nudge condition ($mean = 4.56$, $sd = 0.54$) tended to engage more actively in understanding video content than control condition ($mean = 3.84$, $sd = 1.05$) (See Figure 2). And participants with high background knowledge in health ($\beta = 0.26$) were likely to make more efforts on understanding.

***Engagement of Reflective Thinking*** For reflection, there was a significant influence of nudge on top of background knowledge (nudge: $F(1, 37) = 6.589$, $p = 0.014$; background knowledge: $F(1, 37) = 3.281$, $p = 0.078$) reported in Table 1. Generally, participants in the nudge condition ($mean = 4.18$, $sd = 0.59$) engaged in reflection deeper during the task compared to control condition without nudge ($mean = 3.61$, $sd = 0.80$) (See Figure 2).

***Engagement of Critical Thinking*** In the experiment, seeing others' concept mapping work and comments showed no effect on critical thinking ($F(1, 37) = 0.566$, $p = 0.46$) compared to control condition (nudge condition: $mean = 2.64$, $sd = 0.90$; control condition: $mean = 2.89$, $sd = 1.21$), though the variance is smaller in nudge condition. Moreover, two-sample T-test also confirmed that there is no significant difference in engagement in critical thinking between control condition and nudge condition ($t = -0.74$, $p = 0.46$). We also compared the efforts between reflective thinking and critical thinking efforts within individuals. A paired T-test result showed that the level of engagement in critical thinking is significantly lower than reflection in general ($p = 0.00$), which holds on both individual and nudge conditions.

***Personal Comments*** We identified 37 personal comments in the control condition and 28 comments in the nudge condition. Qualitatively, these comments appeared to cover a rich set of thoughts beyond the video contents, such as personal takeaways, connections between novel and known information, confusions and questions, and reflection with their experiences. The portion of analysis and evaluation comments (i.e, higher-order thinking results) altogether turned over 50% in nudge condition ( Analysis: 46.43%, Evaluation: 7.14%), while it was only 37% in control condition (Analysis: 27.02%, Evaluation: 10.81% ). Quantitatively the amounts of higher-order comments are similar between two conditions: 14 comments in control condition and 15 comments in nudge condition. However, people became more reflective and selective about comments they generated and shared in nudge condition.

## 5 DISCUSSION

Higher-order thinking around high-stakes online content is an essential yet sophisticated and nontrivial process for the general public. By taking the perspective of behavioral and knowledge transparency, nudging with peer thinking activities via shared concept mapping has the potential to help individuals to engage in deeper thinking processes on high-stakes information. In this work, we proposed DeepThinkingMap, a shared concept mapping and commenting interface that affords simultaneous video watching and reflective thinking, and evaluated the engagement in different levels of thinking through a controlled experiment. In summary, the results support that seeing a peer's thoughts and comments

improved the engagement in understanding and reflective thinking, measured using a standardized scale for assessing depth of thinking, but had no significant impact at the level of critical thinking. Also, participants who received the nudging support were shown to engage in the construction of specific comments focusing on analyzing and assessing the health topic.

Our study identifies the potential benefits of utilizing social sharing to empower online users in the context of online information processing through careful nudging design. From our results, the disclosure of individual understanding and reflection can nudge people to take extra efforts to comprehend the information received, and more importantly, reflect deeper on online information that may be fast-spreading but unverified. It reiterates the value of civic engagement, crowd work and the general social sharing of non-expert work with other non-experts. While the quality of shared content remains critical, yet it is not necessarily the only way for such sharing to become useful [10]. For instance, the conceptualization and comments shared by peers may motivate other people to also invest their thinking efforts to reflect on the videos as our design and study illustrated. The conceptual and semantic connections among concepts and comments could also help people overcome visualization barriers to attend to the issues of diversity and to consider what would be the reasonable ways that these concepts and ideas could potentially relate to one another. As the number of peers involved increases, the impact of such social nudge and the visualization mechanism is also expected to scale.

To create more values on social sharing of thoughts, one future direction could be exploring other functions and roles social content could serve, such as disclosing the level of confidence people have on specific information and/or using the content as a starter for free-form conversational interactions for supporting not just personal reflection, but also group deliberation and the grounding of shared knowledge. Furthermore, the current finding suggests more system interventions or recommendations may be introduced to encourage the sharing of conceptual understanding and reflective thoughts, by non-experts, to combat infodemic-related issues, such as misinformation debunking and filter bubble. While much effort has been focusing on using machine learning and automation to label mis- and disinformation for users, our results demonstrated the possibility for people to fight against the influence of online content, even when they are problematic and unlabeled, with appropriate interaction designs that nudge for reflection.

The current experiment has some limitations regarding the nudge content generated. During the nudge process, the content peers shared and visualization could potentially influence the deep thinking trigger. For example, some comments may encourage more opinions and thoughts for peers to share naturally while some others are easy for comments to converge and stop. The concept map organizer may also impact the access of peer comments compared to normal threads. Therefore, future work may investigate whether the existence and presentation of shared content will affect the nudging performance.

To further investigate the influence of DeepThinkingMap on reflective thinking, we plan to study how interactive communications could affect higher-order thinking to supplement the current findings using only one-way nudge design. Previous studies indicate that a myriad of factors may impact nudge performance, such as prior belief and inequity [44]. Social nudge could also fail without considering social expectations and norms [5]. Future studies may investigate the influence of nudge quality and individual dispositions, such where average participants may be less knowledgeable, hold more misconceptions (e.g., environmental sustainability) or become more opinionated, to complete the CHI community's understanding around digital and social nudges for thinking.

## ACKNOWLEDGMENTS

The research is supported in part by UC Davis through Hao-Chuan Wang's startup grant.

## REFERENCES

[1] Kurzgesagt – In a Nutshell. 2015. *The Immune System Explained I – Bacteria Infection.* Retrieved July, 2020 from https://www.youtube.com/watch?v=zQGOcOUBi6s

[2] Lorin W Anderson and David R Krathwohl. 2001. *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives.* Longman.

[3] John A Bargh, Peter M Gollwitzer, Annette Lee-Chai, Kimberly Barndollar, and Roman Trötschel. 2001. The automated will: nonconscious activation and pursuit of behavioral goals. *Journal of personality and social psychology* 81, 6 (2001), 1014.

[4] Md Momen Bhuiyan, Michael Horning, Sang Won Lee, and Tanushree Mitra. 2021. NudgeCred: Supporting News Credibility Assessment on Social Media Through Nudges. *Proceedings of the ACM on Human-Computer Interaction* 5, CSCW2 (2021), 1–30.

[5] Cristina Bicchieri and Eugen Dimant. 2019. Nudging with care: The risks and benefits of social information. *Public choice* (2019), 1–22.

[6] Heather A Butler, Christopher P Dwyer, Michael J Hogan, Amanda Franco, Silvia F Rivas, Carlos Saiz, and Leandro S Almeida. 2012. The Halpern Critical Thinking Assessment and real-world outcomes: Cross-national applications. *Thinking Skills and Creativity* 7, 2 (2012), 112–121.

[7] Alberto J Cañas, Priit Reiska, and Aet Möllits. 2017. Developing higher-order thinking skills with concept mapping: A case of pedagogic frailty. *Knowledge Management & E-Learning: An International Journal* 9, 3 (2017), 348–365.

[8] Ana Caraban, Evangelos Karapanos, Daniel Gonçalves, and Pedro Campos. 2019. 23 ways to nudge: A review of technology-mediated nudging in human-computer interaction. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*. 1–15.

[9] Tanya L Chartrand and Rick Van Baaren. 2009. Human mimicry. *Advances in experimental social psychology* 41 (2009), 219–274.

[10] Robert B Cialdini. 1987. *Influence.* Vol. 3. A. Michel Port Harcourt.

[11] Andrew J Flanagin and Miriam J Metzger. 2000. Perceptions of Internet information credibility. *Journalism & Mass Communication Quarterly* 77, 3 (2000), 515–540.

[12] Martin Flintham, Christian Karner, Khaled Bachour, Helen Creswick, Neha Gupta, and Stuart Moran. 2018. Falling for fake news: investigating the consumption of news via social media. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems*. 1–10.

[13] Christine Geeng, Savanna Yee, and Franziska Roesner. 2020. Fake News on Facebook and Twitter: Investigating How People (Don't) Investigate. In *Proceedings of the 2020 CHI conference on human factors in computing systems*. 1–14.

[14] H Reed Geertsen. 2003. Rethinking thinking about higher-level thinking. *Teaching Sociology* (2003), 1–19.

[15] Google. 2020. *Google Trends in US: health.* https://trends.google.com/trends/explore?geo=US&q=health

[16] Indranil Goswami and Oleg Urminsky. 2016. When should the ask be a nudge? The effect of default amounts on charitable donations. *Journal of Marketing Research* 53, 5 (2016), 829–846.

[17] CW Hu. 2013. A New Measure for Health Consciousness: Development of A Health Consciousness Conceptual Model. In *Unpublished paper presented at National Communication Association 99th Annual Convention, Washington, DC (November 2013)*.

[18] Nicholas K Iammarino and Thomas W O'Rourke. 2018. The challenge of alternative facts and the rise of misinformation in the digital age: Responsibilities and opportunities for health promotion and education. *American journal of health education* 49, 4 (2018), 201–205.

[19] Lucid Software Inc. 2021. *What is a Concept Map.* https://www.lucidchart.com/pages/concept-map#5

[20] Ridley Jones, Lucas Colusso, Katharina Reinecke, and Gary Hsieh. 2019. R/Science: Challenges and Opportunities in Online Science Communication. (2019), 1–14. https://doi.org/10.1145/3290605.3300383

[21] Daniel Kahneman. 2011. *Thinking, fast and slow.* Macmillan.
[22] David Kember, Doris YP Leung, Alice Jones, Alice Yuen Loke, Jan McKay, Kit Sinclair, Harrison Tse, Celia Webb, Frances Kam Yuet Wong, Marian Wong, et al. 2000. Development of a questionnaire to measure the level of reflective thinking. *Assessment & evaluation in higher education* 25, 4 (2000), 381–395.
[23] M Laeeq Khan. 2017. Social media engagement: What motivates user participation and consumption on YouTube? *Computers in human behavior* 66 (2017), 236–247.
[24] Jooyeon Kim, Behzad Tabibian, Alice Oh, Bernhard Schölkopf, and Manuel Gomez-Rodriguez. 2018. Leveraging the crowd to detect and reduce the spread of fake news and misinformation. In *Proceedings of the Eleventh ACM International Conference on Web Search and Data Mining*. ACM, 324–332.
[25] Taewook Kim, Hyunwoo Kim, Juho Kim, and Xiaojuan Ma. 2021. Improving Readers' Awareness of Divergent Viewpoints by Displaying Agendas of Comments in Online News Discussions. In *Companion Publication of the 2021 Conference on Computer Supported Cooperative Work and Social Computing*. 99–103.
[26] Clive Lawless, Pete Smee, and Tim O'Shea. 1998. Using concept sorting and concept mapping in business and public administration, and in education: an overview. *Educational Research* 40, 2 (1998), 219–235.
[27] Jihyun Lee and Hyoseon Choi. 2017. What affects learner's higher-order thinking in technology-enhanced learning environments? The effects of learner factors. *Computers & Education* 115 (2017), 143–152.
[28] Arthur Lewis and David Smith. 1993. Defining higher order thinking. *Theory into practice* 32, 3 (1993), 131–137.
[29] Heidi Oi-Yee Li, Adrian Bailey, David Huynh, and James Chan. 2020. YouTube as a source of information on COVID-19: a pandemic of misinformation? 5, 5 (2020). https://doi.org/10.1136/bmjgh-2020-002604
[30] Margarita Limón. 2001. On the cognitive conflict as an instructional strategy for conceptual change: A critical appraisal. *Learning and instruction* 11, 4-5 (2001), 357–380.
[31] Kapil Chalil Madathil, A Joy Rivera-Rodriguez, Joel S Greenstein, and Anand K Gramopadhye. 2015. Healthcare information on YouTube: a systematic review. *Health informatics journal* 21, 3 (2015), 173–194.
[32] Jennifer A Moon. 2013. *Reflection in learning and professional development: Theory and practice.* Routledge.
[33] Joseph D Novak. 2010. *Learning, creating, and using knowledge: Concept maps as facilitative tools in schools and corporations.* Routledge.
[34] Souneil Park, Seungwoo Kang, Sangyoung Chung, and Junehwa Song. 2009. NewsCube: delivering multiple aspects of news to mitigate media bias. In *Proceedings of the SIGCHI conference on human factors in computing systems*. 443–452.
[35] Jean Piaget et al. 1975. L'équilibration des structures cognitives. Problème central du développement. (1975).
[36] SciShow. 2019. *The Sad Truth About the Turmeric in Your Golden Latte.* Retrieved July, 2020 from https://www.youtube.com/watch?v=Zcy9bfAQ55c
[37] Chengcheng Shao, Giovanni Luca Ciampaglia, Alessandro Flammini, and Filippo Menczer. 2016. Hoaxy: A platform for tracking online misinformation. In *Proceedings of the 25th international conference companion on world wide web*. 745–750.
[38] Cass R Sunstein. 2014. *Why nudge?* Yale university press.
[39] D3 team. 2020. D3 Data-Driven Documents. "https://d3js.org/".
[40] YouTube API Service Team. 2020. YouTube Data API. "https://developers.google.com/youtube/v3/".
[41] Calum Thornhill, Quentin Meeus, Jeroen Peperkamp, and Bettina Berendt. 2019. A digital nudge to counter confirmation bias. *Frontiers in big data* 2 (2019), 11.
[42] W Ben Towne, Carolyn P Rosé, and James D Herbsleb. 2017. Conflict in Comments: Learning but Lowering Perceptions, With Limits. In *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*. 655–666.
[43] Marvin Willerman and Richard A Mac Harg. 1991. The concept map as an advance organizer. *Journal of research in science teaching* 28, 8 (1991), 705–711.
[44] Weiyu Zhang, Tian Yang, and Simon Tangi Perrault. 2021. Nudge for Reflection: More Than Just a Channel to Political Knowledge. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*. 1–10.