MRS Advances (2021) 6:351–354
https://doi.org/10.1557/s43580-021-00069-2

ORIGINAL PAPER

Animated concept-in-context maps as a materials science learning resource in an online flipped classroom

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Received: 16 December 2020 / Accepted: 17 May 2021 / Published online: 24 May 2021

Abstract

The COVID-19 global pandemic has caused a profound change in the teaching pedagogies and assessment strategies in engineering curricula worldwide. Concerning this, the article examines the role of animation-enhanced concept-in-context maps as a learning resource for the introductory materials science course in an online flipped format. The research was conducted on second-year mechanical engineering undergraduates. The methodology used two-group quasi-experimental design where the experimental group received animated concept-in-context maps as a learning resource, in contrast to the control group, which obtained static concept-in-context maps. The student's understanding of the topic was evaluated from their performance in pre-quiz and post-quiz scores. The preliminary results of the pilot study turned out to be in favor of animation-assisted mapping; further research is in process, and in-depth experimentation has been planned.

Introduction

The COVID-19 pandemic has shifted engineering classrooms on virtual platforms. In online teaching, the instructor has limited screen time for delivering lectures to students. It then becomes difficult for an instructor to attend to every students' queries within class hours. This situation restricts the effective teaching–learning process [1]. In such a scenario, the online flipped classroom model has garnered much interest among engineering instructors for wisely utilizing classroom time to meet student's needs [1, 2].

In an online flipped classroom method, the appropriate and necessary learning materials are shared with the students before the class session. So that the students can grasp the content in their personal learning space [2, 3]. However, the earlier studies on the flipped classroom model insist upon video-based instruction, participation in learning activities with little attention to the development of higher-order thinking skills [4–6].

Toto et al. [7], in their research study, pointed out the need for well-ordered and in-depth learning resources instead of lengthy lecture films. Prior educational research documents the effectiveness of diagramming tools, such as concept maps, mind maps, and knowledge graphs as in-depth, organized learning resources [8–10]. Drawing upon these findings, this study presents animated concept-in-context maps (A-CC maps) as a multimedia resource to foster deeper learning in a materials science course for engineering students.

A brief overview of concept-in-context maps (CC maps)

Concept-in-Context maps are gaining interest in the multidisciplinary domain of materials science. These maps are visual illustrations that connect science with its real-world engineering manifestations [11]. The creation of concept-in-context maps considers the combined attributes of concept (C-maps) and mind maps to organize the information [11]. The layout of CC maps emphasizes how to interrelate and hierarchically arrange ideas through relevant details, such as figures, tables, images, mathematical equations etc.[11]. A section of a concept-in-context map related to the failure of metals is shown in Fig. 1.

In the limited available literature on concept-in-context maps, the static format of maps has been used to instruct and assess students learning in the introductory materials science and engineering course [11–13]. In a recent study by authors, it has been observed that the large structure and inherent 'messiness' of concept-in-context maps make

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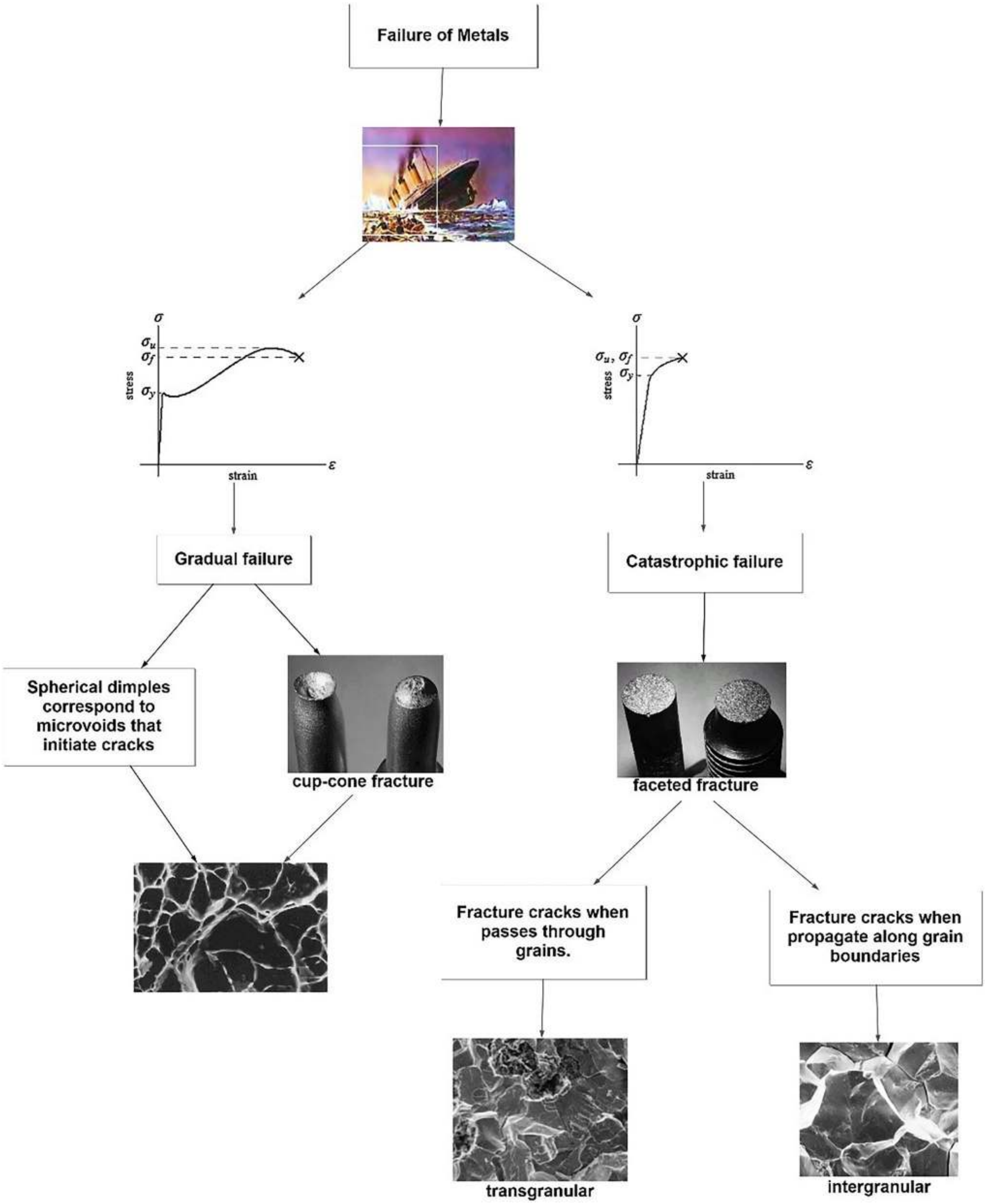

Fig. 1 A section of a concept-in-context map on the failure of metals [11, 13]

it difficult for learners to read and reach its interpretation systematically [13]. This visual complexity can be reduced by presenting the information in a learner-paced animation format.

A study of related work indicates that while there are individual studies on concept-in-context maps, animation, and online flipped classrooms, there is no literature on using animation-assisted concept-in-context maps for learning in an online flipped format. The present study addresses how animated CC maps can be used to graphically represent and organize the learning material in a flipped classroom.

Methodology

This is a two-group quasi-experimental research study conducted with the participation of 30 second-year mechanical engineering students registered in a private engineering university in Pune, India. The participants were placed into two groups: the experimental group ($N = 15$) and the control group ($N = 15$). The experimental group received study content in the form of animated concept-in-context maps, while the control group obtained the same concept-in-context maps for study in static form. The two major topics of the materials science course (1) failure of metals and (2) diffusion were considered for the pilot study. The authors used the concept-in-context maps (on the topics) prepared by Triplett et al. [11] for conducting this pilot study.

The effect of animated concept-in-context maps (A-CC maps) and static concept-in- context maps (S-CC) on students' performance was evaluated online from pre-quiz and post-quiz tests using google forms. The pre-quiz measured students' prior knowledge of the topics are considered in this study. The post-quiz was conducted to evaluate the students' achievement after the A-CC and S-CC map intervention. The pre-quiz and post-quiz contained 30 multiple-choice questions. The reliability KR-20 of the pre-quiz was 0.73, while that of the post-quiz was 0.75. In the end, students' views on A-CC mapping as a learning resource were recorded through the google feedback form. The feedback questionnaire consisted of six statements and was rated on a Likert's 5-point scale with options ranging from strongly disagree (1) to agree (5) strongly. The Cronbach's alpha of this scale was 0.82.

Procedure

The study was carried out in two weeks. In the first week, the instructor explained the idea of concept-in-context maps and demonstrated the strategies to—(a) identify key concepts, (b) arrange hierarchy, and (c) connect concepts with branches or crosslinks using the Inspiration™ tool (computer software) to both groups. The learning material was shared with the two groups through a group email. The groups were given one week to study from the learning aids. The post-quiz was taken at the end of the second week. Further, the experimental group was asked to fill the online feedback google form to share their views and learning experience with animated concept-in-context maps.

Results

The experimental group ($N = 15$) secured an average score of 17.36 in the pre-quiz. The control group received a mean score of 15.80 out of the highest possible score of 30. A *t*-test for independent samples showed an insignificant difference in the mean score of the two groups; $t = 1.21$, $p > 0.05$ (Table 1).

The post-quiz score summarizes scores obtained from solving knowledge level (KLQ) and comprehension level (CLQ) questions. A t-test for independent samples was carried out to determine the impact of CC map with animation and static effects on the abovementioned cognitive levels of learning (Table 2). A significant difference was found at the recall level ($t = 3.72$, $p < 0.05$) and at the comprehension level ($t = 3.28$, $p < 0.05$).

Table 1 Statistics on pre-quiz scores of experimental and control group—($N = 15$)

	Experimental group		Control group		t	p
Measure	Mean	Standard deviation	Mean	Standard deviation		
Pre-quiz	17.36	5.92	15.80	4.04	1.21	0.22

Table 2 Post-quiz performance at the recall and comprehension level of experimental and control group—($N = 15$)

	Experimental group		Control group		t	p
Measure	Mean	Standard deviation	Mean	Standard deviation		
KLQ	12.87	1.59	10.27	1.72	3.72	0.007
CLQ	11.04	1.47	7.76	2.60	3.28	0.002

Table 3 Views of students on different aspects of animated CC map (using the LIKERT SCALE)

S. No	Item	% support/ strongly supported
1	Animated CC maps helped to correlate science with its engineering application	86.40
2	Animating CC maps were simple and smooth	79.02
3	CC maps can guide you while referring to other learning resources like textbooks and video lectures	89.35
4	Animated CC maps assisted in visualizing, remembering and comprehending various concepts	93.80
5	The intervention of animated CC map motivates you to apply in different materials science topics	82.28

The results (Table 2) suggest that the intervention of animation-enhanced concept-in-context maps positively impacts students' achievement scores. Specifically, the results indicate that when CC maps were animated, the participants scored relatively higher on the same questions than those treated with static CC maps.

Table 3 lists the feedback of students on various aspects of the animation-enhanced concept-context map. Most of the students (93.80%) felt that animated CC maps helped them to understand the content through clear visual illustrations. A high proportion of students (86.4%) agreed upon the ability of animated CC maps to connect science to real context better. Most of the students (79%) found the construction of animated CC maps simple and easy. About 89% of students reported using animated CC maps as a multimedia guide while referring to textbooks and lecture films. Many students (82%) agreed to develop animated CC maps for other materials science contents. The feedback of students supports the potential of animated CC maps in developing knowledge frameworks.

Conclusion

The preliminary findings show the potential of animated concept-in-context maps as an influential online multimedia learning resource. The animation of (CC) maps guides students to establish a link between different concepts and boosts their learning ability. Thus, allowing learners to correlate content at their own pace.

A more detailed study is in process, and the extended outcomes will be reported in the near future.

Acknowledgements The authors extend their sincere gratitude toward students and instructors for their online cooperation to carry out this study amid the COVID-19 pandemic.

Declarations

Conflict of interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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