The effect of case nodes in problem-based learning on the length and quality of discussion: a 2x2 factorial study

L'effet du nœud dans le scénario sur la durée et la qualité de la discussion dans l'apprentissage par problèmes : une étude factorielle 2x2

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Abstract

Background: Problem-based learning (PBL) relies heavily on case structure for their success. To make more meaningful cases, faculty introduced a "case node" that requires students to make a group decision on the action they will take at a given point in the case. The purpose of this study was to determine whether case nodes enhance PBL discussions.

Methods: Two PBL cases were designed with and without a node. In 2011, 2012, and 2015, first-year medical students were assigned one PBL case with a node and one without a node. In total, 26 groups processed cases with a node while 27 groups processed the same cases without the node. All sessions were audio recorded and analyzed to determine the length and quality of discussions.

Results: Groups with a node, regardless of case ($M = 25.62$, $SD = 12.25$) spent significantly more time in discussion on the node topic than those without a node ($M = 16.54$, $SD = 10.33$, $p=.005$, $d = .80$). Groups with a node, regardless of case ($M = 14.38$, $SD = 8.04$) expressed an opinion significantly more frequently than those without a node ($M = 6.07$, $SD = 5.80$, $p < .001$, $d = 1.19$).

Conclusions: Case nodes increased both the length and depth of discussion on a topic and may be an effective way to enhance case-based instruction.

Résumé

Contexte : Le succès de l'apprentissage par problèmes (APP) repose en grande partie sur la structure des cas. Pour rendre les cas plus significatifs, les membres du corps professoral ont introduit dans les scénarios un « nœud », ou un point nodal, marquant un moment où les étudiants doivent prendre une décision de groupe quant à l'action à entreprendre. L'objectif de cette étude était de déterminer si les cas comportant de tels points nodaux amélioraient la discussion dans le cadre de l'APP.

Méthodes : On a conçu deux cas d'APP en deux versions, l'une comportant un nœud, l'autre non. En 2011, 2012 et 2015, on a soumis à des étudiants en première année de médecine un cas d'APP avec un nœud et un cas sans nœud. Au total, 26 groupes ont travaillé sur le cas avec un nœud et 27 groupes sur le cas sans nœud. Toutes les séances ont été enregistrées et analysées afin de déterminer la durée et la qualité des discussions.

Résultats : Les groupes qui ont travaillé sur un cas comportant un nœud, quel que soit le cas ($M = 25.62$, $SD = 12.25$), ont consacré significativement plus de temps à la discussion que ceux qui avaient un cas sans nœud ($M = 16.54$, $SD =1 0.33$, $p = .005$, $d = .80$). Les premiers ont également exprimé des opinions significativement plus fréquemment, quel que soit le cas ($M = 14.38$, $SD = 8.04$), que les seconds ($M = 6.07$, $SD = 5.80$, $p < .001$, $d = 1.19$).

Conclusions : Les nœuds introduits dans les cas ont entraîné des discussions à la fois plus longues et plus approfondies sur le sujet abordé. Par conséquent, ils constitueraient un moyen efficace d'améliorer l'enseignement fondé sur l'étude de cas.

Introduction

Many medical schools around the world use problem-based learning (PBL) or some variation to train pre-clerkship medical students. PBL incorporates elements of small cooperative groups.[1,2] It is important to create effective PBL problems,[3,4] however, we found little evidence to support specific elements of the PBL small group experience. Much advice is only based on personal experiences, careful observations, and anecdotes.[5] We located only a few articles that used empirical data to compare variations in case presentations.[6-11] While these studies found promising results, they did not use a theory to explain their findings. Cooperative learning may be helpful in that regard.

Cooperative learning (CL)[1,2] highlights the importance of five key elements that together contribute to high levels of collaboration and effective group activity.[1,12-14] The one feature that is most germane to our study is *promotive interaction.* Promotive interaction is the collaboration that takes place when individuals are engaged in purposeful, relevant activity such as joint decision-making. Improving promotive interaction according to CL theory[12,13] improves small group experience and subsequently student learning. Our "case node" innovation falls within this element of cooperative learning.

For many years, educators at John A. Burns School of Medicine (JABSOM) used a local innovation in their PBL cases they called "nodes," a place where the students needed to make a joint decision. We knew from internal data and our own observations that case nodes increased student engagement and that students seemed to remember and enjoy the cases with nodes more than those without. We decided to test empirically our hypothesis that the case nodes were effective tools for enhancing PBL discussions and enlisted the support of colleagues from the University of Saskatchewan (authors MD and KT) to conduct this study. The purpose of our study, therefore, was to provide some evidence that the case nodes improved the discussions at that point in the PBL case. We speculated that we would find more time spent in discussion on each node and a greater number of statements reflecting the following criteria: 1) expressing opinions, 2) providing justifications, 3) asking others for opinions, and 4) sharing personal experiences. We created these categories based on our prior personal observations facilitating groups, especially from what had been informally observed when using case nodes.

Methods

IRB approval: This study was approved in September of 2011 by the University of Hawaii Committee on Human Studies and remained active for the duration of the study period (2011-2015). A requirement by the institution for an annual review has since been approved, but was not in effect at the time of our study.

Setting

This study took place at JABSOM at the University of Hawaii. PBL is required and is the main educational modality, occurring for three hours each on Mondays and Thursdays, and is supported by two half-days (3-4 hours) of related lectures that are optional and occur between the PBL sessions. JABSOM PBL consists of presenting small groups of medical students (five or six), under the guidance of a tutor/facilitator, with a multi-page clinical case organized by chief complaint, history, physical exam, diagnostics, and clinical course. Students respond to each page of the case by determining the facts and problems, creating/refining a list of potential diagnoses, deciding what more they need to know from and about the patient, what aspects of the case they wish to research in the biological, clinical, populational and behavioral domains, and then at the next session, presenting and discussing their new knowledge to better understand the patient's situation. One modification to JABSOM's PBL cases is called a "case node" that asks the group of students to make a collective decision that affects how the case ends. Both groups have similar suggested learning priorities and are allowed to see the alternate pages at the conclusion of the following session, when the case is completed.

Study design, participants, and sample size

In 2011, 2012, and 2015, we assigned PBL groups consisting of all first-year medical students in the course on cardiovascular and pulmonary disease, to one of two PBL cases designed to have a node. This was the first time that students had experienced a case node at JABSOM. One case involved a request for physician-assisted suicide (PAS) before this was legal in Hawaii, in which the students had to decide whether they would or would not provide PAS. The other case presented a grateful patient who offers the physician a handcrafted gift of precious wood in which the students had to decide whether they would or would not accept the gift.

We set the study up as a 2x2 factorial design with the main effects of case node (case node – no case node) and the type of case (ethics of receiving gifts – ethics of PAS). We

were also interested in interaction effects between node or no node and type of case. All students experienced one of these two cases as a node, and the other case without a node. No case node meant the way the PBL cases were usually conducted: no requirement for a collective decision and no opportunity to affect the outcome of the case. Assigning groups to receive the first or second case node were based on whether the group was numbered odd or even after all groups were ordered alphabetically by the faculty tutor's last name.

For groups with a case node, when the students arrived at that point in the case, the tutor told the students that before moving on, they all needed to discuss and then come to a group decision that would determine how the case ended. For groups without a case node, the tutors encouraged a discussion but did not suggest they needed to decide as a group before moving on.

Data collection

We distributed an IRB-approved form to all students to inform them and receive their consent in being audio-recorded and for us to use their data for research purposes. We audio recorded those tutorial groups in which all students gave consent using a small, unobtrusive recording device. This allowed us to maintain the PBL environment as similar to "normal" as possible. We were concerned that the presence of "strangers" observing and conducting research would inhibit the discussion.

Analysis

We downloaded and then extracted data directly from the audio files using a simple quantitative content analysis.[15] For each group, we recorded time spent in discussion on each node and identified and tallied the number of statements reflecting the following criteria: 1) expressing opinions, 2) providing justifications, 3) asking others for opinions, and 4) sharing personal experiences.

MD trained our research assistant (RA). MD had been a PBL facilitator at his home institution and had published short articles about PBL. The RA was a JABSOM medical student at the time and had experienced case nodes while in training. MD and the RA first met to discuss the scoring rubric and then independently listened to and analyzed an audio recording of one of the groups. They then compared scores and discussed the results. After one more time independently completing an analysis of a different group recording, their scores were again very similar and we were confident that our RA was prepared to conduct the rest of the analysis on his own. Our RA completed the scoring for 2011 and 2012. For the 2015 data, our RA had graduated

and we felt that it would be most consistent to have MD do the analysis.

We conducted an Analyses of Variance (ANOVAs) using SPSS software to identify main effects of case (ethics of receiving gifts vs. ethics of PAS), of condition (case node vs. no case node), and the interactions between the two. While our primary purpose was to test our hypothesis that the nodes improved discussion, we were concerned that the topic of the case might affect the impact of the node. We therefore explored interaction effects. We also calculated *post-hoc* effect sizes (Cohen's *d*) as a measure of practical importance where .2 is considered small, .5 medium, and .8 large.

After collecting and analyzing data from 2011 and 2012, we found a moderate effect size (d = .40). When we conducted a post-hoc power analysis, we found we needed a total sample size of 52 groups for this effect size to be statistically significant. We collected an additional year of data in 2015. In all, twenty-seven groups did not have a case node, and 26 had one. Our total sample size was 53 groups, which met our power calculations.

Results

To justify grouping the data from the first two years analyzed by our RA and the third year of data analyzed by MD, we conducted an ANOVA and post hoc analyses. We found one statistically significant difference between the two sets of data using t-tests. MD had identified more examples of justifications in both the node (*p* = .032) and the no node (*p* = .026) groups. We therefore aggregated the two sets of data as the differences would not likely affect the comparisons between node and no node groups.

When comparing the aggregated data for all 53 groups, we found four main effects, two for the case node (Table 1) and two for case content (Table 2) but did not find any interaction effects. Groups with a case node, regardless of which case, spent more time in discussion and expressed opinions more frequently than those who did not experience a case node. These significant differences had large and very large effect sizes, respectively.

For case content, groups in the PAS-request case, regardless of whether they had a node, spent significantly more time in discussion than those in the gift-giving case. Students in the gift-giving case, regardless of whether they had a node, were significantly more likely to share their personal experiences and opinions than those in the PAS-request case. These differences had medium and a large effect sizes, respectively.

Table 1. Comparison of groups with and without a case node

Case	Criteria	Case Node		No Case Node			
		M	SD	M	SD	p	d
Cardiovascular Case (request from patient to accept a hand-crafted gift)	Total time in discussion* (minutes)	21.6	12.4	11.7	7.4	.025	.99
	Opinion* (frequency)	16.0	10.2	5.0	3.7	.002	1.48
	Justification (frequency)	14.5	13.9	12.9	11.4	.758	.13
	Asking others for opinion (frequency)	9.8	5.7	8.2	5.3	.486	.29
	Sharing personal experiences (frequency)	4.0	3.7	3.8	3.7	.880	.06
Pulmonary Case (request for physician assisted suicide)	Total time in discussion (minutes)	28.6	11.7	21.0	10.9	.083	.67
	Opinion* (frequency)	13.2	6.1	7.1	7.3	.020	.92
	Justification (frequency)	18.2	1.0	8.2	9.5	.064	.72
	Asking others for opinion (frequency)	9.5	5.3	7.1	6.5	.274	.42
	Sharing personal experiences (frequency)	1.2	2.4	1.4	1.8	.778	-.11
Both Cases	Total time in discussion* (minutes)	25.6	12.2	16.5	10.3	.005	0.80
	Opinion* (frequency)	14.4	8.0	6.1	5.8	<.001	1.19
	Justification (frequency)	16.6	15.6	10.4	10.5	.122	.47
	Asking others for opinion (frequency)	9.7	5.4	7.6	5.6	.207	.36
	Sharing personal experiences (frequency)	2.4	3.3	2.6	3.0	.999	-.05

* Statistically significant difference

Table 2. Comparison of groups between the two ethical topics

Criteria	Cardiovascular Case (request from patient to accept a hand-crafted gift)		Pulmonary Case (request for physician assisted suicide)			
	M	SD	M	SD	p	d
Total time in discussion* (minutes)	16.3	11.0	24.9	11.8	.009	-.76
Opinion (frequency)	10.0	9.2	10.2	7.3	.852	-.02
Justification (frequency)	13.6	12.3	13.4	14.6	.905	.02
Asking others for opinion (frequency)	9.0	5.4	8.3	6.0	.651	.11
Sharing personal experiences* (frequency)	3.9	3.6	1.3	2.1	.003	.89

* Statistically significant difference

Discussion

When conducting our literature review, we found no empirical evidence for the effectiveness of specific elements within a PBL case. We only found advice about how to write cases mainly based on personal experiences.[5] While there have been studies of "triggers" in PBL[16] these have been about the case as a whole without exploring the specifics of the case as we have done. One study did analyze the texts of cases[17] exploring how they represented patients, not for their pedagogical elements such as features of CL. We have therefore situated our study within a literature that has not investigated specific features of small group cooperative learning.

The results from our study show that the case node increased both the time spent in discussion and the frequency of statements of opinion over and above not having a node with simple facilitator encouragement to discuss. This empirical evidence means that the nodes did improve some aspects of the discussion in keeping with the value of *promotive interaction* as postulated in CL theory and could result in improved learning.

We found no other statistically significant differences in the other criteria measured: providing justifications and asking others for opinions. While the means were higher for the nodes for both cases, these differences were not statistically significant. In the gift giving case, the means for justification were 14.5 with the node and 12.9 without the node, and for asking opinions, the means were 9.8 and 5.3. In the PAS case, the means for justification were 18.2 with the node and 8.2 without, and for asking opinions, the means were 9.5 and 7.1. Additional differences in support of our hypothesis would have strengthened our case; however, the results that were not statistically significant did not weaken it either.

We believe as well that the differences between the data from the first two years and the third year, even though MD found more examples of justification in the 2015 data than RA found in the 2011 and 2012 data, did not materially bias the results in favor of justifications. We found no statistically significant differences between the node and no node groups in statements of justification.

The situations discussed in the cases were also important. There was a large and statistically significant main effect of

the case on sharing personal experiences and time on discussion. The situation of gift giving is much more common and so we would expect it to stimulate the recall of more personal experiences than that of physician-assisted suicide. Perhaps situations that are closer to the lived world of students would stimulate their recall and increased sharing of personal experiences.

Nodes are a practical innovation. Inserting a case node into existing cases is relatively simple. Educators at other institutions can easily apply this innovation to existing PBL cases in any institutional setting and perhaps in other small group case-based curricula such as team-based learning, peer assisted learning, and inter-professional education as suggested by Johnson & Johnson and McKee. Educators could also use nodes that involve diagnostic, therapeutic and management decisions in clinical case discussions in the clerkship years and/or in residency. We are confident in promoting this innovation for other PBL and small group learning approaches.

Limitations

There are several limitations to our study. It was impossible to blind the condition (node or no-node) from those who did the analysis, as the recordings clearly highlighted the conditions of the discussion especially if it was a case node. Use of non-author coders may have avoided a confirmation bias. However, two effects were unexpected (more time in discussion for the request for PAS case and more sharing of personal experiences for the gift-giving case) which provide some indication of impartial analysis.

Some facilitators were more active than others during the group discussions. Since it was not possible when listening to the audio recordings to distinguish the tutor from the students, all comments for all group members (students and tutors) were counted. This addition may have affected the results.

Only one researcher extracted data from the audio recordings (our research assistant) for 2011 and 2012 and then a different researcher (MD) extracted the data from the audio recordings from 2015. Ideally, two researchers would listen, extract, and compare data to arrive at consensus. This was not feasible in our situation and may have affected the data. However, consensus between our RA and MD was achieved during training and subsequent analysis between RA and MD showed one statistically significant difference that was deemed unlikely to affect the comparisons in our study.

An anomaly in this study is the time lapse between the first data collection points in 2011 and 2012 and the third in 2015. Although the interest value of the situations we used (PAS and gift giving) may have changed from 2012 to 2015, the structure of the PBL cases utilized in this study did not. Furthermore, JABSOM continues to use case nodes in their PBL cases, one related to PAS (but modified slightly given that PAS was legalized in Hawaii) and others related to cultural competence and cultural humility.

Conclusion

Our study demonstrated that the addition of case nodes to the PBL small group process resulted in more time spent in discussion and more opinions being offered in discussion. We found no other statistically significant differences that might have called our hypothesis into question. We also found that the topic of discussion did matter. There was more sharing of personal experiences in the gift-giving case and more time spent in discussion for the PAS case. To enhance the PBL experience, educators may find it helpful to use innovations to support promotive interaction such as nodes, and topics or situations such as gift-giving, that are closer to the lived world of students to promote sharing.

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