Effectiveness of Field Simulation Approach for Problem-Based Learning That Incorporates the One Health Concept

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ABSTRACT

One Health problem-based learning (PBL) is known as an effective method in teaching zoonotic diseases. However, the classic classroom setting limits real-life exposure for students. Simulation-based learning may improve the learning experience without exposing the students to unnecessary risks. Hence, this study aimed to assess the effectiveness of field simulation PBL compared to a classic classroom setting using a module developed based on the One Health concept by examining the students' reactions to the learning and by assessing the students' performance. A quasi-experimental design was adopted in this study. Veterinary and medical undergraduate students participated in both types of PBL settings, and their knowledge and satisfaction were evaluated through a pre- and post-test as well as a feedback survey. The mean satisfaction score of students undergoing field simulation was significantly higher than the mean satisfaction score of students undergoing classic PBL ($p > .05$). The respondents from both programs found the field simulation, in comparison to classic PBL, was more effective, and they were more satisfied with the overall learning experience, workloads, and facilitation. The attainment of the cognitive domain was comparable between both PBL groups, which was possibly due to the type of assessment used. In conclusion, field simulation enhanced the students' positive learning experiences as they exhibited better attitudes toward learning. Future studies on the impact of the simulation on long-term knowledge retention and psychomotor skills are thus warranted.

Key words: One Health, problem-based learning, field simulation, veterinary medicine, medicine

INTRODUCTION

Medical and veterinary-based education needs to be constantly evolved to face the accelerating amount of clinical and research information. The transition was made from being teacher-based learning, which relied mostly on didactic lecture series and memorising, to an active learning process. Students are encouraged to decipher, analyze, evaluate, and reevaluate to achieve their learning objectives instead of just churning out the information given. With the active learning process, students would acquire transferable skills such as critical thinking, collaboration, and problem solving that can be applied to any disciplines and are ingrained in their lifelong learning process when working in the health care industry.[1,2]

Problem-based learning (PBL) was first introduced in medical schools in the mid-1960s as a teaching method for active learning to encourage problem-solving skills in medical education and is considered an alternative option in veterinary curricula.[3–5] Over the years, small-group active learning approaches such as case-based learning, team-based learning, and simulation-based learning were introduced, in which the students were given information and topics prior to discussion.[6] The case-based learning is preferred over PBL by learners due to structured discussion and less time-consuming nature of case-based learning, while team-based learning has an advantage in terms of its standardized assessment. Simulation-based learning, on the other hand, has been shown to increase the students' understanding as it involves learning through experience and encompasses team-based discussion.[7,8] In contrast to didactic teaching, simulation activities provide opportunities for the students to have on-site experience to develop their clinical skills that are required when working in the industry. These simulation activities expose the students to real-life scenarios, stimulate their critical thinking for independent learning, and engage them in their learning. In addition, simulation-based learning also benefits the students by allowing them to manage a scenario and reflect on their mistakes without placing actual risk.[9,10] This results in a learning approach that facilitates retention of knowledge so that they can readily apply the knowledge in the future.

The One Health concept is a renamed concept based on the *One Medicine* concept coined by Sir W. Osler.[11] The benefits of the One Health approach are substantial in that it promotes the advancement of biomedical research and scientific knowledge, increases the efficiency of the public health approach, and avoids the use of redundant resources.[12] However, still there are barriers to getting the concept across multiple disciplines. Problem-based learning is an educational strategy in the One Health approach whereby students from multiple disciplines collaborate to enhance their learning through real-life experience.[7,8,13] Medical students are often trained to address issues related to humans, while veterinary students only focus on animals, thus limiting the benefits of the One Health approach. Zoonotic diseases are used in the One Health-based PBL as it involves inter-professional integration and communication, including public health, community clinics, tertiary hospitals, and veterinary services. On the other hand, the classic classroom PBL, which involves group discussions, has been proven effective in improving students' understanding of various topics, although it limits real-life exposure among students.[14]

Therefore, this study aimed to assess the learning effectiveness of field simulation PBL in comparison with a classroom setting using a module developed based on the One Health concept. On account of the importance of the One Health concept in zoonotic disease outbreaks and the educational gap of students across multiple disciplines, this study incorporated a development of a field simulation PBL module based on a rabies disease outbreak. The outcome of this module and its field simulation was aimed to address the barriers involving the One Health approach and the preparedness of our future medical doctors and veterinarians in facing disease outbreaks.

MATERIALS AND METHODS

Study Design

Participants consisted of undergraduate students from two programs: all 103 (100%) final-year Doctor of Veterinary Medicine (DVM) students and 26 out of 99 (26.2%) third-year Bachelor of Medicine and Surgery (MBBS) students from Universiti Putra Malaysia (UPM) (Figure 1). The participants were required to undergo a training program during the study. The training program was compulsory for the DVM students as it was a component of the core curriculum, while it was not compulsory for the MBBS students. Due to difficulty in finding mutual timing between these two cohorts of students, participation from the MBBS students was on a voluntary basis, resulting in a small number of MBBS students participating in the training programme.

A quasi-experimental design was utilized in this study. The participants were assigned in no particular order to be either in the control group (classroom) or the experimental group (field simulation). Within these two groups, the students were further divided into smaller subgroups with stratification based on gender and ethnicity. Another criterion used to assign the participants among the DVM students was academic performance, where each subgroup consisted of students with different levels of academic performance. Due to a logistic limitation to transport the experimental groups to the study area, only a maximum number of 55 students were accommodated. Ethical clearance was obtained from the Ethics Committee for Research involving Human Subjects, Universiti Putra Malaysia (JKEUPM-2018-261). Written consent forms were collected from all participants prior to the commencement of the training program.

Development of PBL Case

A rabies disease outbreak module was used to run a field simulation based on the One Health concept. Rabies was chosen due to the occurrence of a recent rabies outbreak and the potential of reoccurrence due to the endemic rabies status in the neighboring countries such as Indonesia and Thailand. Representatives from the Faculty of Veterinary Medicine, Faculty of Medical and Health Sciences, Department of Veterinary Services, and Ministry of Health were involved in developing the rabies case for the experimental and field simulation PBL. Six stations were used for both groups, each with intended learning outcomes. The rabies case was written in two parts to address the learning outcomes: (a) case prompts, which consisted of background information of the rabies case for students and notes for facilitators for each station (see Supplementary Information 1); and (b) case module, which consisted of items and activities for each station as guidance for the facilitators. The first three stations revolved around medical aspects focusing on history taking, clinical presentation of viral encephalitis, decision making on sample collection, diagnostic procedures, interpretation on clinical findings, management of rabies encephalitis, and disease control. The next three stations emphasized the veterinary components including disease notification, field investigation, disease control, and surveillance, followed by public awareness campaigns. The module content and the study instrument were evaluated and approved by committee members and three independent experts, namely a veterinary pathologist with research emphasis on rabies, a clinical microbiologist with One Health training, and a clinical microbiologist with medical education expertise.

Development of Study Instrument

A test with 60 multiple-choice questions was developed to assess the students' knowledge on rabies. Three independent expert assessors who assessed the module also validated and reviewed the pre- and post-test questions and scored them based on a 4-point scale: highly relevant, relevant, irrelevant, completely irrelevant (see Supplementary Information 2 and 3). Only questions that scored highly relevant and relevant were utilized in this study. The post-test questions were paraphrased and arranged in a random order to avoid recall bias. A modified feedback survey using a 5-point Likert scale to measure the students' reaction was used (1—strongly disagree, 2—disagree, 3—slightly agree, 4—agree, and 5—strongly agree) (see Supplementary Information 4).[15,16] Seven domains evaluated through the feedback survey included overall satisfaction, clear goals, appropriate workload, effectiveness, independence, overall experience, and feedback on the facilitator.

Study Conduct

The field simulation was conducted in 2 days in Hulu Perak district, Perak Darul Ridzuan, Malaysia. The location was chosen based on the area's previous history of rabies outbreaks and because this location provided a new and *in situ* environment for the students so that they could better visualize the different environmental factors that could account for disease transmission. Each case prompt was designated a station where the students would interact with simulated patients or actors. The students in the experimental groups had to go to six simulated stations with a zoonotic outbreak theme, which required team discussions, site investigations, and creation of a manage-

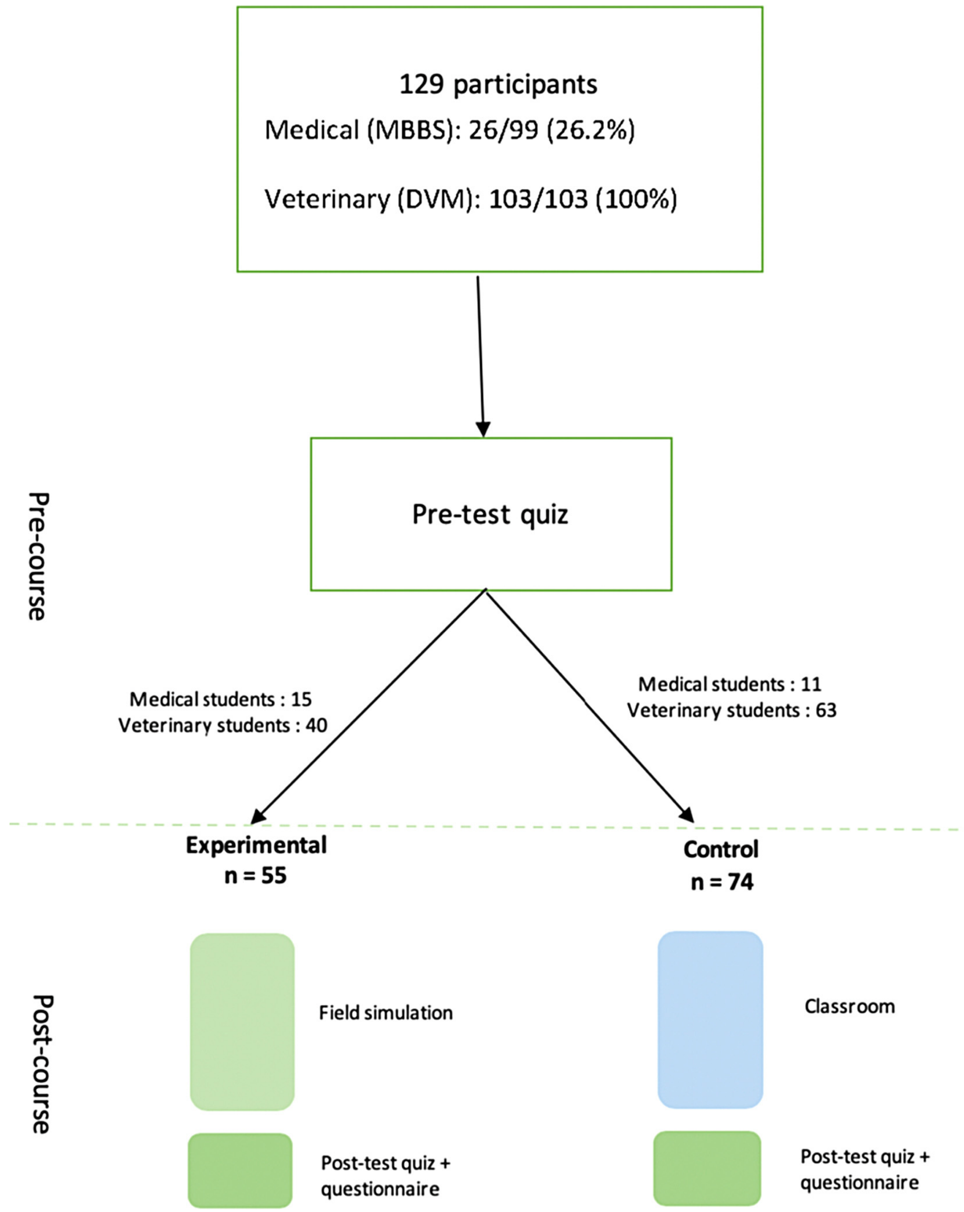

Figure 1: Overview of field simulation vs. classroom PBL activities

ment protocol. They had to perform interviews, handle affected patients, conduct surveillance, and control the rabies outbreaks. At the end of every station, the students were expected to come up with learning issues under the guidance of a facilitator. For the control group, the PBL activity was conducted in a classroom setting 1 week after the field simulation, which took place at the Faculty of Veterinary Medicine, UPM. The classroom PBL was carried out over two sessions of 3-hour durations. Similar case prompts were used like the experimental groups and were conducted in accordance with the standard PBL methods. A dedicated workshop was organized to train all facilitators prior to both exercises. A debriefing session for facilitators was conducted shortly after both PBL training programs to discuss concerns and insights regarding the PBL sessions.

All participants in both groups answered pre- and post-test quizzes that consisted of 60 questions. The participants also completed a feedback survey after the PBL training. Experts from the Ministry of Health and Department of Veterinary Services, Malaysia, who were involved in the field handling of zoonotic outbreaks, acted as observers during the experimental activities. They were then invited for a debriefing session to provide feedback to all the participants on the flow and protocol of zoonotic outbreak investigation intra- and inter-agency, incorporating the importance of the One Health concept. The students were also required to collaborate to develop a campaign awareness strategy as a part of the outcomes, of which the invited experts evaluated their products. However, the results were not a part of the analyses in this study.

Statistical Analysis

Data from both groups were analyzed using an independent sample *t*-test and factorial repeated measure one-way ANOVA. Demographic profiles and descriptive statistics such as mean and standard deviation were used to represent the data.

Table 1: Demographic characteristics of classroom PBL and field simulation PBL groups

	(Classroom PBL) Control group $n = 74$	(Field simulation PBL) Experimental group $n = 55$
Gender		
Male	17	12
Female	57	43
Program		
Medicine year 3	11	15
Veterinary medicine year 5	63	40
Ethnicity		
Malay	46	26
Chinese	17	16
Indian	5	7
Others	6	6

A p value of $\leq .05$ was considered as significant. All analyses were performed using SPSS software version 24.0 (IBM, USA).

RESULTS

The demographic characteristics of respondents in the classroom and field simulation groups are summarized in Table 1. Overall, a total of 129 students participated in the study, consisting of 103 DVM students and 26 MBBS students. Of these numbers, 74 ($n = 63$ among DVM students and $n = 11$ among MBBS students) involved in the classroom PBL and 55 ($n = 40$ among DVM students and $n = 15$ among MBBS students) participated in the field simulation (Figure 1). The gender distribution was dominated by female students, with 85% and 73% for classroom and field simulation, respectively. One fifth of the total participants were MBBS students. More than 50% of the respondents were Malay, followed by Chinese at 26%, and Indian and other ethnicities, each recorded 12%.

The students' overall post-score was 61.4 ± 0.7, which was higher than the pre-test score mean of 55.6 ± 0.8, as shown in Table 2. Also, the differences between the pre-test score and post-test score, as shown in Table 3, were significant: $F(1,119) = 72.5$, $p < .05$. However, a comparison of pre- and post-test scores between the simulation (experimental) and classroom PBL (control) groups showed no significant difference ($F[3,119] = 2.0$, $p = .114$). In addition, the pre- and post-test score differences between gender as well as program were not statistically significant (data not shown). The overall learning experience between the control and experimental groups through the feedback survey was also evaluated. Table 4 compares the results of the satisfaction survey results between the control and experimental groups. The overall satisfaction score of students in the experimental group was significantly higher than the overall satisfaction score of students in the control group. Respondents in the experimental group found that the field simulation was more significantly effective than the classroom PBL, and they were more satisfied with the overall learning experience, workloads, and facilitation than the control group. The clear goals domain did not show a significant difference between both groups. However, this was expected as similar objectives were set for both groups.

Table 2: Overall mean differences in knowledge score pre- vs. post-test for both simulation vs. classroom activities

	Mean ± *SD*	Range (95% CI)
Pre-test score	55.6 ± 0.8	54.1–57.1
Post-test score	61.4 ± 0.7	60.1–62.8

Table 3: Differences in test score between students attending two different types of PBL

Variables	*df*	*MS*	*F*	*p*
Pre–post overall	1	1,348.3	72.5	.000
Pre–post between groups	3	37.7	2.0	.114
Error	119	18.6		

Table 4: Mean differences on students' overall experience score in classroom PBL and field simulation PBL

	Classroom PBL (Control group) ($n = 74$)	Field simulation PBL (Experimental group) ($n = 55$)	*p*
Overall satisfaction	3.58 ± 0.50	3.90 ± 0.38	.000*
Clear goals	3.54 ± 0.41	3.65 ± 0.38	.121
Appropriate workload	3.18 ± 0.74	3.62 ± 0.74	.001*
Effectiveness	3.86 ± 0.60	4.17 ± 0.44	.001*
Independence	3.36 ± 0.62	3.57 ± 0.54	.046*
Overall experience	3.76 ± 0.79	4.18 ± 0.60	.001*
Feedback on facilitator	3.80 ± 0.59	4.18 ± 0.50	.000*

Note: Values are mean ± *SD*
$^{*}p < .05$

DISCUSSION

Problem-based learning is widely utilized as an educational strategy for the One Health approach that aims to enhance learning through collaboration among students from multiple disciplines.[3,4] The One Health-based PBL session involves face-to-face interactions at the same place and time. However, this method limits the PBL potential as it reduces the real-life exposure for students. On the other hand, simulation-based education has been shown to increase students' understanding as it involves learning through experience and team-based collaboration.[16,17] The present study was aimed at comparing the effectiveness of the simulation-based PBL approach to the classic PBL on knowledge retention and perceived satisfaction.

One of the important findings in our study was that the simulation-based exercises improved mean knowledge on rabies, based on the post-test score (61.4 ± 0.7) compared to the pre-test score (55.6 ± 0.8). However, there was no significant difference between the experimental and control groups ($p = .114$). Whether it was the classic PBL or field simulation, the activities successfully reinforced the students' understanding on the strategies to tackle rabies outbreaks. This finding was expected as the quizzes conducted in this study were not designed to test psychomotor and inter-professional skills of the students, regardless of the two PBL methods used. This was also one of the limitations of the study. Due to time constraint and lack of manpower, the assessment was designed purely to test the students' knowledge and lack of psychomotor components exposed to the experimental group. Hands-on assessments such as direct observation of procedural skills (DOPS) and objective structured clinical examination (OSCE) to assess students' competency on clinical skills post-training would give more insights on the effectiveness on the field-simulation training.[18,19] Moreover, PBL is a pedagogical approach that engages in active learning skills, which require students to participate directly in the learning process. Studies have shown that PBL increases knowledge retention, performance, and skills.[3,4] However, short-term knowledge acquisition and retention were reported to show no difference from the classroom methods. Despite that, we did not document the long-term effects of this field simulation. Further studies investigating the impact of the simulation on long-term knowledge retention are thus warranted.

Three essential components, namely physical environment, human environment, and medical activities, must be incorporated into the simulation exercises to mimic real-life experiences for the students. As found in the present study, the students involved in PBL-simulation exercise exhibited higher overall experiences compared to the students undergoing classic PBL ($p = .001$). Several factors were identified as critical to the success of this simulation: adequate workforce, available funding, authenticity and realism of the modules, training, and comprehensive facilitators' guide. Experts from different fields and sectors carefully wrote the modules, and the format was designed to accommodate both MBBS and DVM students. Multiple interviews were conducted with veterinary and medical officers in their respective disciplines to ensure the module's relevancy and to guarantee that the scenarios were realistic. The training was compulsory for all personnel involved to ensure the smooth sailing of the event, albeit there were minor technical issues. Simulated patients were trained according to the prepared scripts and were given clear instructions to ensure a standard interview experience for all groups. Both MBBS and DVM students had an equal number of modules, where they were assigned with different activities related to their fields. The MBBS students were primarily engaged in medical history taking and disease notification, while the DVM students were responsible for outbreak investigation, including community interviews, sample processing/transportation, and donning/doffing personal protective equipment.

Furthermore, the One Health curricular exercise provides a common ground for medical and veterinary educators to engage students across both health-related fields.[20] As found in the present study, the field simulation enhanced the students' perceived learning, highlighted inter-professional training, and increased awareness of national policies, as described under the effectiveness domain in the post-activity feedback survey. Ideally, it is best to match the MBBS and DVM students among the clinical cohorts. However, asynchronous academic curricula and schedules in both programs hindered the possibility. The year-3 MBBS students were selected as they were the youngest among the clinical cohorts. However, the gaps in their knowledge and confidence level were noticeable. They had basic communication skills but had not been exposed to various zoonotic scenarios. On the other hand, the year 5 DVM students had been in full-mode clinical rotations and had broad experience in communication, which was a key skill in this simulation. In addition, the MBBS students participated voluntarily in the study, thus explaining the small sample size in this cohort. Although members in each group were assigned across programs, genders, and races, the uneven distribution of MBBS and DVM students caused the latter to dominate the medical history taking. Despite the disadvantages, the facilitators observed that the senior students demonstrated high self-confidence and could interact with the junior students naturally. The facilitators also reported that the senior DVM students positively influenced the younger MBBS students, thus benefiting both parties.

Other than that, the students from both programs found the exercise enjoyable and simultaneously effective, and they preferred simulation as opposed to classic PBL settings they had experienced throughout their academic years. In addition, this simulation was purposely designed to mimic real-life situations to allow the students to engage in active learning skills while working collaboratively in a dynamic team consisting of MBBS and DVM students. The students also felt that the workload was adequate for this simulation, which may contribute to the overall satisfaction ($p < .001$). In addition, the students involved in the field simulation-based learning appeared to be more independent than the students undergoing classic PBL ($p = .046$). The former had high satisfaction toward their work burden and the program's effectiveness compared to the students undergoing classic PBL. This could be due to the increased motivation among the students involved in the field simulation-based learning that stemmed from their ability to draw links between the theoretical facts and the field situation as well as the learning environment that occurred in a controlled setting.[21]

Moreover, the need to incorporate interdisciplinary collaboration between human and veterinary medicine is increasingly expected in undergraduate education.[22] Inter-professional education (IPE) is introduced into medical-based education to address this undesirable aspect of the multi-health alliance to create awareness on various roles and respectful collaboration among health alliances where two or more professions learn from, with, and about each other to improve collaboration and quality of care.[23,24] Despite the challenges in putting IPE into a practical reality, various studies involving collaboration among MBBS and DVM students have shown positive feedback. These studies have indicated increased confidence in one's skills, attitude toward inter-professional collaboration, and understanding of issues pertaining to both fields among the students involved.[25] In fact, IPE was also a key component during the simulation in this present study. However, the students' opinions and appreciation were not documented in this study. It is hoped that future local studies that incorporate inter-professional education and assess knowledge, skills, and attitudes between the two student cohorts could positively address human, animal, and environmental conflicts.[22]

Finally, the role of facilitators was positively valued by the students involved in the field simulation ($p < .001$). The facilitators were highly regarded and relied on throughout the field simulation. This finding was encouraging as facilitators in classic PBL often have limited involvement throughout the session, and their role is consistently reported as ineffective. Moreover, in the present study, the debriefing session was conducted for the experts to provide specific feedback about their observation on the two student cohorts. Their feedback was focused on how the students employed the One Health approach in disease outbreak investigation. The students expressed their overwhelming preference for the field simulation. However, this feedback was merely subjective and may impose bias as the students may respond in favor of the committee. An advocacy-inquiry method (AIM) could be the way forward in applying the debriefing session post-simulation learning to target the behaviour and thought process involved during the learning sessions.[26] It has been shown that the AIM debriefing could increase students' perception by emphasizing good clinical practices and promoting *in situ* clinical questions and problems that occurred during the simulation. Therefore, the roles of the facilitators in these two settings need to be further characterized, and the AIM debriefing sessions could be explored to determine the factors involved in effective learning, especially in medical-based simulation.

Overall, the field simulation improved the students' satisfaction and learning experience, but with no changes in the post-test scores compared to groups in a classic PBL setting. Although no significant differences were observed in cognitive outcomes between the groups, the differences could be due to the type of assessment method used. A practical or hands-on examination would be able to show the specific skills and competency associated with field simulation and may impose significant differences, unlike the classic PBL. Therefore, we highly recommend that simulation-based PBL be incorporated into the One Health teaching and learning activities. However, one must note that coordinating such activities is time-consuming and funding-dependent, and often requires a massive workforce. As the framework of the disease outbreak approach is relatively similar, the knowledge and experiences obtained from this study could be applied to any disease outbreak involving humans, animals, or both.

CONCLUSION

In conclusion, field simulation enhances students' learning experience by exhibiting better attitudes toward learning. Nevertheless, field simulation PBL and classroom PBL show comparable students' cognitive attainment.

DATA ACCESS STATEMENT

The data that support the findings will be made available upon request from the corresponding authors.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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