



A Comprehensive Approach to Enhancing Volleyball Skills: The Role of Problem-Based Learning, Constraint-Led Approach, and Motivation

Awaluddin Awaluddin^{1ABD}, Samsudin Samsudin^{1ACD}, Wahyuningtyas Puspitorini^{3ACD},
Widiatuti Widiastuti^{1AD} and Syahrudin Syahrudin^{2CD}

¹Jakarta State University

²Makassar State University

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Corresponding Author: Awaluddin, e-mail: awaluddin_9904920010@mhs.unj.ac.id

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Abstract

Objectives. This study aimed to assess whether there is a difference in influence between Constraint-Based Problem-Solving (CBA-PBL) and PBL (Problem-Based Learning), whether there is an interaction between the PBL-CBA model and motivation, and whether there is a difference in influence between students who have high and low motivation after undergoing PBL-CBA and PBL models.

Materials and methods. The study employed an experimental method with a 2×2 factorial design, where treatment was needed, involving 40 students.

Results. The results of the study obtained the value of F count PBL-CBA (A1) and PBL (A2) = 105.144 ($p < 0.05$), thereby indicating a significant difference ($\mu A1 = 106.6 > \mu A2 = 100.4$). Fcount interaction PBL (A)*motivation (B) = 280.779 ($p < 0.05$), thus there is a substantial interaction. A comparison of $\mu A1B1$ and $\mu A2B1$ yielded a result of 23.5000*, [Sig. 0.000 < 0.05; CI 95% = 212.156 - 257.844]. A comparison of the effect of $\mu A1B2$ and $\mu A2B2$ is -3.9000*, [Sig. 0.000 < 0.05; CI 95% = -61.844 - -16.156], reinforced by homogeneous results from different sub-sets.

Conclusions. The conclusion of this study is that PBL can be pushed further in the sense that learners enter into real problems, become part of the problem situation, and problems or constraints can be improved in terms of constellation. The findings suggest that there is an interaction between PBL and motivation, the existence of a problem in the form of a task generates motivation to solve it, and the problem is successfully solved when the learner has motivation. Learning with a constraint-led approach must be appropriate to the learner's characteristics, any attempt to increase the task must be given and reviewed very wisely.

Keywords: project-based learning, constraint-led approach, motivation, volleyball.

Introduction

Physical education (PE) in schools and PE/sport pedagogy in universities are required to synergize with the times and the dynamics of science. One of the synergy efforts in question is the transition from the paradigm of teacher-centered learning (TCL) to student-centered learning (SCL) (Rusli et al., 2024; Awaluddin et al., 2023). This transition became the spirit of the formulation of the Merdeka Curriculum (KM) in Indonesia. KM is realized when SCL

and experiential learning are implemented (Azmi & Iswanto, 2022). KM aims to foster 21st-century skills through SCL-based learning (Arrasyid, 2023). SCL-based learning in KM; should be project and problem-based, technology integration, positive environment, and instill resilience in students (Noptario et al., 2024). However, field facts show that KM and SCL in PE in schools and PE/sport pedagogy in universities are still problematic and not running optimally.

The most common problem is the slow transition of teaching and learning habits from TCL to SCL, this problem is found in primary education (Fahrozi et al., 2024), secondary education (Lismana et al., 2022; Is et al., 2024; Fadlan & Anshor, 2022; Wasak & Rohi, 2024), higher education (Sudrajat et al., 2023; Utami et al., 2022; Rochmat et al.,

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2022; Syafruddin & Sutriawan, 2024), and higher education (Rusli et al., 2024; Atmaja et al., 2022). The slow transition is predicted because learners lack motivation and confidence (Safitri et al., 2024; Ezeddine et al., 2023), low critical thinking skills and lack of interactive and collaborative learners (Rahmadi et al., 2023; Dupri et al., 2020). The solution to solve the existing problems is problem-based learning (PBL). PBL is 'problem-based learning' and has better effectiveness than direct learning (Wallace et al., 2020; Pakaya et al., 2023). PBL allows learners to gain experience in identifying the limitations of their knowledge (Saqr et al., 2023). PBL encourages learning motivation, reasoning, and collaboration (Ramdani et al., 2022). PBL characteristics; learners are the core of the learning process, placed in small groups, instructors act as facilitators, and learners are presented with authentic problems at the beginning of learning (Boye & Agyei, 2023).

PBL can be further maximized through the concept of constraint-led approach (C-la). C-la is a learning concept that prioritizes giving tasks in the form of constraint/challenge manipulation, even the constraints/challenges must be increased/difficulties in each phase, with the increasingly difficult constraints/challenges making learners increasingly try to produce specific solutions, play an active role, interact, collaborate, and be motivated (Renshaw et al., 2010; Renshaw & Chow, 2019). There are three types of constraint/challenge manipulation in C-la; organism manipulation (height and weight, fatigue level, and motivation), environment (weather, temperature, light, and social encouragement), and task (rules, equipment, restrictions, opponents, and peers) (Davies et al., 2023). The elaboration of PBL and C-la is new compared to previous research. Using PBL to improve students' critical thinking skills and cooperation in practical courses (Dupri et al., 2020), student's interest and learning effectiveness in exercise physiology courses (X. Liu et al., 2023). Using PBL to improve PE motivation and learning outcomes (Arisetiyana et al., 2020), students' badminton playing skills (Prabandaru et al., 2020), volleyball activeness and learning outcomes (Prasetyo et al., 2022), basketball playing skills (Fadlan & Anshor, 2022; Rahmadi et al., 2023), critical thinking skills (Is et al., 2024), knowledge, attitude, and psychomotor aspects (Wasak & Rohi, 2024). Comparing PBL and Teams Games Tournament on soccer learning outcomes (Panuntun, 2020), PBL and Flipped classroom on pencak silat learning outcomes (Lubis et al., 2022), PBL and conventional PE on increasing motivation and learning outcomes (Ezeddine et al., 2023), cognitive, affective, and psychomotor improvements (Endrawan & Aliriad, 2023).

This study proposes the existence of motivation from the perspective of Self-determination theory (S-dt) as a moderate variable to add novelty value. As well as research comparing Project-Based Learning-based PE, and self-confidence on athletic learning outcomes (Safitri et al., 2024). We propose this because motivation through the S-dt perspective is proven to influence the motion learning process (van Aart et al., 2017). Humans become more motivated when given full authority to determine their own destiny, as they feel they have greater control (Leo et al., 2022). Motivation through the S-dt perspective occurs due to three aspects; (1) Autonomy (being given the authority to determine behavior and goals), (2) Competence (feeling the ability to complete tasks), and (3) Connection/relationship

(completing tasks because they feel related to others) (de Bruijn et al., 2022). For this reason, we propose one of the courses in the PE program in higher education, namely learning volleyball through the PBL model. The hypotheses proposed; (1) There is a difference in influence between the PBL-CBA Model (Elaboration between PBL and constraint-led approach) and the PBL Model (conventional PBL). (2) There is an interaction between PBL model (1 and 2) and motivation (from the Self-determination theory point of view). (3) There is a difference in effect between students who have high and low motivation after undergoing the PBL model (1 and 2).

Materials and Methods

Study Design

The research employed an experimental method with a 2×2 factorial design where treatment was needed. This study was approved by the Ethics Committee of the State University of Makassar.

Participants

The population came from students who were studying volleyball in the PE study program at Megarezky University located in Makassar City, Indonesia, totalling 101 students. Then the sample was drawn using random sampling through a lottery, all selected samples signed an agreement to participate in the study. The selected sample underwent A Test of Self-Determination Theory in the Exercise Domain (Edmunds et al., 2006), then used the Verducci Formula (27% upper and lower limits) to distribute the sample into 4 groups, resulting in 10 samples/group. Distribution results:

Table 1. Factorial Design

Motivation (B)	PBL Learning Model (A)			Total n	
	PBL-CBA Model (A1)	n	PBL Model (A2)		
High (B1)	A1B1	10	A2B1	10	20
Low (B2)	A1B2	10	A2B2	10	20

Dependent Variable (C); Volleyball playing skills

Procedures

After the PBL group is formed systematically, then all groups involved are directed to undergo the PBL model. The following is the PBL syntax used in this study. In the first stage according to the PBL Model syntax; (1) Group A1B1 and A1B2 obtained problem orientation by directly experiencing the task/problem given, learners were directly present in the middle of the game, carrying out all and every rule of the game, even the task/problem was increased in each phase; group mates vs group mates, group members vs learners outside the group, and group members vs pro-campus athletes. (2) Groups A2B1 and A2B2 received conventional problem orientation; through literature, discussions, and videos of volleyball playing skills problems. After undergoing treatment, the volleyball lower passing ability test was carried out, the test used in two dimensions,

namely assessing the process and results. To assess the process using test instruments according to (Durrwachter, 1986) and to assess the results using test instruments according to (Widiastuti, 2011).

Statistical Analysis

The prerequisite tests were the normality test using the Kolmogorov Smirnov test ($p > 0.005$) and the homogeneity test using Levene statistics ($p > 0.005$). Furthermore, data analysis uses two-way ANOVA at the significance level $\alpha = 0.05$. If the test results show an interaction then continue with the Tukey test.

Result

Descriptive

Based on table 2, the mean and std. deviation values of A1 [106.60 ± 14.199], A2 [100.45 ± 14.097], A1B1 [120.30 ± 18.885], A1B2 [92.90 ± 22.335], A2B1 [104.10 ± 20.248], A2B2 [96.80 ± 13.165] are known. Minimum and maximum values A1 [90 ± 124], A2 [95 ± 107], A1B1 [117 ± 124], A1B2 [90 ± 96], A2B1 [101 ± 107], A2B2 [95 ± 99].

Table 2. Bottom Serve Results

Group	n	Min ± Max	Mean ± SD
A1	20	90 ± 124	106.60 ± 14.199
A2	20	95 ± 107	100.45 ± 14.097
A1B1	10	117 ± 124	120.30 ± 18.885
A1B2	10	90 ± 96	92.90 ± 22.335
A2B1	10	101 ± 107	104.10 ± 20.248
A2B2	10	95 ± 99	96.80 ± 13.165

Prerequisite Test

Based on table 3, A1B1 shows that, with $n = 10$ has a significance of more than 0.200 ($0.200 \geq 0.05$) meaning A1B1 is normally distributed. A1B2 shows that, with $n = 10$ has a significance of more than 0.200 ($0.200 \geq 0.05$) meaning A1B2 is normally distributed. A2B1 shows that, with $n = 10$ has a significance of more than 0.200 ($0.200 \geq 0.05$) meaning A2B1 is normally distributed. A2B2 shows that, with $n = 10$ has a significance of over 0.200 ($0.200 \geq 0.05$) meaning A2B2 is normally distributed.

Table 3. Data normality test results

Group	Kolmogorov-Smirnov		
	Statistics	df	Significance
A1B1	0.11319	10	0.200*
A1B2	0.14097	10	0.200*
A2B1	0.09861	10	0.200*
A2B2	0.11111	10	0.200*

Based on table 4, the results of the Levene-test calculation between A1 and A2, obtained a significant price of $0.216 > 0.05$, thus the two population cells variance (A1 and A2) are Homogeneous.

Table 4. Homogeneity Test Results

Group	Levene Statistics	df1	df2	Sig
A1 and A2	1.560	3	36	0.216

After being declared normal and homogeneous, the variance analysis requirements have been met. Furthermore, hypothesis testing uses two-way analysis of variance (ANOVA). If there is interaction, the analysis used is the Tukey Test.

Table 5. Results of Differences in the Effect of PBL-CBA Model and PBL Model

Source	df	Type III Sum of Squares	Mean Square	F	Sig.
PBL (A)	1	378.225	378.225	105.144	0.000
Motivation (B)	1	3010.225	3010.225	836.819	0.000
A*B interaction	1	1010.025	1010.025	280.779	0.000
Error	36	129.500	3.597		0.000
Total	40	433225.000			

Hypothesis 1

Based on table 5, the price of F (calculate) the difference between the PBL-CBA model (A1) and the PBL model (A2) obtained $F = 105.144$ ($p < 0.05$). Thus there is a significant difference between the PBL-CBA model and the PBL model to improve the results of volleyball lower passing skills. Where PBL-CBA is better than PBL it can be seen from $\mu A1 = 106.6 > \mu A2 = 100.4$.

Hypothesis 2

Based on table 5, the price of F count interaction between PBL model (A) * motivation (B) is obtained = 280.779 with probability level sig = 0.000. Thus it can be concluded that there is a significant interaction between the PBL model (1 and 2) with motivation in the skill of passing under volleyball ($p < 0.05$).

In accordance with the results listed in table 4, further analysis is carried out with the Tukey test. A summary of the results of the Tukey test calculation can be seen in the following table:

Table 6. Multiple Comparisons Tukey HSD

(I) PBL-CBA	(J) PBL	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A1B1	A2B1	23.5000*	.84820	0.000	212.156	257.844
A1B2	A2B2	-3.9000*	.84820	0.000	-61.844	-16.156

Hypothesis 3

Based on table 6, the comparison of the average number of effects of A1B1 and A2B1 is 23.5000 *, the comparison of the average effect of the lower bound is 212.156 and the Upper Bound is 257.844 at the 95% confidence level, and the Sig value is known. $0,000 < 0,05$. Thus there is a

difference in influence between A1B1 and A2B1, where A1B1 is better than A2B1. Furthermore, the comparison of the average number of influences of A1B2 and A2B2 is -3.9000^* , the comparison of the average influence of the lower bound is -61.844 and the Upper Bound is -16.156 at the 95% confidence level, and the Sig value is known. $0.000 < 0.05$. Thus there is a difference in influence between A1B2 and A2B2, where A2B2 is better than A1B2. These results are also reinforced by the Homogeneous Subsets results (see table 7) that the four PBL groups are in different sub-sets.

Table 7. Homogeneous Subsets

PBL	n	Subset			
		1	2	3	4
A1B2	10	92.90			
A2B2	10		96.80		
A2B1	10			104.10	
A1B1	10				120.30
Sig.		1.000	1.000	1.000	1.000

Discussion

There is a difference in effect between PBL-CBA and PBL, where PBL-CBA is better than PBL. Our findings are in line with other findings that learning with constraint-led approach can encourage people to acquire new skills, adapt, participate in physical activities, and at the same time create a dynamic and explorative learning environment, and foster motivation and creativity (C. Liu, 2023). The existence of improved constraints that are simulated in the learning process helps one to gain new insights in the decision-making process (Sánchez-García, 2023). Manipulating the training environment (constraint-led approach) in volleyball serve training increases students' exploratory power to learn motor skills (Moy, Renshaw, & Gorman, 2024). Perceived constraints support positively predicted effort and engagement in PE (Pan & Hsu, 2024). It is important to modify activities, rules, and equipment, all to increase learning opportunities, foster the perception of developmentally appropriate motor skills, and encourage moderate to vigorous physical activity (Moon & Lee, 2025). Another study that applied constraint-led approach to early childhood by comparing children's success using conventional bicycles, one group of children practicing with assistive wheel bicycles and another group using balance cycles, the trial results showed that children using balance cycles had 100% success compared to assistive wheel bicycles which were only 75%, this finding was predicted because the balance cycle made children make extra efforts and independence when balancing the bicycle, controlling the speed and braking the bicycle (Mercé et al., 2023). Our results suggest that PBL can be pushed further in the future, so that learners are not only given problems through lecturers' explanations either through stories, assignments, visual information or scripts. It can be pushed further, meaning that the learners enter into the problem in a real way, become part of the problem situation, and even the problem or obstacle is increasing in its constancy over time.

There is an interaction between PBL and motivation, in essence PBL contains the concept of non-pedagogic learning where learners are given the freedom to learn

according to the problem at hand according to their ability to understand and solve the problem. As for motivation (from the point of view of Self-determination theory), it is born from autonomy or authority to determine their behavior and goals, competence to complete the task at hand, and connection/relationship to complete the task because they feel related to others. This means that PBL is able to give way directly or indirectly to learners who have motivation based on the Self-determination theory point of view. Some studies are in line and reinforce the existence of our research results; the learners responded that their motivation increased during the briefing process by the lecturer and the assigned problem solving process (Nor Farida et al., 2012). PBL has an effect on increasing student learning motivation (Safitri et al., 2023; Arisetiyana et al., 2020). There is a difference in increasing student motivation between the two proposed learning methods (PBL and conventional) (Kho et al., 2024). Elaboration between PBL and Discovery Learning effectively increases student motivation and learning outcomes (Panggabean et al., 2023). PBL successfully increases student motivation and learning outcomes, students' badminton playing skills (Prabandaru et al., 2020), PBL-based PE is more effective than conventional PE in junior high school students on increasing motivation and learning outcomes (Ezeddine et al., 2023). It can be seen that there is an intense interaction between the two (PBL and motivation), the existence of problems in the form of tasks raises the motivation of a learner to solve it and problems in the form of tasks can be successfully resolved when the learner has motivation.

There is a difference in the effect between PBL-CBA and PBL, for low and high motivated students, where low motivated students are more suitable for PBL than PBL-CBA and high motivated students are more suitable for PBL-CBA than PBL-CBA. It can be understood that PBL-CBA which contains the concept of constraint-led approach can only be digested by learners when they have high motivation, while PBL tends to be suitable for learners who have low motivation. Many unique things can be assumed from this result, such as learners' independence that must be questioned in solving problems after authority is given (Leo et al., 2022), not to mention the lack of confidence in their competence, as well as the absence of strong group connectivity (de Bruijn et al., 2022), when undergoing the PBL-CBA process. Another important finding that requires further explanation is that low-motivated learners performed better in PBL than PBL-CBA. This phenomenon is possible due to the heavy burden of problems assigned to a person's exercise performance can be disrupted and lead to mental fatigue, for that decrease in task load can be reviewed so as to reduce the demands of cognition and physical performance (Daub et al., 2023; Bahrami, Moradi, & Etaati, 2020). The severity of task load can reduce cognitive performance such as the take-the-first (TTF) heuristic and/or decision-making ability (Cao et al., 2022). Our findings confirm that learning with a constraint-led approach must be appropriate to the characteristics of the learners, any attempt to increase the task must be given and reviewed very wisely.

Conclusion

There is a difference in the effect between PBL-CBA and PBL, where PBL-CBA is better than PBL, thus PBL

can be pushed further in the sense that learners enter into the problem in real terms, become part of the problem situation, and even the problem or obstacle is increasingly enhanced over time. There is an interaction between PBL and motivation (from the viewpoint of Self-determination theory), meaning that the existence of a problem in the form of a task raises the motivation of a learner to solve it and the problem in the form of a task can be successfully solved when the learner has motivation. There is a difference in the effect between PBL-CBA and PBL, on students who have low and high motivation, where students who have low motivation are more suitable for PBL than PBL-CBA and students who have high motivation are more suitable for PBL-CBA than PBL-CBA, thus learning with a constraint-led approach must be in accordance with the characteristics of the learner, the effort to add tasks must be given and reviewed very wisely. PE and sport pedagogic/education learning in the future can be maximized with PBL or other learning models that are student centered learning and non-pedagogic learning through joint elaboration of the concept of constraint-led approach, and pay attention to motivation from the perspective of Self-determination theory. Of course, this conclusion requires further research in the future.

Conflict of interest

The authors have no conflicts of interest to declare.

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Комплексний підхід до підвищення спортивної майстерності у волейболі: Роль проблемно-орієнтованого навчання, обмежено-керованого підходу та мотивації

Авалуддін Авалуддін^{1ABD}, Самсудін Самсудін^{1ACD}, Вахюнінгтіас Пуспіторіні^{3ACD}, Відіатуті Відіастуті^{1AD}, Сяхруддін Сяхруддін^{2CD}

¹Джакартський державний університет

²Макассарський державний університет

Авторський вклад: А – дизайн дослідження; В – збір даних; С – статаналіз; D – підготовка рукопису; E – збір коштів

Реферат. Стаття: 8 с., 6 табл., 48 джерел.

Мета дослідження. Це дослідження мало на меті визначити, чи існують відмінності у впливі між розв'язанням задач на основі обмежень (Constraint-Based Problem-Solving, CBA-PBL) та проблемно-орієнтованим навчанням (Problem-Based Learning, PBL), чи є взаємозв'язок між моделлю PBL-CBA та мотивацією, а також чи спостерігається різниця щодо впливу між студентами з високим та низьким рівнем мотивації після застосування моделей PBL-CBA та PBL.

Матеріали та методи. У дослідженні використовувався експериментальний метод із застосуванням факторіального дизайну 2 × 2, де необхідним було проведення випробування, в якому брали участь 40 студентів.

Результати. За результатами дослідження отримано значення F-розрахунку PBL-CBA (A1) та PBL (A2) = 105,144 (p < 0,05), що свідчить про достовірну різницю показників ($\mu A1 = 106,6 > \mu A2 = 100,4$). Взаємодія F-розрахунку PBL (A)*мотивація (B) = 280,779 (p < 0,05), що вказує на суттєвий взаємозв'язок. Порівняльний аналіз $\mu A1B1$ і $\mu A2B1$ показав результат 23,5000*, [Sig. 0,000 < 0,05; CI 95% = 212,156 - 257,844]. Порівняння ефекту $\mu A1B2$ і $\mu A2B2$ становить -3,9000*, [Sig. 0,000 < 0,05; CI 95% = -61,844 - -16,156], що підтверджується однорідними результатами з різних підмножин.

Висновки. У цьому дослідженні зроблено висновок про можливість подальшого розвитку методу PBL в тому розумінні, що учні стикаються з реальними труднощами, стають частиною проблемної ситуації, а самі складнощі або обмеження можна поліпшити з точки зору констеляції. Результати дослідження вказують на наявність взаємодії між методом

PBL і мотивацією, існування проблеми у вигляді завдання породжує мотивацію до її розв'язання, при цьому проблема успішно вирішується в умовах наявності в учня мотивації. Навчання із застосуванням обмежено-керованого підходу має враховувати індивідуальні особливості учня, а будь-яка спроба підвищити складність завдання має надаватися та розглядатися з максимальною раціональністю.

Ключові слова: навчання з використанням проєктів, обмежено-керований підхід, мотивація, волейбол.

Information about the authors:

Awaluddin: awaluddin_9904920010@mhs.unj.ac.id; <https://orcid.org/0000-0001-9706-5182>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Samsudin: samsudin@unj.ac.id; <https://orcid.org/0000-0003-1565-4202>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Puspitorini, Wahyuningtyas: wahyu_puspitorini@unj.ac.id; <https://orcid.org/0000-0003-1114-3640>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia.

Widiastuti: widiastuti@unj.ac.id; <https://orcid.org/0000-0003-4047-1969>; Department of Sport Science, Faculty of Sport Science, Universitas Negeri Jakarta, Pemuda, No. 10 Street, Kota Jakarta Timur, Daerah Khusus Ibukota Jakarta 13220, Indonesia

Syahrudin: syahrudin@unm.ac.id; <https://orcid.org/0000-0002-1667-2405>; Departemen of Sport Science, Faculty of Sport and Health Science, Makassar State University, Wijaya Kusuma No. 14 Street, Kota Makassar 90233, Indonesia.

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