The Effect of Game-Based Learning Media Word Square "Pena" On Increasing Knowledge of Diabetes Mellitus in SMK N 4 Yogyakarta Students

Maria Friskila[1], Furaida Khasanah[1,2*], Ida Mardalena[1], Harmilah[1,]
[1] Jurusan Keperawatan, Poltekkes Kemenkes Yogyakarta,
Jl. Tata Bumi No.3, Banyuraden,Yogyakarta, 55293
[2] School of Cardiovascular and Metabolic Health, College of Medical, Veterinary, and Life Sciences, University of Glasgow, United Kingdom
Email: furaida.khasanah@poltekkesjogja.ac.id

ABSTRACT

Background: The Indonesian Medical Association reported in January 2023 that cases of diabetes among adolescents had increased 70-fold. Efforts are made to increase knowledge through game-based learning media. The learning media used is Word Square "PENA".
Objective: To analyse the effect of Word Square "PENA" on diabetes mellitus knowledge among students of SMK N 4 Yogyakarta.
Methods: This research is a quasi-experimental research using an equivalent control group design. The sampling technique used was simple random sampling. The samples used were students of SMK N 4 Yogyakarta, totalling 98 respondents, consisting of experimental and control groups. Statistical tests using the Wilcoxon signed rank test and the Mann-Whitney.
Results: This study shows that 59.2% of respondents were in the poor knowledge category of diabetes mellitus based on the pre-test results. After being given education using the Word Square "PENA", their knowledge increased by 71.4%, moving to the high category. Statistical test results show p-value = 0.000 (P< 0.05). To determine the effect of the Word Square "PENA" on the knowledge of diabetes mellitus among students of SMK N 4 Yogyakarta.
Conclusion: The interactive learning media Word Square "PENA" is recommended as a strategic innovation in diabetes prevention education in schools, especially for the digital generation, which needs adaptive and fun learning methods.

Keywords: Diabetes Mellitus, Word Square, Knowledge, Adolescents, Interactive learning media

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterised by hyperglycemia, contributing to a significant global mortality rate with 41 million annual deaths from non-communicable diseases [2]. The International Diabetes Federation (2021) reports 536.6 million cases worldwide, with Indonesia ranking fifth highest at 19.5 million, projected to reach 48.6 million by 2045 [3]. Yogyakarta City saw a rise in cases from 13,676 (2022) to 15,595 (2023), indicating a significant expansion of the epidemic [4]. A noteworthy phenomenon is the epidemiologic shift to younger age groups. The Indonesian Medical Association (2023) reported that the number of cases among adolescents increased 70-fold over the past two decades.

This condition is exacerbated by low levels of DM knowledge; based on preliminary studies conducted at SMK N 4 Yogyakarta, 85.7% of adolescents do not

know about diabetes mellitus. This is in line with the research by Fajrin et al. (2024), who reported that around 43.2% of adolescents have insufficient knowledge of diabetes mellitus and its risk factors (5). In fact, health knowledge is a key determinant in the formation of prevention [6]. Possible long-term complications include cardiovascular disorders (41%), retinopathy (35.4%), and renal dysfunction (33%), which can significantly reduce quality of life [7].

In the context of health education for Generation Z, conventional approaches are considered less effective because they do not match the learning characteristics of the digital generation [8]. Game-based interactive learning media, such as Word Square "PENA" (Prevention and Education), offers a potential solution by disguising answers in a letter matrix, thereby increasing learning engagement [9]. Previous studies have demonstrated the effectiveness of this medium in improving learning outcomes[10], but its application specifically for diabetes mellitus education among adolescents in Indonesia has not been widely explored, making this study of important novelty value.

MATERIAL AND METHOD

This research is a quantitative study with a quasi-experimental design using an equivalent group design. The research was conducted at SMK N 4 in February – March 2025. The study population comprises all students of SMK N 4 Yogyakarta, totalling 1904 respondents. The total sample consisted of 98 respondents, divided into two groups: 49 in the experimental group and 49 in the control group. The experimental group received instruction using a word square, and the control group received instruction using PowerPoint. Research conducted by [(11)] says that adolescents who are most at risk of diabetes mellitus are aged 16 and 17. SMK adolescents aged 16 and 17 years are in class XI, so the sample in this study is class XI.

The research instrument used the DKQ-18 standardised questionnaire, which was translated into Indonesian using a sworn translator. The intervention was carried out within 1 day, and then the post-test was given 7 days after the pre-test. This was done to provide a clear picture of the intervention’s effectiveness in increasing respondents' knowledge[12]. Data were analysed by the Wilcoxon and Mann-Whitney tests using SPSS 21. This study was approved by the Health Research Ethics Committee of the Poltekkes Kemenkes Yogyakarta (No. DP.04.03/e- KPK.1/142/2025). All respondents received informed written consent. Data were kept anonymous as they were coded and all respondents received education on diabetes mellitus.

RESULTS AND DISCUSSION

Cross-tabulation of Knowledge Level Pre test and Post test in Experimental Group and Control Group

Table 1 Cross-tabulation of Knowledge Levels in the Intervention and Control Groups

Category		*Pretest*				*Posttest*			
		High	**Medium**	**Less**	**Total**	**High**	**Medium**	**Less**	**Total**
Experiment Group									
Age									
16	Total	0	5	16	21	15	6	0	21
	%	0	42.8	57.2	100	71.4	28.6	0	100
17	Total	0	15	13	28	20	8	0	28
	%	0	39.3	60.7	100	71.4	28.6	0	100
Gender									
Male	Total	0	1	7	8	2	6	0	8
	%	0	12.5	87.5	100	25	75	0	100
Female	Total	0	18	23	41	11	27	3	41
	%	0	43.9	56.1	100	26.8	65.9	7.3	100
Family History of DM									
There is	Total	0	10	5	15	12	3	0	15
	%	0	66.7	33.3	100	80	20	0	100
None	Total	0	10	24	34	23	11	0	34
	%	0	29.4	70.6	100	67.6	32.4	0	100
IMT									
Less	Total	0	6	4	10	5	5	0	10
	%	0	60	40	100	50	50	0	100
Normal	Total	0	14	14	28	8	20	0	28
	%	0	50	50	100	28.6	71.4	0	100
Pros	Total	0	2	4	6	0	6	0	6
(Overweight)	%	0	33.3	66.4	100	0	100	0	100
Obesity	Total	0	2	3	5	1	4	0	5
	%	0	40	60	100	20	80	0	100
Obesity II	Total	0	0	0	0	0	0	0	0
	%	0	0	0	0	0	0	0	0
Control Group									
Age									
16	Total	0	10	9	19	0	12	7	19
	%	0	52.6	47.4	100	0	63.2	36.8	100
17	Total	0	13	17	30	0	18	12	30
	%	0	43.3	56.7	100	0	60	40	100
Gender									
Male	Total	0	2	10	12	0	5	7	12
	%	0	16.7	83.3	100	0	41.7	58.3	100

Female	Total	0	20	17	37	0	26	11	37
	%	0	54.1	45.9	100	0	70.3	29.7	100
Family History of DM									
There is	Total	0	6	4	10	0	7	3	10
	%	0	60	40	100	0	70	30	100
None	Total	0	9	30	39	0	20	19	39
	%	0	23.1	76.9	100	0	51.3	48.7	100
Pros	Total	0	2	1	3	0	2	1	3
(Overweight)	%	0	66.7	33.3	100	0	66.7	33.3	100
Obesity	Total	0	4	2	6	0	5	1	6
	%	0	66.7	33.3	100	0	83.3	16.7	100
Obesity II	Total	0	0	0	0	0	0	0	0
	%	0	0	0	0	0	0	0	0

In the experimental group, an analysis by respondent characteristics showed that the intervention significantly improved knowledge. By age, the proportion of high-knowledge categories increased from 57.2% to 71.4% in the 16-year-old group and from 60.7% to 71.4% in the 17-year-old group. In terms of gender, males increased from 87.5% in the poor category to 75% in the moderate category, while females increased from 56.1% in the poor category to 65.9% in the moderate category. Respondents with a family history of DM showed an increase from 66.7% in the moderate category to 80% in the high category, while those without a family history of DM increased from 70.6% in the less category to 67.6% in the high category. Based on BMI, the overweight group experienced the most significant increase, from 66.4% in the underweight category to 100% in the moderate category, followed by the obese group, which increased from 60% in the underweight category to 80% in the moderate category.

In the control group, the analysis of respondent characteristics showed that the intervention increased knowledge across groups. By age, respondents aged 16 years increased from 52.6% in the moderate category to 63.2% in the high category, while the 17-year-old group increased from 56.7% in the low category to 70.6% in the high category. In terms of gender, males remained dominant in the moderate category (54.1% to 58.3%), while females showed an increase from 56.1% in the less category to 70.3% in the moderate category. Respondents with a history of DM experienced an increase from 60% to 70% in the moderate category, while those without a family history of DM experienced a decrease in the proportion of the moderate category from 70.6% to 51.3%.

Based on BMI, the underweight group increased from 60% to 72.7% in the moderate category, the normal BMI group increased from 58.6% in the underweight category to 51.7% in the moderate category, the overweight group remained stable at 66.7% in the moderate category, and the obese group increased from 66.7% to 83.3% in the moderate category.

The majority of respondents were 16-17 years old, belonging to the middle-adolescent group, which is vulnerable to environmental influences and unhealthy lifestyles but also responsive to educational interventions. This study showed an increase in diabetes mellitus knowledge in the intervention group at that age, from moderate to high category, in line with the findings of Putri and Suryanto (2022), which stated that DM education can increase knowledge by 60%[13.] This increase in knowledge is significant because it can influence healthier dietary behaviour and physical activity, thereby reducing the risk of DM in adulthood. In addition to age, gender also has an effect; women tend to be more concerned and open to health education, so they experience a more significant increase than men[14]. However, male involvement is still important given the same risk of DM if unhealthy lifestyles continue.

Other factors that influence DM knowledge are family history and BMI. Of the 15 respondents with a family history of DM, 12 experienced an increase in knowledge from moderate to high due to exposure to information and direct experience related to this disease [15]. BMI is also an important risk factor; in this study, there were respondents with overweight, obesity, and underweight who tended to have lower DM knowledge compared to those with a normal BMI. This is in line with the study by Alzahrani et al. (2022), which reported lower DM knowledge among the obese group [16]. Lack of knowledge in the abnormal BMI group may exacerbate the increasing trend of DM cases. Therefore, the Global Diabetes Prevention Group (2024) recommends specific educational interventions for adolescents with high BMI and family history of DM to reduce the risk of developing diabetes by 58% within three years[16,17].

Level of Diabetes Mellitus Knowledge Before and After Intervention in Experimental and Control Groups

Table 2 Diabetes Mellitus Knowledge Before and After Intervention in Experimental and Control Groups

Group	Category	*F*	%	*Mean Rank*	*Sum Rank*	*P Value*
Intervention	*Post test< Pre Test*	1	2	37.50	37.50	

	Post test> Pre Test	48	98	24.74	1187.50	0.000
	Post test= Pre Test	0	0	0.00	0.00	
Control	*Post test< Pre Test*	7	14.3	12.86	90.00	
	Post test> Pre Test	28	57.1	19.29	540.00	0.000
	Post test= Pre Test	14	28.6	0.00	0.00	

The results of the Wilcoxon test showed that in the experimental group, there was a significant effect of word square learning media "PENA" on increasing the knowledge of diabetes mellitus students of SMK N 4 Yogyakarta with a significance value of 0.05.0.000 ($p< 0.05$), characterised by a change in knowledge category from pre-test to post-test. Meanwhile, in the control group that used PowerPoint media, there was also an increase in knowledge, with a significance value of 0.000 ($p < 0.05$), but knowledge remained in the moderate category, and as many as 14 respondents (14.3%) did not experience an increase in knowledge.

The word square learning media intervention "PENA" significantly increased diabetes mellitus knowledge in the experimental group, with a p-value = 0.000 ($p<0.05$). A total of 98% of respondents experienced an increase in post-test scores, which supports the findings of Khotari (2021) and Chan et al. (2023) that interactive learning media and educational games are effective in improving understanding and retention of health knowledge, especially in complex diseases such as diabetes mellitus [17, 18]. On the other hand, the control group using PowerPoint media also showed a significant increase in knowledge ($p = 0.000$; $p < 0.05$), but only 57.1% of respondents experienced an increase, and the increase was still in the moderate category. Some respondents experienced no change or a decrease in score, indicating that the effectiveness of PowerPoint depends on the suitability of the respondent's characteristics [19,20].

Differences in Post-Test Knowledge Levels Between the Intervention and Control Groups

Table 3 Differences in Diabetes Mellitus Knowledge in the Experimental Group and Control Group

Category	**F**	**%**	***Mean Rank***	***Sum Rank***	***Z***	***P Value***

Experiment	49	50	62.26	3050.50		
Control	49	50	36.74	1800.50	-4.505	0.000
Total	98	100	0.00	0.00		

There was a significant difference between the experimental and control groups in terms of knowledge improvement, with the experimental group showing a significantly higher mean rank (62.26) than the control group (36.74). The Mann-Whitney test results reinforced this finding, with a p-value of 0.000 (<0.05), indicating a statistically significant difference between the two independent groups. Thus, it can be concluded that the intervention provided to the experimental group had a more effective impact on increasing knowledge than that of the control group.

This finding is in line with the research by Rintamaki et al. (2021), which demonstrates that interactive media, such as word squares, are more effective at increasing health knowledge than conventional methods [21]. The consistency of these results is reinforced by Hakim's study (2020), which states that a participatory approach in health education can increase memory retention by 40% compared to the lecture method [22]. This data suggests that the "PENA" word square not only delivers strong results but also encourages sustainable health behaviour change.

The advantage of the "PENA" word square lies in its fun, participatory learning design, in which participants actively develop concepts related to diabetes mellitus through word and visual associations. This is different from one-way methods that tend to be passive. Bharath Kumar & Udaya Kumar's research (2023) explains that visual stimulation, such as a word square, can increase long-term memory activation in the hippocampus, which is key to knowledge retention [23].

In addition, Rochman et al. (2022) found that game-based learning increased cognitive engagement by 2.3-fold in diabetes education [24]. The combination of visual and kinesthetic elements in the word square "PENA" proved effective in facilitating understanding of the complexity of diabetes mellitus. Education using the word square "PENA" not only improves knowledge but also builds critical awareness about diabetes mellitus management. The study of Alex et al. (2023) revealed that educational interventions with an active recall component (such as composing words) reduced misinterpretation of health information by 28%23. This finding was reinforced by Arora et al. (2024), who stated that problem-solving-based learning models, such as word square, significantly improved participants' analytical skills in the context of chronic

diseases [24]. Thus, the word square "PENA" can be adopted as an innovative educational strategy for diabetes prevention programs, especially in schools.

CONCLUSION

This study showed that the use of interactive word square “PENA” learning media significantly improved knowledge about diabetes mellitus among adolescents of SMK N 4 Yogyakarta, with the experimental group receiving this intervention experiencing an increase in knowledge category from moderate to high compared to the control group, who only used PowerPoint media. Knowledge improvement was most pronounced among 16-17-year-olds, females, respondents with a family history of diabetes, and those with overweight or obesity, confirming the importance of educational approaches responsive to learner characteristics and individual risk factors. The advantage of the word square “PENA” lies in its participatory design and visual elements, which can improve memory retention and cognitive engagement, and build critical awareness and analytical skills in participants.

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DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author upon reasonable request. All data were collected and analysed specifically for this research and are not publicly available due to privacy and institutional restrictions.

DISCLOSURE STATEMENT

The views and opinions expressed in this article are solely those of the authors and do not necessarily reflect the official policy or position of any agency with which the authors are affiliated. Furthermore, the data presented herein is the result of the authors' original research and has not been published previously in any form.

REFERENCE

1. PERKENI. Guidelines for the management and prevention of adult type 2 diabetes mellitus in INDONESIA - 2021. 2021;
2. WHO. Advancing the global agenda on prevention and control of noncommunicable diseases 2000 to 2020. 2023.
3. Wahidin M, Achadi A, Besral B, Kosen S, Nadjib M, Nurwahyuni A, et al. Projection of diabetes morbidity and mortality till 2045 in Indonesia based on risk factors and NCD prevention and control programs. Sci Rep. 2024 Mar 5;14(1):5424.
4. Yogyakarta Special Region Health Office 2022. D.I.Yogyakarta Health Profile 2022.
5. Fajrin V, Asriati, Fransina AI, Natalia Paskawati A. Improving Diabetes Mellitus Risk Factor Literacy among Adolescents in Jayapura City. 2024.
6. Ramadhani AA, Khotami R. Relationship between Level of Education, Knowledge, Age and Family History of DM with Diabetes Mellitus Type Prevention Behavior
7. 2 in Young Adults. SEHATMAS J Science of Public Health. Jan 30, 2023;2(1):137-47.
8. Fortuna TA, Karuniawati H, Purnamasari D, Purlinda DE. Factors Affecting Complications in Diabetes Mellitus Patients at Dr. Moewardi Hospital. Pharmacon J Farm Indones. 2023 Jul 1;20(1):27-35.
9. Zhao D, Muntean CH, Chis AE, Rozinaj G, Muntean GM. Game-Based Learning: Enhancing Student Experience, Knowledge Gain, and Usability in Higher Education Programming Courses. IEEE Trans Educ. Nov 2022;65(4):502-13.
10. Ulpah YD, Nurdianti RRS, Afriza EF. Application of Cooperative Learning Model Type TGT (Teams Games Tournament) Assisted by Word Square Media in Improving Student Learning Outcomes in Economics Subjects. J Science Educator. 2024;1.
11. Mulyari I, Adam DH, Ritonga N, Siregar ZA. Utilization of Word Square Media to Improve Biology Learning Outcomes of Human Immune System Material in Class Xi Sma Negeri 1 Torgamba. 2022;3(2).
12. Qifti F, Malini H, Yetti H. Characteristics of High School Adolescents with Diabetes Mellitus Risk Factors in Padang City. J Ilm Univ Batanghari Jambi. 2020 Jul 1;20(2):560.
13. Khoirunnisa S, Kurniasari R, Sefrina LR. The effect of using animated videos and Twitter threads on nutritional knowledge during the Covid-19 pandemic. Ikesma. Dec 2022;18(4):266.
14. Putri, R. D, Suryanto, T. Effectiveness of Diabetes Education in Middle School Adolescents. 2022;
15. Roddiyah Furry AN, Tanto H, Warsono. The Difference Level Of Knowledge About Diabetes Mellitus Type Ii Before You Give Education With Audio Visual Media On Patients Dm Type Ii In Dusun Sentong Desa Karangduren Kecamatan Pakisaji Malang. Nurs News (Meriden). 2021;3.
16. Widyastuti, E, Ramadhani, F. Relationship between Family History and Early Awareness of Type 2 Diabetes Mellitus. 2021;
17. Alzahrani, A. M, Alghamdi, A. S, Alqarni, T. A, Alshahrani, N. Z, Alzahrani, M.
18. S. Diabetes awareness and risk factors in populations with abnormal BMI: A cross-sectional study in Saudia Arabia. 2022;

19. Kothari U. Seafarers, the mission and the archive: Affective, embodied and sensory traces of sea-mobilities in Melbourne, Australia. J Hist Geogr. 2021 Apr;72:73-84.

20. Chan RHW, Wong TY, Dong D, Kim JH. Alcohol Social Media Marketing in Hong Kong: A Content Analysis of Facebook Posts. J Adolesc Health. Sep 2023;73(3):461-9.

21. Lee Hyunju, Park S, Kim J. Impact of PowerPoint-Based Education on Health Literacy: Patient Education and Counseling. 2022;

22. Anderson, R., Brown, T. Effectiveness of Visual Learning Tools in Health Education. Journal of Health Communication. 2023;

23. Rintamäki R, Rautio N, Peltonen M, Jokelainen J, Keinänen-Kiukaanniemi S, Oksa H, et al. Long-term outcomes of lifestyle intervention to prevent type 2 diabetes in people at high risk in primary health care. Prim Care Diabetes. 2021 Jun;15(3):444-50.

24. Hakim, A. Participatory Learning in Diabetes Education Research. 2020;

25. Al Sadi K, Balachandran W. Leveraging a 7-Layer Long Short-Term Memory Model for Early Detection and Prevention of Diabetes in Oman: An Innovative Approach. Bioengineering. 2024 Apr 15;11(4):379.

26. Lu HY, Lu P, Hirst JE, Mackillop L, Clifton DA. A Stacked Long Short-Term Memory Approach for Predictive Blood Glucose Monitoring in Women with Gestational Diabetes Mellitus. Sensors. Jan 2023;23(18):7990.