

Improving Language Teaching and Learning Process with Dual Coding Theory Approaches

Citra Kurniawan¹, Shirly Rizki Kusumaningrum², Kee-Fui Turner Lam^{3a,b}, Ence Surahman^{4a,b}

¹Department of Educational Technology, Faculty of Education, Universitas Negeri Malang, Indonesia

²Basic Education, Graduate School, Universitas Negeri Malang, Indonesia

^{3a}Head of International Collaboration, National Tsing Hua University, Taiwan

^{3b}Academic Director, Edu-Aequitas, Singapore

^{4a}International Intercollegiate PhD Program, National Tsing Hua University, Hsinchu, Taiwan

^{4b}Department of Educational Technology, Faculty of Education, State University of Malang, Indonesia

ARTICLE INFO

Article History:

Accepted: 07-07-2022

Approved: 08-08-2022

Keywords:

dual coding theory;
visual-verbal preferences;
learning outcomes;
language teaching;

Correspondence Address:

Citra Kurniawan
Department of Educational
Faculty of Education
Universitas Negeri Malang
E-mail: citra.kurniawan.fip@um.ac.id

ABSTRACT

Abstract: Dual coding theory (DCT) allows students to process information based on stimuli in the form of visual-verbal signals. This study aims to measure the relationship between the implementation of DCT on the process of Teaching & Learning. An experimental approach involving 101 students was used. The results showed that the DCT theoretical approach can be used to improve the language learning process. The research findings also showed that the learning strategies correlation coefficient is positive 0.826** which means that DCT has a very strong relationship with learning outcomes. In addition, the variables of gender and learning strategies demonstrated a positive relationship to learning outcomes with a positive correlation coefficient of 0.448**. Future studies are expected to consider several variables other than demographic variables.

Learning generally uses a teacher-based design and a “one size fits all” approach where this approach ignores the different characteristics and preferences of students. Incompatibility of learning design with learning preferences is thought to affect learning outcomes. The learning process is often repeated with the same presentation mode regardless of the learning style of each student. In general, a teacher prepares learning materials and then teaches in the classroom. Students sit and listen to lectures from the teacher throughout the entire duration, for example in learning language material. However, this does not imply all students will learn effectively with the same method. The thing that needs to be considered is the different needs of students in the classroom. Of course, current learning refers to the 21st-century learning approach where learning is student-centered (Raleiras et al., 2022). Today's learner-centered learning provides opportunities to develop an understanding based on their experiences. The learning process in a learner-centered approach makes the class more active compared to teacher-centered learning (Serin, 2018). In addition, the learning style of students is something that needs to be considered to increase the effectiveness of learning. The learning style approach is considered in the learning process, both in the Teaching & Learning processes. The presentation of learning materials is designed using a visual-verbal preference approach. Visual-verbal preference is one of the dimensions developed by Felder & Silverman (1988), which consists of four dimensions, namely sensing-intuitive, visual-verbal, active-reflective, and sequential-global (Felder & Spurlin, 2005). Visual-verbal preferences influence how students process the information they get during the learning process. There are differences in the learning performance of students who have appropriate learning styles with the form of learning materials compared to the performance of students who are given general learning materials (J. Wang et al., 2019). Learning is effective if it is supported by the ability of visual representation and verbal representation when processing information in the learning process. Learning outcomes that pay attention to students' learning styles based on their personalities. The process of identifying learning styles is carried out to plan learning strategies (Kamal & Radhakrishnan, 2019). Many previous researches have discussed a lot about the relationship between the influence of the suitability of learning styles on the learning process. Research conducted by Cimermanová (2018) shows that learning styles and forms of teaching do not affect learning outcomes.

The results of the study are of course interesting because they have the opportunity to investigate whether other factors influence the results of the study. Other research shows that identification of learning styles can reduce the workload of teachers because students act as learning resources (Lwande et al., 2021). However, the research that has developed has not yet discussed specifically regarding visual-verbal preferences. Visual-verbal preference is an approach from dual coding theory. Based on this, the research has a research question, namely, How is the relationship between DCT and learning outcomes that have an impact on the language teaching and learning process?

Language Learning and Teaching With Technology

Technology is not a cutting edge as it has been integrated in language classrooms for decades. Simply defined, technology has been growing rapidly and transited from black board and overhead projectors to computer-based technology in which many are tied integrally to the Internet. This “changing winds and shifting sands”, as what Johnson (2017) says, is as a cyclical pattern in which a new paradigm emerged about every quarter of a century, with each new method breaking from the old, but at the same time taking with it some of the positive aspects of the previous paradigm. Such rapid technological advancement in recent years has provided teachers and learners with opportunities to use technology for education (Shadiev & Huang, 2020).

A number of previous studies have provided the evidence that the use of technology can promote the learning performance of language learners, increase learning motivation, and provide them with more efficient means for language learning (Jin, 2018). In relation to language skills (i.e., listening, reading, speaking, and writing), technology should be in line with the nature and this can be in the form of audio, video, or even combine these two as audio-visual. The use of the technology, of course, should also be able to facilitate the learners’ differences, motivation, and levels (Harmer, 2007).

Dual Coding Theory

21st-century learning suggests involving a multimodal approach in the language learning process. However, several studies failed to increase the effectiveness of vocabulary learning because it has an impact on giving more burden to the learning process (Li et al., 2022). It is necessary to adjust the learning media to the multimodal owned by the students. Visual-verbal preference is an interesting learning style indicator to discuss because these two modes are components of dual coding theory. Learning a language has a close relationship with the ability to remember vocabulary, word structure, and grammar. The dual coding theory approach allows it to be implemented in language learning because this approach combines visual recognition, images, and information processing in the spatial domain (Luo, 2022). The process that occurs in DCT involves a decoding process that aims to change the received message so that it can be understood easily. In addition, the process that occurs is the process of understanding and responding to sentences that are received simply. DCT is the key underlying vocabulary learning and visual-auditory alignment in language learning (Wong, 2019). The DCT technique retains twice as much information as to processing information that does not involve learning styles. The principles of incorporating DCT in the learning process reinforce the acceptance of information because the reinforcement of information is deeper (Cuevas & Dawson, 2018).

DCT affects the process of receiving information based on interconnected visual and verbal cues where students have good reading skills by making mental representations of writing. The DCT technique has a consistent referential relationship between the visual and verbal systems so that students easily interpret and understand the meaning of paragraphs (L. Wang, 2020). DCT helps students to build a mental picture of the sentences presented in the learning material. Students who have good reading skills can easily present the language mentally. Subsequent research stated that DCT could identify more vocabulary compared to students who did not use DCT. There is an investigation into the benefits of DCT on the use of language learning media where language proficiency is an important factor in vocabulary learning (Wong & Samudra, 2021).

In general, the learning process takes place in two directions where there is a communication process between the teacher and students. The learning communication process from the teacher to the students is presented by several methods, including using the lecture method and learning media. Learning media is presented in several forms according to visual-verbal preferences. The form of learning media is presented in visual and verbal forms to meet the needs of students. Learning materials designed in visual form are associated with objects that allow adaptive attention to the images presented (Jiang et al., 2020). The process of remembering and presenting specific information can be done with a dual coding theory approach. Dual coding theory is applied to the field of educational psychology in terms of problem-solving and language learning. The three basic dual coding theories (DCT) developed include: referential, associative, and representational (Sadoski & Krasny, 2018), as shown in Figure 1.

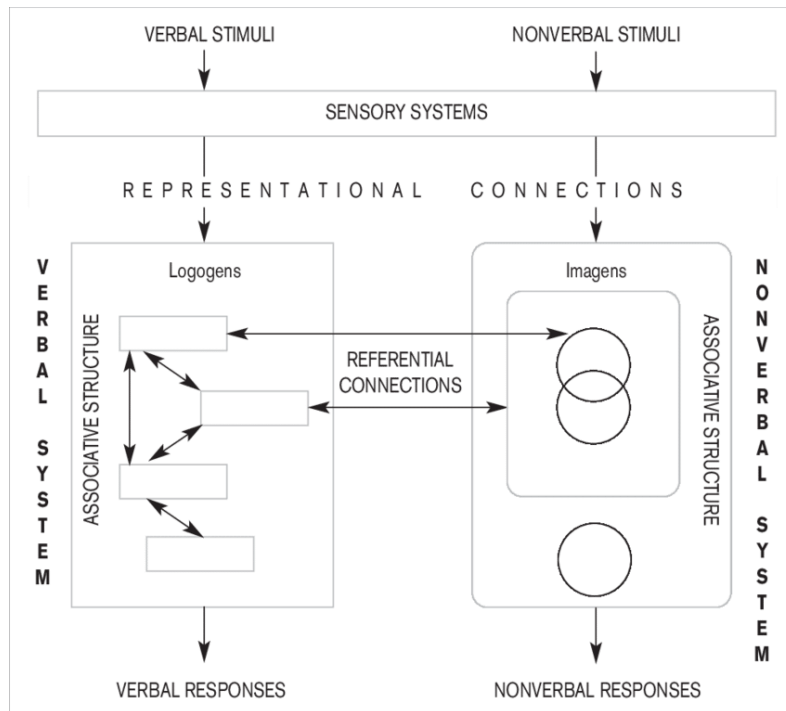
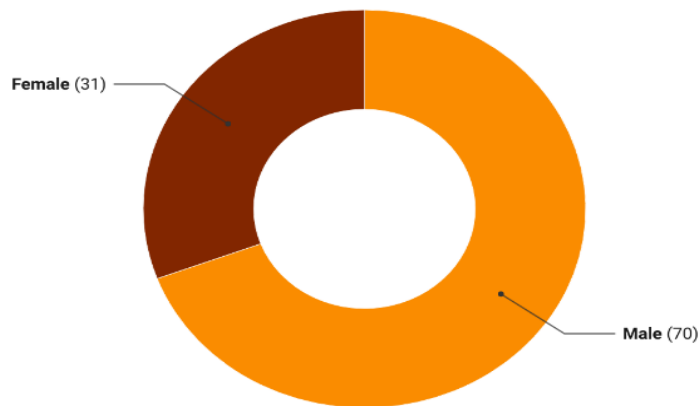


Figure 1. Dual coding theory (Sadoski & Paivio, 2004)

METHODS

Around 125 students were given the index of learning style (ILS) instrument, but only about 101 students completed filling out the ILS within two to three weeks. This study involved 101 students enrolled in the even semester of 2021/2022, State University of Malang or as many as 31 female students and 70 male students, as shown in Figure 1. Students who were selected as respondents because they took general courses at the university that were the same, were divided into two study groups.



Created with Datawrapper

Figure 1. Research Respondent

Figure 1 shows the respondents who were involved in the study where male respondents were dominantly participating compared to female respondents although the issue of gender diversification was not discussed in this study. The responden involved consisted.

Table 1. Respondent of The Research

Gender	Semester			Total	%
	2nd	4th	6th		
Female	9	14	8	31	30.69%
Male	26	33	11	70	69.31%
	35	47	19	101	

ILS is used to measure the tendency of visual preference and verbal preference based on the instrument development of Felder & Silverman (1988). One of the dimensions used is the input/presentation dimension which consists of two forms, namely visual-verbal. A total of 16 items were presented to represent students' tendencies in measuring visual-verbal preferences. Research respondents were asked to choose one answer, whether they chose an answer in the form of a picture or whether they chose an answer in the form of a narrative. Each answer is added up where if the respondent chooses a visual indicator, it will be worth "1" and if the respondent chooses a verbal indicator it will be worth "0". Summation scores between zero and 16 on visual-verbal preference. Scores above 8 ± 9 tend towards visual preference. Respondents can get a high score because of the consistency of the answers to one of the preferences, as in Figure 2. Meanwhile, the stages of how the learning materials presented in the form of figures and texts act as stimuli. Students who tend towards visuals tend to be more comfortable and choose learning materials in the form of pictures. Meanwhile, students who have verbal tendencies are more comfortable studying learning materials in the form of text narratives.

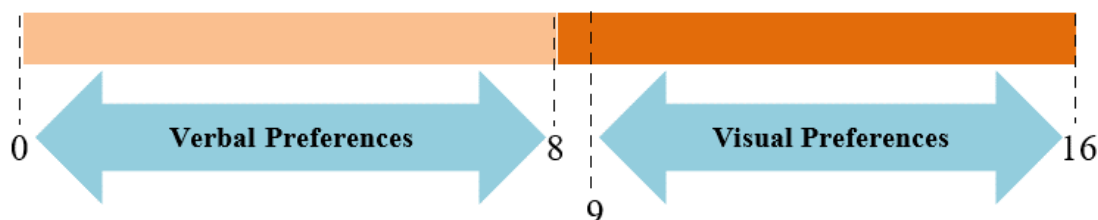


Figure 2. Score Indicators

Figure 2 shows the indicators of the sum of the scores for each item of the visual-verbal preference measurement question used in the DCT technique. The next stage is verbal processing and non-verbal processing, where at this stage the information received is sorted based on the preferences of students and converted into knowledge as shown in Figure 3. The instrument used in this study consisted of 16 questions as shown in table 2.

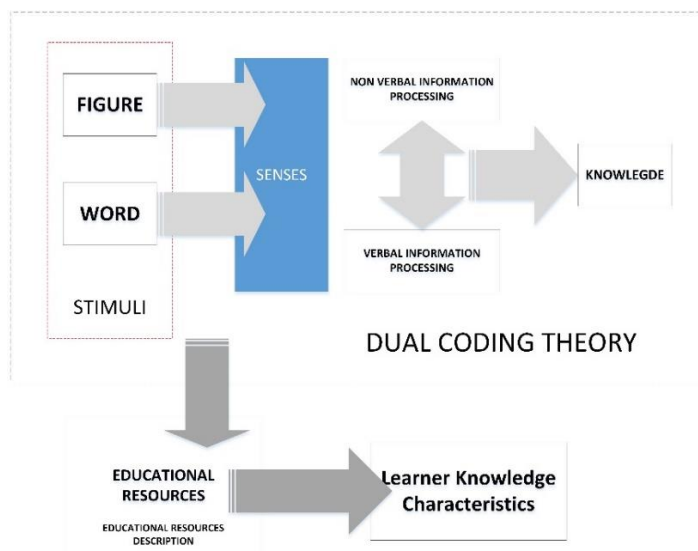


Figure 3. Research Stage

Table 2. Visual-Verbal Preferences

Item Number (Q)	Question	Visual "1"	Verbal "0"
Q1	When reading study materials, I always think of something related to:	Chart / Schematic	Narrative explanation theory
Q2	If I get learning material then the first thing I do:	Looking for charts / schematics in learning materials	Reading topics on learning materials
Q3	If the learning material is presented on only 1 page, what I notice:	Presented Charts/Schematics	Narrative of learning materials
Q4	I prefer if the learning materials are presented in the form of:	Picture	Writing and detailed explanation
Q5	In the learning material described in the previous session, the parts that I remember the most are:	Charts and Pictures	Understanding and explanation of learning materials
Q6	To better understand the learning material, I prefer if the learning syntax is presented in the form:	Learning syntax chart / schematic	Narrative
Q7	I can understand better if the teacher explains the learning material in the form of:	Chart / Schematic	Order of learning syntax explanation
Q8	I tend to find it easier to analyze data if the data is presented in the form:	Charts	Detailed writing/text
Q9	To identify problems in learning preparation, I pay more attention to:	Learning syntax drawing	Written instructions
Q10	Learning media used in the learning process is better in the form of:	Pictures / Posters	The sequence of steps in the form of a textbook
Q11	The placement of information on learning materials is easy to understand if it is presented in the form of:	Precise and accurate pictures	Detailed text
Q12	The workflow/steps of the learning process can be easily completed by:	Work chart	Work order
Q13	Before understanding learning materials and technical instructions, I tend to read:	Work illustration	Order of work instructions
Q14	The interpretation of the learning strategy that will be designed is more easily presented in the form of:	Workflow figures	The interpretation of the learning strategy that will be designed is more easily presented in the form of:
Q15	When I first got information about learning strategies, what I was looking for were:	Scheme / figures	Written instructions
Q16	I can better understand the material if the teacher:	Explain by demonstrating pictures	Explain in detail the work order

The approach used in this research is descriptive statistics using IBM SPSS 26 software, where each question item is analyzed to show the tendency of students' learning styles to visual preferences and verbal preferences. Several demographic variables are used to measure whether there are other factors involved in the influence of DCT on the learning process. The variables used in this study include Gender (Male, Female); Visualization Interest(Yes, No); and Preferences (Visual, Verbal). This study used two research groups, namely the control group and the experimental group. The control group was given a learning strategy approach without using DCT, while the experimental group used DCT. The grouping in this study aims to determine whether there is an influence of DCT on learning outcomes so that it can be seen the effectiveness of the DCT approach in the process of improving language learning.

RESULT AND DISCUSSION

This study measures the extent to which the DCT approach can affect the learning process. The process of Teaching & Learning are two things that cannot be separated. Both are important components in interrelated learning because students can gain knowledge from teaching activities that have been held. This study carried out several stages, one of which was the process of measuring visual-verbal preferences. The results of the measurement of visual-verbal preferences show that 76 students (75.2%) tend toward visuals, while 25 students (24.8%) tend toward verbal, as shown in Figure 4. Students who have visual tendencies can easily accept learning materials if presented in the form of pictures, charts, and graphs. Meanwhile, students who have verbal tendencies prefer the narrative presented by the learning material. Explanation of texts and sequences presented in paragraph form

is highly favored by students who have verbal preferences. DCT plays a role in this learning condition where DCT can help students to be able to predict good input when several sensory routes are available when they read learning material (Huang et al., 2019). The DCT process makes it easier for students to choose the form of learning material that suits their preferences.

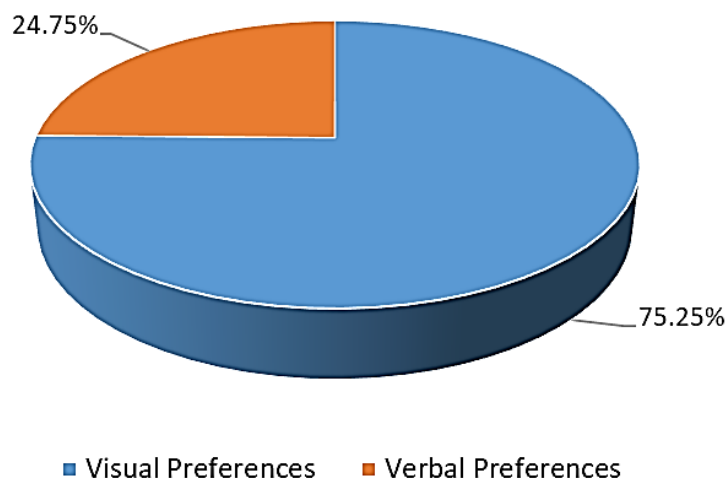


Figure 4. Visual-Verbal respondent

Visual-verbal preferences were identified using indicators obtained by students where participants who obtained a total score above 8 ± 9 tended visual preferences. The distribution of visual-verbal preferences is determined by how much students tend to have a visual-verbal preference, as shown in Figure 5. Figure 5 shows that most students have visual preferences compared to verbal preferences. To find out whether the DCT approach influences the learning process in teaching and learning activities, the DCT correlation on learning outcomes is measured. Meanwhile, demographic variables such as Gender, Visualization_Interest, and Preferences to see if there are other factors besides DCT that influence or also influence learning outcomes. This study reveals how much correlation each variable has with learning outcomes, in addition to whether different strategies have an impact on learning outcomes, as shown in table 3.

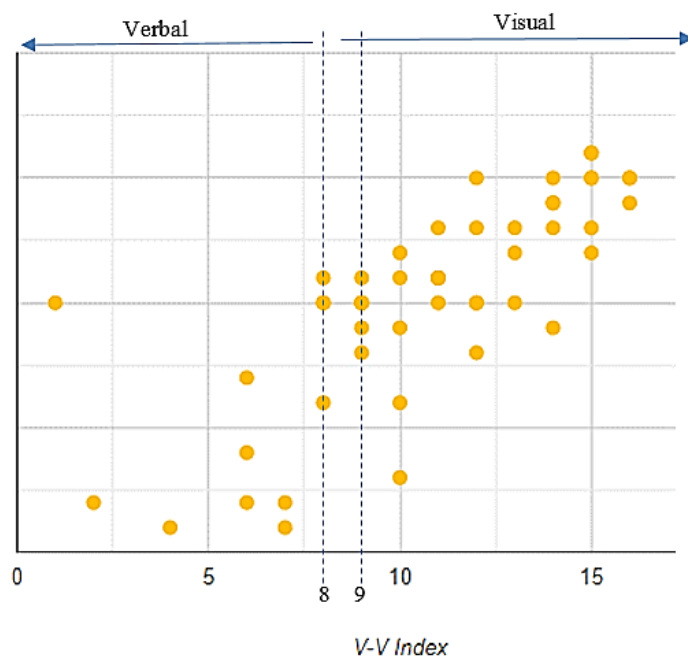


Figure 5. Distribution of Visual-Verbal Preference

Table 3. Statistical Analysis of DCT

		Gender	Visualization_Interest	Preferences	Learning_Strategies	Learning_Outcomes
Gender	Correlation Coefficient	1.000	-0.127	-0.183	.659**	.448**
	Sig. (2-tailed)		0.205	0.067	0.000	0.000
	N	101	101	101	101	101
Visualization_In terest	Correlation Coefficient	-0.127	1.000	0.190	-0.089	-0.004
	Sig. (2-tailed)	0.205		0.058	0.374	0.970
	N	101	101	101	101	101
Preferences	Correlation Coefficient	-0.183	0.190	1.000	-0.075	0.192
	Sig. (2-tailed)	0.067	0.058		0.459	0.054
	N	101	101	101	101	101
Learning_Strategies	Correlation Coefficient	.659**	-0.089	-0.075	1.000	.826**
	Sig. (2-tailed)	0.000	0.374	0.459		0.000
	N	101	101	101	101	101
Learning_Outcomes	Correlation Coefficient	.448**	-0.004	0.192	.826**	1.000
	Sig. (2-tailed)	0.000	0.970	0.054	0.000	
	N	101	101	101	101	101

Table 3 shows the correlation and effect of different learning strategies on learning outcomes. Gender has a coefficient of 0.448** which indicates that the correlation level is quite strong and significant between gender and learning outcomes. The correlation between gender and learning outcomes is positive so that it shows the relationship between the two is unidirectional. The results of this study are of course contrary to the results of research which shows that there is no significant difference between men and women in learning outcomes (Haruna et al., 2021). Gender differences do not have a significant effect on learning outcomes. While other studies support the results of this study, gender differences are considered to determine the correlation between learning conceptions and learning outcomes (Pinto et al., 2018). The results also show a significant value or Sig. (2-tailed) is 0.000 where the significance value is <0.05, the gender significance value has a significant relationship between gender variables and learning outcomes.

This study provides findings not only related to several variables that have a close relationship with learning output but also found some surprising things, namely visualization interest, which questioned each student regarding their interest in pictures or not, it turned out that it could not have a significant effect. The same result is also obtained by the preferences variable which does not affect learning outcomes. Different results were obtained on visualization interests and preferences which showed that they did not have a significant relationship with learning outcomes, which respectively had a significant value of Sig. 0.970 and 0.054. Visualization interest has a non-unidirectional relationship with learning outcomes which is indicated by a negative correlation coefficient of -0.004. Meanwhile, preferences have a unidirectional relationship with a positive correlation coefficient of 0.192. Findings related to preferences are of course contrary to the results of research which states that the dimensions of learning styles also interact in collaborative learning that affects learning outcomes Student achievement has a positive relationship with perceptions of learning modalities (Price Banks & Vergez, 2022), where there are significant differences in students' achievements and perceptions.

Furthermore, the findings of this study indicate that DCT influences learning outcomes. The value of the correlation coefficient of learning strategies shows a positive value of 0.826** which means that the relationship between learning strategies and learning outcomes is unidirectional. The correlation coefficient value of 0.826** indicates that the relationship between learning strategies and learning outcomes is very strong so the influence of the DCT approach is highly considered in teaching and learning activities. This study also found that the significance value, Sig. (2-tailed) of 0.000. Value of Sig. <0.05 indicates that the relationship between the variables of learning strategies and learning outcomes is significant. Learning using the DCT approach provides students with a choice of forms of learning materials. Students choose the form of learning materials according

to their preferences of students. The findings of this study agree with research that states that video learning material that provides visualization is more effective than textual material (Ge et al., 2019). The findings of this study support the results of previous research which states that there is a level of comfort when studying learning material if it is presented by the characteristics of learning. Based on this, it is clear that if someone is comfortable learning then learning can be optimized for results. This study also supports previous research where when students learn independently, and are presented with information that is not to their preferences, there will be cognitive overload. Meanwhile, when the information mode on the learning media has been adjusted to the learning preferences, comfortable learning becomes an atmosphere that supports the learning process (Cuevas & Dawson, 2018). The DCT technique provides an opportunity for teachers to develop learning media according to the learning preferences of students. As for students, the DCT technique can be used to optimize the learning process so that learning objectives can be achieved easily.

CONCLUSION

In general, learning is presented to students in the same form regardless of the characteristics and preferences of their learning styles. Teaching and Learning models that are not to the preferences of students result in non-optimal learning outcomes. The Dual Code Theory (DCT) approach was applied in this study to assist students in improvising language learning. DCT is used to help students process the information on learning materials based on their learning preferences. Research findings indicate that gender and learning strategies have a positive relationship with learning outcomes. DCT has a direct relationship with learning outcomes, as shown by the positive correlation coefficient value of 0.826**. In addition, when viewed from the significance value (Sig. <0.05), it can be concluded that the implementation of DCT has a significant effect on learning outcomes. The selection of information on learning materials based on the preferences of each student provides opportunities for students to learn more easily and optimize their learning process. As for teachers, DCT provides opportunities for teachers to design learning materials by adjusting the characteristics of students. Learning materials designed with the DCT approach have the potential to encourage better learning. This research has been able to provide findings of DCT, but it needs to be further developed by conducting research not only using statistical tests but also using a machine learning approach. The machine learning approach process is expected to be able to predict learning activities that are more adaptive to the preferences of students. The implementation of the findings of this study can of course has an impact on the learning process that is adaptive to the characteristics of students.

REFERENCES

- Cimermanová, I. (2018). The Effect of Learning Styles on Academic Achievement in Different Forms of Teaching. *International Journal of Instruction*, 11(3), 219–232.
- Cuevas, J., & Dawson, B. L. (2018). A test of two alternative cognitive processing models: Learning styles and dual coding. *Theory and Research in Education*, 16(1), 40–64. <https://doi.org/10.1177/1477878517731450>
- Felder, R. M., & Silverman, L. K. (1988). Learning and teaching styles in engineering education. *Engineering Education*, 78(7), 674–681.
- Felder, R. M., & Spurlin, J. (2005). Applications, Reliability and Validity of the Index of Learning Styles. *International Journal of Engineering Education*, 21(1), 103–112. <https://doi.org/0949/-149X/91>
- Ge, Z., Zhou, M., & Zhang, A. (2019). Video Learning Material vs. Text-only Learning Material in E-learners' Autonomous Language Learning. *2019 IEEE International Conference on Artificial Intelligence and Computer Applications (ICAICA)*, 34–38. <https://doi.org/10.1109/ICAICA.2019.8873493>
- Harmer, J. (2007). *The practice of English language teaching*. Pearson longman.
- Haruna, H., Zainuddin, Z., Okoye, K., Mellecker, R. R., Hu, X., Chu, S. K. W., & Hosseini, S. (2021). Improving instruction and sexual health literacy with serious games and gamification interventions: an outlook to students' learning outcomes and gender differences. *Interactive Learning Environments*, 1–19. <https://doi.org/10.1080/10494820.2021.1888754>
- Huang, X., Kim, N., & Christianson, K. (2019). Gesture and vocabulary learning in a second language. *Language Learning*, 69(1), 177–197. <https://doi.org/10.1111/lang.12326>
- Jiang, X., Yu, J., Qin, Z., Zhuang, Y., Zhang, X., Hu, Y., & Wu, Q. (2020). Dualvd: An adaptive dual encoding model for deep visual understanding in visual dialogue. *Proceedings of the AAAI Conference on Artificial Intelligence*, 34(07), 11125–11132. <https://doi.org/10.1609/aaai.v34i07.6769>
- Jin, L. (2018). Digital affordances on WeChat: Learning Chinese as a second language. *Computer Assisted Language Learning*, 31(1–2), 27–52.
- Johnson, K. (2017). *An introduction to foreign language learning and teaching*. Routledge.
- Kamal, A., & Radhakrishnan, S. (2019). Individual learning preferences based on personality traits in an E-learning scenario. *Education and Information Technologies*, 24(1), 407–435. <https://doi.org/10.1007/s10639-018-9777-4>

- Li, W., Yu, J., Zhang, Z., & Liu, X. (2022). Dual Coding or Cognitive Load? Exploring the Effect of Multimodal Input on English as a Foreign Language Learners' Vocabulary Learning. *Frontiers in Psychology*, *13*, 834706. <https://doi.org/10.3389/fpsyg.2022.834706>
- Luo, L. (2022). A Study on the Application of Computer-Aided Dual-Coding Theory in English Vocabulary Teaching. *Scientific Programming*, *2022*. <https://doi.org/10.1155/2022/5951844>
- Lwande, C., Muchemi, L., & Oboko, R. (2021). Identifying learning styles and cognitive traits in a learning management system. *Heliyon*, *7*(8), e07701. <https://doi.org/10.1016/j.heliyon.2021.e07701>
- Pinto, G., Bigozzi, L., Vettori, G., & Vezzani, C. (2018). The relationship between conceptions of learning and academic outcomes in middle school students according to gender differences. *Learning, Culture and Social Interaction*, *16*, 45–54. <https://doi.org/10.1016/j.lcsi.2017.11.001>
- Price Banks, D., & Vergez, S. M. (2022). Online and In-person learning preferences during the COVID-19 pandemic among students attending the City University of New York. *Journal of Microbiology & Biology Education*, e00012-22. <https://doi.org/10.1128/jmbe.00012-22>
- Raleiras, M., Nabizadeh, A. H., & Costa, F. A. (2022). Automatic learning styles prediction: A survey of the State-of-the-Art (2006–2021). *Journal of Computers in Education*, 1–93. <https://doi.org/10.1007/s40692-021-00215-7>
- Sadoski, M., & Krasny, K. A. (2018). Dual Coding Theory: An Embodied Theory of Literacy. In *Theoretical Models and Processes of Literacy* (pp. 161–177). Routledge.
- Sadoski, M., & Paivio, A. (2004). A dual coding theoretical model of reading. *Theoretical Models and Processes of Reading*, *5*, 1329–1362.
- Serin, H. (2018). A comparison of teacher-centered and student-centered approaches in educational settings. *International Journal of Social Sciences & Educational Studies*, *5*(1), 164–167. <https://doi.org/10.23918/ijsses.v5i1p164>
- Shadiev, R., & Huang, Y.-M. (2020). Investigating student attention, meditation, cognitive load, and satisfaction during lectures in a foreign language supported by speech-enabled language translation. *Computer Assisted Language Learning*, *33*(3), 301–326.
- Wang, J., Mendori, T., & Hoel, T. (2019). Strategies for multimedia learning object recommendation in a language learning support system: Verbal learners vs. visual learners. *International Journal of Human-Computer Interaction*, *35*(4–5), 345–355. <https://doi.org/10.1080/10447318.2018.1543085>
- Wang, L. (2020). Using dual-coded multimedia instructions to assist TESOL students in reading comprehension. *Innovate Learning Summit*, 332–336.
- Wong, K. M. (2019). Learning Vocabulary through Educational Media: Extending Dual-Coding Theory to Dual-Language Learners. *2019 Conference of the American Association for Applied Linguistics (AAAL)*.
- Wong, K. M., & Samudra, P. G. (2021). L2 vocabulary learning from educational media: Extending dual-coding theory to dual-language learners. *Computer Assisted Language Learning*, *34*(8), 1182–1204. <https://doi.org/10.1080/09588221.2019.1666150>