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The Effect of E-Chemagz in the RADEC Model on Students Creativity and Learning Outcomes

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ABSTRACT

This study aims to determine the effect of e-chemagz in the RADEC model on creativity and learning outcomes of 10th-grade students of State Senior High School 8 Makassar on the subject of chemical bonds. The method used is a quasi-experimental method with a posttest only control group design. The population in this study was all 10th-grade students of State Senior High School 8 Makassar. Random sampling was used to determine the research sample, and Class X Merdeka 1 was selected as the experimental class that used e-Chemagz in the RADEC model, while Class X Merdeka 2 was selected as the control class that did not use e-Chemagz in the RADEC model. Based on inferential analysis using the Mann Whitney test, it shows that student learning creativity obtained Z_{count} = 2.53 at (α) = 0.05 and obtained Z_{table} = 1.64, indicating that Z_{count} (2.53) > Z_{table} (1.64). while for learning outcomes, Zcount = 4.25 at (α) = 0.05 and Ztable= 1.64, indicating that Zcount (4.25) > Ztable (1.64). It can be concluded that E-Chemagz has an effect on the RADEC model in terms of creativity and learning outcomes of 10th-grade students of State Senior High School 8 Makassar on the subject of chemical bonding.

Keywords: E-Chemagz, Learning outcomes, Creativity, RADEC

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INTRODUCTION

The rapid development of Science and Technology and its increasingly visible role in every aspect of life are characteristic of the 21st century. Education in the 21st century has become important for innovative learning that can prepare students to face the demands of the times. Education is expected to create quality human resources who are able to compete in the era of globalization. Thus, education must be oriented towards the necessary skills, one of which is creativity in learning.

Creativity is a competency that a person possesses to discover and create new

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things, new ways, and new ideas that are useful for themselves and society (Sudarti, 2020). Several studies have shown that the use of learning media can have a positive effect on students' creativity (Hadi & Purmadi, 2018). Previous studies by (Nugraha, 2020; Ayukinah, 2022) and have stated that there is a positive effect on chemistry learning with learning media on students' learning creativity. Based on the research that has been conducted, media greatly influences students' creativity. Therefore, learning needs to be designed to make learning more interesting.

Creativity plays an important role in learning, especially in chemistry. Chemistry is one of the subjects taught in high school that covers several topics, including chemical bonding. Chemical bonding is important to understand because it forms the basis for learning chemistry topics related to interactions between atoms. The topic of chemical bonding should be taught well so that students understand and master the material.

The implementation of chemistry learning at Makassar State High School 8, particularly on the subject of chemical bonds, revealed that the learning process already uses the learning model recommended by the independent curriculum. However, this model has not been fully implemented at the school, and the lack of learning media has resulted in students feeling bored and less engaged during the learning process. This was also evident when the teacher explained that interaction only occurred between the teacher and students, with little interaction among students. The use of available teaching materials, such as textbooks, tends to contain chemical theories that are too dense in content.

This has an impact on the lack of creativity among students and also affects their learning outcomes. In addition, it is also known from the interview results that for grade X in chemistry, Minimum Passing Score is 75. However, less than 50% of students are able to achieve the Minimum Passing Score. One way that educators can do this is by using interesting learning models and media. One learning model that teachers can use is the RADEC (Read, Answer, Discuss, Explain, Create) learning model. The RADEC learning model is an innovative learning model that focuses on mastering competencies and skills, making it suitable for application in the Indonesian learning system (Setiawan dalam Predi, Supriadi, & Suri, 2022).

One of the learning media that can be used in the RADEC (Read, Answer, Discuss, Explain, Create) learning model is a chemistry magazine that can be presented in electronic form. Chemistry magazines are learning media that are presented in an attractive manner with various supporting features such as images, videos, and audio. This chemistry magazine is titled “E-Chemagz” which refers to the meaning of Electronic Chemistry Magazine. One of its characteristics is that the display of images or text in E-Chemagz can give an impression that is not boring, making it more interesting than printed books read by students (Algiffary, Aulia, & Husain, 2022).

Therefore, the use of learning media can make students more active during the learning process. Learning media in the RADEC model applied to chemistry learning, especially chemical bonding material, is appropriate because this material requires an understanding of chemical concepts, and the RADEC model can help students through each stage of the model. Then, creativity and learning outcomes will be better.

Several researchers have proven that the RADEC model has an impact on student learning outcomes and creativity. Previous research conducted by several authors shows that in a study conducted by (Afifah, Sitompul, & Habellia, 2023) student learning outcomes before using

RADEC were in the low category, and after using RADEC, learning outcomes were in the high category. This is also in line with the research conducted (Hanum, Zulfadli, & Nisa, 2023) that the completeness of student learning outcomes with the RADEC learning model was in the good category.

Based on the above descriptions, the author is interested in conducting research entitled "The Effect of E-Chemagz in the RADEC Model on the Creativity and Learning Outcomes of 10th-grade students of State Senior High School 8 Makassar (A Study of Chemical Bonding Material)".

RESEARCH METHOD

This type of research is a quasi-experimental study. The research was conducted in the even semester of the 2024/2025 academic year. The research was conducted at State Senior High School 8 Makassar (SMA Negeri 8 Makassar), located at Jl. Andi Mangerangi 2 Lorong 3 No.24, Bongaya, Kec. Tamalate, Makassar City, South Sulawesi Province. The research design used was a posttest-only control group design using two sample classes that would be used as the experimental and control classes. The population in this study was all 10th grade students at State Senior High School 8 Makassar in the 2024/2025 academic year. The sample in this study was determined using random sampling, which is the random selection of samples from the population without regard to the strata in the population. The samples selected in this study were students in Class X Merdeka 1 as the experimental group and Class X Merdeka 2 as the control group, with 36 students in each group.

The research variables consist of two types, namely independent variables and dependent variables. The independent variables in this study are E-Chemagz in the RADEC model and the RADEC model without E-Chemagz assistance. Meanwhile, the dependent variables in this study are students' creativity and learning outcomes. The research instruments are a student creativity questionnaire, a learning outcome test, and an observation sheet on the implementation of learning.

Data collection techniques were used to measure students' learning creativity by giving them a creativity questionnaire. The creativity questionnaire consisted of 25 statements, divided into two types: positive and negative statements. The creativity questionnaire was created using a Likert scale in the form of a checklist and consisted of five criteria. Then, learning outcomes were measured by administering a posttest at the end of the meeting to the experimental class and the control class. The posttest was a multiple-choice test consisting of 25 questions with five alternative answers. The data analysis technique used was descriptive statistical analysis and inferential statistical analysis.

Descriptive Statistical Analysis

1. Calculating students' creativity scores

To determine the creativity scores of students, the scores obtained by students are converted into values using the following formula:

$$\text{Score} = \frac{\text{number of correct scores}}{\text{maximum possible score}} \; x \; 100 \; \ldots\ldots. (1)$$

The creativity scores obtained by students are grouped into five criteria. The following criteria for student creativity can be seen in Table 1.

Table 1. Criteria for student creativity

Creativity Score	Criteria
<45	Very low creativity
45-59	Not very creative
60-74	Fairly creative
75-89	Creative
90-100	Very creative

2. Individual Completion

$$Tp = \frac{JB}{JS} \; x \; 100 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

Description:
Tp : individual completion
JB : score for each student
JS : maximum score

The individual completion scores used at State Senior High School 8 Makassar can be seen in Table 2.

Table 2. Student completion criteria

Level of Completion	Criteria
≥ 75	Complete
< 75	Not complete

3. Class Completion

$$Tk = \frac{\sum Tp}{n} \; x \; 100\% \ldots\ldots\ldots\ldots\ldots\ldots (3)$$

Description:
Tk : class completion
∑Tp : number of individual completions
n : maximum score

4. Inferential Statistical Analysis

Inferential statistics are used to test research hypotheses. In inferential statistics, before testing hypotheses, research data must meet analysis requirements, including a normality test using chi-square. The chi-square formula used is:

$$x^2_{count} = \sum \frac{(O_i - E_i)^2}{E_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Then, the homogeneity test uses Fisher's test. The formula for the homogeneity test used is:

$$F_{count} = \frac{\text{Big variance}}{\text{Small variance}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

After both tests are fulfilled, the hypothesis test using the t-test is continued. To find the value in the t-test, the following formula is used:

$$t_{count} = \frac{\bar{X}_1 - \bar{X}_2}{S\sqrt{\frac{1}{n_1} + \frac{1}{n_2}}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

If the creativity and learning outcomes of the experimental and control groups do not meet the requirements for parametric testing, then non-parametric testing (Mann Whitney test) is used.

$$Z_{count} = \frac{U - \mu U}{\sigma U} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (7)$$

$$Z_{count} = \frac{U - \frac{n1n2}{2}}{\sqrt{\left(\frac{n1n2}{N(N-1)}\right)\left(\frac{N_3 - N}{12} - \sum T\right)}} \ldots\ldots\ldots\ldots\ldots (8)$$

The hypothesis is as follows:

H_o : $\vartheta_1 \leq \vartheta_2$
H_1 : $\vartheta_1 > \vartheta_2$

Description:
H_o: E-Chemagz has no effect on the RADEC model in terms of students' creativity and learning outcomes in chemical bonding material.
H_1: E-Chemagz in the RADEC model has an effect on students' creativity and learning outcomes in chemical bonding material.
ϑ_1: average creativity and learning outcomes of students in the experimental group
ϑ_2: average creativity and learning outcomes of students in the control group

RESULT AND DISCUSSION

Research Results

In this study, descriptive analysis was conducted to measure the average value of each indicator of student learning creativity. These average values are presented in a diagram that can be seen in Figure 1.

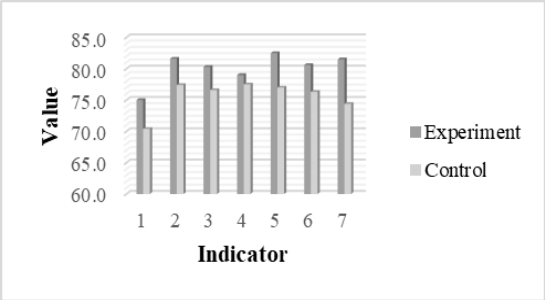

Figure 1. Average scores for creativity indicators

Based on Figure 1, it can be seen that the average learning creativity scores of students in the experimental class are higher than the average scores of the control class.

The aspects measured are fluency with indicators (able to generate many ideas, answers, solutions to problems or questions), flexibility with indicators (able to see a problem from different perspectives, generate varied ideas, answers, or questions), originality with indicators (able to produce new and unique things, have the determination to complete tasks), and elaboration with indicators (responding to questions actively and enthusiastically in completing tasks, enjoy looking for practical ways or methods of learning). The criteria for student learning creativity can be seen in Table 3.

Based on Table 3, the criteria for student learning creativity consist of VLC (Very Low Creativity), LC (Low Creativity), CC (Moderate Creativity), C (Creative), and HC (High Creativity). When viewed from the percentage of criteria, both the experimental and control classes were in the Moderately Creative, Creative, and Very Creative criteria. Specifically, the percentage of the Very Creative criterion in the experimental class (22,22%) was higher than that in the control class (11,11%). This shows that the creativity of students in the experimental class was better than that in the control.

Tabel 3. Criteria for student learning creativity

Score	Criteria	Experiment		Control	
		F	P (%)	F	P (%)
<45	VLC	0	0	0	0
45-59	LC	0	0	0	0
60-74	CC	10	27,78	17	47,22
75-89	C	18	50	15	41,67
90-100	HC	8	22,22	4	11,11
Total		36	100	36	100

Next, inferential analysis began with prerequisite tests, namely normality and homogeneity tests. Based on the data from the normality test of student learning creativity with a significance level of 0,05, $X^2_{count} \leq X^2_{table}$ (3,22 ≤ 7,81), the experimental class was normally distributed and the control class was not normally distributed because $X^2_{count} > X^2_{table}$ (11,47 > 7,81). Then, testing the homogeneity of student creativity with a significance level of 0.05 obtained $F_{count} \leq F_{table}$ (1,38 ≤ 1,84), both classes came from homogeneous variances. Because the data did not meet the assumptions of parametric tests based on the results of the prerequisite tests, hypothesis testing was carried out using non-parametric tests, namely the test. Mann-Whitney with one way testing, this can be seen in Table 4.

Table 4. Hypothesis test results

Class	Z_{count}	Z_{table}	Conclusion
Experiment Control	2,53	1,64	H_0 rejected dan H_1 accepted

Based on Table 4, it can be seen that the calculation of student learning creativity using the Mann Whitney test obtained Z_{count} = 2,53 and Z_{table} = 1,64 at a significance level of 0.05. Because $Z_{count} > Z_{table}$ (2,53 > 1,64), H_0 is rejected and H_1 is accepted. Based on these results, it can be concluded that E-Chemagz in the RADEC model has an effect on the learning creativity of grade X students of SMA Negeri 8 Makassar studying chemical bonding.

A descriptive analysis was also conducted to determine the learning outcomes of students with individual mastery scores ≥ 75. This can be seen in Table 5.

Table 5. Student learning completion data

Score	Mastery Criteria	Experiment		Control	
		Frequency	Percentage	Frequency	Percentage
≥ 75	Complete	30	83,3%	22	61,1%
< 75	Not complete	6	16,7%	14	38,9%
Total		36	100%	36	100%

Based on Table 5, it can be seen that the learning completeness of students was higher in the experimental class at 83.3%, while in the control class it was 61.1%. In addition, this study also examined the percentage of student learning outcomes on chemical bonding material through several learning objectives, which can be seen in Table 6.

Table 6. Percentage of Learning Outcomes Learners

Learning Objectives	Experiment		Control	
	Percentage	Criteria	Percentage	Criteria
Explains the tendency of an element to achieve stability based on its electron configuration	87%	Complete	82,4%	Complete
Defining the formation of ionic bonds accurately	91,6%	Complete	80,5%	Complete
Describing the process of ion bond formation using Lewis structures	83,3%	Complete	76,35%	Not Complete
Analyzing the properties of ionic compounds	87%	Complete	68,4%	Not Complete
Defining the formation of covalent bonds	77,7%	Not Complete	83,3%	Complete
Describing the formation of covalent bonds using Lewis structures	76,8%	Not Complete	63,8%	Not Complete
Analyzing types of covalent bonds	81,2%	Complete	66,62%	Not Complete
Concluding polar and nonpolar covalent compounds	70,75%	Not Complete	75%	Not Complete
Analyzing the properties of compounds formed from covalent bonds	81,9%	Complete	70,8%	Not Complete
Defining the formation of metallic bonds	76,35%	Not Complete	70,8%	Not Complete
Examining the properties of compounds formed from metallic bonds	84,7%	Complete	86,05%	Complete

Based on Table 6, it can be seen that the completeness of student learning outcomes on chemical bonding material for the experimental group has a higher learning objective than students in the control group.

Next, inferential analysis began with prerequisite tests, namely normality and homogeneity tests. Based on the normality test data of student learning outcomes with a significance level of 0,05, $X^2_{count} > X^2_{table}$ (12,65 > 7,81) was obtained for the experimental class and the control class obtained $X^2_{count} > X^2_{table}$ (13,54 > 7,81) for both classes, indicating that neither is normally distributed. Then, the homogeneity test of student learning outcomes with a significance level of 0.05 obtained $F_{count} \leq F_{table}$ (1,64 ≤ 1,84), indicating that both classes come from homogeneous variances. Because the data did not meet the assumptions of parametric tests based on the results of the prerequisite tests, hypothesis testing was performed using nonparametric tests, namely the Mann-Whitney test with a one-way test, as shown in Table 7.

Table 7. Hypothesis test results

Class	Z_{count}	Z_{table}	Conclusion
Experiment Control	4,25	1,64	H_0 rejected dan H_1 accepted

Table 7 shows that the analysis results obtained a Z_{count} = 4,25 and Z_{table} = 1,64 at a significance level of 0,05. Because $Z_{count} > Z_{table}$ (4,25 > 1,64), H_0 is rejected and H_1 is accepted. Based on these results, it can be concluded that E-Chemagz has an effect on the RADEC model in the learning outcomes of grade X students of SMA Negeri 8 Makassar studying chemical bonding material.

Discussion

This study was conducted to determine the effect of E-Chemagz in the RADEC model on students' creativity and learning outcomes in chemical bonding. The study was conducted in the even semester with a total of 72 respondents from two classes, namely Class X Merdeka 1 as the experimental group and class X Merdeka 2 as the control group, with 36 students in each group. This study was conducted over four meetings, consisting of three learning processes for each meeting and a post-test administered at the last meeting. Both the experimental and control groups were taught using the RADEC model, but the experimental group specifically used E-Chemagz (Electronic Chemistry Magazine).

This is in line with research conducted by (Bella, Kasmawati, & Ihsan, 2024) that students who use media for learning will be more engaged and enthusiastic and more likely to participate actively during the teaching and learning process.

This shows that, in general, the use of E-Chemagz in the RADEC model has a positive effect on students' learning creativity. This study is supported by research (Hutabarat & Hasibuan, 2020) which states that increased student creativity is marked by an increase in creativity indicators. The use of this chemistry magazine as a learning medium is expected to help students learn independently and facilitate their understanding of the material (Ristiyani & Wiyarsi, 2023).

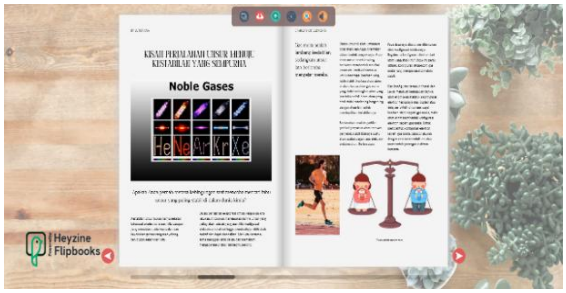

Figure 2. Display of E-Chemagz (Electronic Chemistry Magazine)

Figure 2 shows the E-Chemagz display given to students in the second syntax (Read) in the RADEC model. In this syntax, students independently explore information related to chemical bonding material. This is because giving students independent assignments or learning activities such as this can make the learning process more effective and encourage classroom learning to focus more on material that is considered difficult.

In addition, the use of E-Chemagz is also attractive because of the pictures and videos contained in E-Chemagz, which make it easy for students to understand the material. This is in line with research conducted (Afriani et al., 2022) that E-Chemagz has benefits in improving student learning outcomes because of the content, videos, and pictures in the magazine, which can help students improve the material they have read. During the learning process, students were very enthusiastic and active, as seen from their use of E-Chemagz, which was given to them to read and contained questions that they could answer after reading. The questions provided were also answered well by the students.

The use of E-Chemagz can influence the creativity and learning outcomes of students in the experimental group. This can be seen in the percentage of learning objectives 1 and 2, which are both in the mastery criteria, both in the experimental group and the control group. Although both are in the mastery criteria, the experimental group has a higher percentage than the control group. Learning objective 1, which is "to explain the tendency of an element to achieve stability based on electron configuration", in the experimental group, the use of E-Chemagz can help students understand the material. Then, learning objective 2 is "to define the formation of ionic bonds". This is because the use of E-Chemagz in the RADEC model helps students see the visualization of electron transfer between atoms. This strengthens their understanding of the concept and makes it easier for students to define ionic bonds correctly.

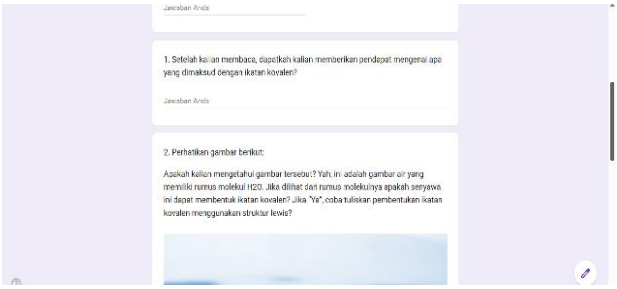

Figure 3. Questions in answer syntax

This can also be seen in Figure 3, where after reading the material, students will answer several questions related to the material in E-Chemagz. The purpose of this activity is for students to learn independently by looking at difficult material and assessing their ability to complete pre-learning questions. This stage differs from the read stage because student performance is not expected from others, so students are more focused on themselves (Kusumaningpuri & Fauziati, 2021).

Students become more proactive in understanding the material through the RADEC steps, such as the discussion stage that directs students to discuss the questions listed in the LKPD, and they are more focused on participating in discussions and expressing explanations in front of other students (Hanum, Zulfadli, & Nisa, 2023). In this way, it can be determined which groups have mastered the material and which groups have creative answers to the questions. At the end of the learning process, students are asked to create mind maps with the aim of helping to improve understanding, facilitate creative thinking, facilitate the learning and memorization process, and solve problems.

Based on the above explanation, several researchers explain that the use of learning media has an effect on stimulating students' curiosity and providing

opportunities for students to be more active in the learning process so that their creativity can increase (Winarni & Astuti, 2019).

This study is supported by previous research (Harahap & Pradana, 2024) that the use of learning media is more effective in supporting the teaching and learning process so that learning objectives can be achieved. This means that the use of E-Chemagz can help students be more active during the learning process so that they can improve their learning outcomes (Khaerunnisah, Sopandi, & Wahyu, 2023). This is also in line with research conducted by (Kiyai, Lihawa, & Rusiyah, 2025) that the use of learning media has a positive effect on student learning outcomes.

CONCLUSION

Based on the results of data analysis and discussion, it can be concluded that E-Chemagz has an influence on the RADEC model in terms of creativity and learning outcomes of 10th-grade students of State Senior High School 8 Makassar in the subject of chemical bonds. However, there are limitations in this study, namely the lack of interactive features and the fact that this media is only used in one experimental group. Therefore, future researchers can add interactive features such as educational games to increase student engagement and further integrate E-Chemagz into every syntax of the learning model used.

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