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Application of Culturally Responsive Transformative Teaching (CRTT) Assisted by Podcasts and E-Assessments to Improve Student Creativity and Science Literacy

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Abstract

This study investigated the impact of the influence of the Culturally Responsive Transformative Teaching (CRTT) Model, assisted by podcasts and e-assessments, on students' creativity and science literacy abilities in reaction rate materials. Quasi-experimental design with a cluster random sampling technique to select experimental classes and a control group from a public high school in the city of Karanganyar. Descriptive and inferential analyses were conducted by the Mann-Whitney test for the testing of the creativity hypothesis with significant results (<0.05), the independent samples t-test for testing the science literacy hypothesis with significant results (<0.05), and the Kruskal-Wallis test for the simultaneous hypothesis of two variables with significant results (<0.05). In conclusion, the podcast-assisted CRTT model and e-assessment on reaction rate materials can affect students' creativity and science literacy skills. In addition, this model includes culture-based learning equipped with podcasts as a flexible media facility, and e-assessments provide ease of assessment. These findings support the use of a podcast-assisted CRTT model and e-assessment as effective tools for enhancing chemistry learning, boosting students' motivation, and improving their skills in line with the demands of 21st-century education.

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INTRODUCTION

Education in the 21st century often faces complex challenges as technological developments, globalization, and cultural shifts also affect the characteristics of students. Science learning, especially chemistry, is not only required with mastery of concepts but must be able to develop high-level thinking skills, creativity, and science literacy (Rahmawati & Salehudin, 2021). Students often feel that chemistry learning tends to be one of the difficult, abstract, and formula-oriented learnings, so it has an impact on the low interest in learning and conceptual understanding of students (Nerita et al., 2023). According to Johnstone 1982 in (Nimah et al., 2020), chemistry has characteristics that require the understanding of the participants of the three levels of representation, namely

microscopic, sub-microscopic, and symbolic. In learning practice in schools, the three levels of representation have not been fully integrated optimally. Learning tends to focus on symbolic aspects, such as the use of mathematical formulas and equations, while macroscopic and submicroscopic differentiation tends to receive less attention (Gomollón-Bel & García-Martínez, 2024). This condition causes students to have difficulty understanding chemistry holistically and meaningfully. One of the chemical materials that reflects this problem is the reaction rate, which contains abstract concepts such as impact theory, activation energy, and the law of reaction rate.

The problem of chemistry learning is also reflected in the low science literacy ability of students in Indonesia. Based on the results of the 2022 programme for international student assessment (PISA), it shows that Indonesia's science literacy score is still below the OECD average. This shows that most students are still not able to apply science knowledge in the context of daily life. On the other hand, students' creativity skills are important because they are one of the abilities in the 21st century that are closely related to science literacy, as both require students to have the ability to think critically and innovatively, and solve problems (Ayu et al., 2025). Therefore, there is a need for learning model innovations that are able to develop students' creativity as well as science literacy.

One of the alternative learning models that is relevant to answer these challenges is culturally responsive transformative teaching (CRTT). The CRTT model is a learning model that integrates students' cultural backgrounds into the learning process and encourages critical reflection and changes in students' perspectives (Widarti et al., 2025). Through this model, it is hoped that the learning process can become more contextual, inclusive, and meaningful because it links scientific concepts with social and cultural experiences that are close to students' lives (Febriana et al., 2025). This study supports the implementation of the CRTT learning model through the use of innovative media and assessment systems. One such medium is the podcast, which offers flexibility and ease of access as an audio- and video-based learning tool that can be used anytime and anywhere (Supendra et al., 2022). In addition, the use of e-assessment as a digital-based evaluation method represents a novelty in previous research, as it enables the learning evaluation process to be conducted more effectively, efficiently, and objectively, both in assessing the learning process and the learning outcomes of students (Yanti, 2025). Therefore, this study would integrate the CRTT learning model with the help of podcasts and e-assessments on reaction rate materials. With the aim of finding out the effect of the application of the podcast-assisted CRTT learning model and e-assessment on students' creativity and science literacy skills, on the reaction rate of materials.

METHODS

This research was conducted at a public high school in Karanganyar City, Central Java. The population consists of 252 students in grade XI MIPA for the 2025-2026 school year from seven classes, namely (XI 1-7). Two classes were selected using the cluster random sampling method. These classes were then designated as experimental groups and control groups. The homogeneity between the classes was tested based on the daily test value (UH) of chemistry.

This study uses a quasi-experimental method (see Table 1), where data from the population sample obtained was analyzed using appropriate statistical methods (Saputri, 2025). The experimental group gets the application of the CRTT learning model with the help of podcasts and e-assessments, while the control class gets the discovery learning model with PowerPoint. Initial diagnostic tests prior to the learning activity intervention were conducted in both groups. Then, the two groups underwent a post-intervention test. Then, the data was analyzed to evaluate the impact of the CRTT learning model on students' creativity and science literacy in reaction rate material.

Table 1 Quasi-experimental design

Groups	Pretest	Treatment	Posttest
Control	O_1	X_1	O_2
Experiment	O_3	X_2	O_4

Information
X_1 : Learning treatment with PowerPoint media and package book
X_2 : Treatment of learning with a learning model CRTT help *podcast* and *e-assessment*
O_1 : Pretest control group
O_2 : Posttest control group
O_3 : Pretest experimental group
O_4 : Posttest experimental group

In this study, there are 3 (three) stages of research, namely the preparation stage, the implementation stage, and the final stage. In the preparation stage, it includes a) observation of schools and students, and b) the implementation of a homogeneity test of chemical UH values to determine the control group and the experimental group (Mutia & Hadinugrahaningsih, 2019). The science literacy measurement tool uses indicators according to Shwartz by influencing culture. Meanwhile, the measuring tool for students' creativity ability is developed based on creativity indicators according to Munandar, which include smoothness, flexibility, authenticity, and detail.

Implementation stages: a) provide a pretest for the experimental group and the control group, b) provide the experimental group treatment with a learning model CRTT *(Culturally Responsive Transformative Teaching)* with the help of podcasts and e-assessments, c) provide the control group treatment with the discovery learning model with PowerPoint media (PPT) and package books, and d) provide posttests to the experimental group and the control group. The last stage is to determine the analysis and test the hypothesis. From the results obtained, the formulation of the problem in this study can be analyzed, namely, whether there is an effect of the application of the CRTT learning model on students' creativity and science literacy skills on the reaction rate of the material.

Table 2. Implementation of the learning process in the experimental and control classes

Time Allotment (minutes)	Experimental Class (CRTT)	Control Class (discovery learning)
JP 1 80 minutes	Conducting the reaction rate pretest	Conducting the reaction rate pretest
JP 2 80 minutes	Teaching by linking local cultural contexts to the concept of reaction rates and their measurement	The lesson does not incorporate local cultural concepts related to the topic of reaction rates and their measurement
JP 3 80 minutes	Learning by relating local cultural contexts to factors affecting reaction rates, collision theory, activation energy, and catalysts	The lesson does not incorporate local cultural concepts into the subtopics on factors affecting reaction rates, collision theory, activation energy, and catalysts
JP 4 80 minutes	Learning by incorporating local cultural context into the subsections on reaction rate equations and reaction order	The lesson does not incorporate local cultural concepts in the subsections on reaction rate equations and reaction order
JP 5 80 minutes	Conducting the reaction rate posttest	Conducting the reaction rate posttest

Data processing is carried out using SPSS 26. Creativity ability was evaluated using culture-based essay questions, while science literacy was evaluated using culture-based multiple-choice questions using e-assessment media. In hypothesis testing, it was determined that the data generated in this study was not normally distributed. Therefore,

the Kruskal-Wallis test is carried out to find out the difference in aspects simultaneously (Juan, 2022).

RESULTS AND DISCUSSION

The Influence of the CRTT Learning Model with the Help of Podcasts and e-Assessments on Students' Creativity Abilities

Table 3 shows the pretest and posttest results for the experimental and control classes. The pretest was administered to both classes before they received different treatments involving the use of different learning models. The average scores for the experimental and control classes were 34.22 and 35.25, respectively. Following the learning process using the different learning models, posttests were conducted. The average posttest scores for the experimental and control classes were 82.86 and 74.72, respectively. These results indicate that the experimental class achieved a higher average score. Further analysis would involve an N-Gain test of the creativity skills of students in the experimental and control classes, as shown in Table 3.

Table 3 Description of value data

Treatment	Classes	Lowest Score	Highest Score	Average
Pretest	Experiment	20	56.25	34.22
	Control	20	50	35.25
Posttest	Experiment	69	100	82.86
	Control	44	94	74.72

Based on the N-Gain calculation results, the average N-Gain scores for the experimental class and the control class were 0.73 and 0.64, respectively. This indicates that the experimental class met the “High” criterion, while the control class met the “Moderate” criterion.

Table 4 N-Gain comparison

Classes	Highest N-Gain	Lowest N-Gain	Average N-Gain	Criteria
Experiment	1.00	0.38	0.73	High
Control	0.92	0.45	0.64	Moderate

Statistical analysis

Table 5 shows the results of the normality test for creativity scores in the experimental and control classes, with significance values of 0.402 and 0.008, respectively. This indicates that the data on students’ creativity scores in the experimental class are normally distributed (sig. >0.05), whereas those in the control class are not normally distributed (sig. <0.05). Next, homogeneity would be tested in Table 5.

Table 5 A test of students' creativity

Classes	N	Sig.	Results	Conclusion
Experiment	36	0.402	H_0 accepted	Normally distributed
Control	36	0.008	H_0 rejected	Abnormal distribution

Table 6 shows the results of the homogeneity test for students’ creativity scores in the experimental and control classes, with a significance level of 0.774. Thus, it can be concluded that the data on students’ creativity scores are homogeneous but not normally distributed, as Table 4 indicates that the control class is not normally distributed. Next, a hypothesis test on creativity was conducted and shown in Table 6.

Table 6 Test the homogeneity of students' creativity

Classes	N	Sig.	Results	Conclusion
Experiment	36	0.774	H_0 Accepted	Homogeneous data
Controls	36			

Table 7 shows the results of the hypothesis test for the creativity of students in the experimental and control classes, with a p-value of 0.038, indicating a significance level of <0.05. Therefore, it can be concluded that there is a significant difference between the experimental and control classes. The hypothesis test used the Mann-Whitney U test because the data were not normally distributed.

Table 7. Hypothesis test

Classes	N	Sig.	Results	Conclusion
Experiment	36	0.038	H_0 Rejected	There are significant differences
Control	36			

The Influence of the CRTT Learning Model with the Help of Podcasts and e-Assessments on Science Literacy Ability

Table 8 shows the pretest and posttest scores for the experimental and control classes. The pretest was administered to both classes before they received different instructional models. The average pretest scores for the experimental and control classes were 38.83 and 56.47, respectively. Then, after the learning process using different learning models was carried out, a posttest was conducted on the experimental and control classes, yielding average posttest scores of 87 and 78.05 for the experimental and control classes, respectively. The obtained average posttest results indicate that the experimental class achieved higher scores. Subsequently, an N-Gain test was conducted to determine whether there was an increase in science literacy in the experimental and control classes, as shown in Table 8.

Table 8. Description of value data

	Classes	Lowest Score	Highest Score	Average
Pretest	Experiment	20	80	38.83
	Control	20	82	56.47
Posttest	Experiment	72	100	87
	Control	70	100	78.05

Table 9 shows the results of the N-Gain calculations, with the average N-Gain values for the experimental class and the control class being 0.75 and 0.66, respectively. This demonstrates that the experimental class meets the "High" criterion, while the control class meets the "Moderate" criterion.

Table 9 N-Gain comparison

Classes	Highest N-Gain	Lowest N-Gain	Average N-Gain	Criteria
Experiment	1.00	0.10	0.75	High
Control	1.00	0.33	0.66	Moderate

Statistical analysis

Table 10 shows that the normality test for science literacy in the experimental class yielded a significance value of 0.736 (>0.05), while the control class yielded a significance value of 0.054 (<0.05). Therefore, it can be concluded that the science literacy data from the experimental and control classes are normally distributed, as they meet the criterion of a significance value >0.05. Next, homogeneity was tested, and the results are given in Table 10.

Table 10 A test of science literacy

Classes	N	Sig.	Results	Conclusion
Experiment	36	0.736	H_0 accepted	Normally distributed
Controls	36	0.054	H_0 accepted	Normally distributed

Table 11 shows the results of the homogeneity test for science literacy in the experimental and control classes, with a significance value of 0.596. Therefore, it can be concluded that the data are homogeneous. Next, a hypothesis test on science literacy was conducted, and the results are shown in Table 12.

Table 11 Test of the homogeneity of science literacy

Classes	N	Sig.	Results	Conclusion
Experiment Control	36 36	0.596	H_0 Accepted	Homogeneous data

Table 12 shows the results of the hypothesis test for science literacy between the experimental and control classes, with a p-value of 0.000 and a significance level of <0.05. Therefore, it can be concluded that there is a significant difference between the experimental and control classes. The hypothesis test was conducted using an independent samples t-test because the data were normally distributed.

Table 12 Science literacy hypothesis test

Classes	N	Sig.	Results	Conclusion
Experiment Control	36 36	0.000	H_0 Rejected	There are significant differences

Table 13 test hypothesis of two dependent variables simultaneously with nonparametric Kruskal-Wallis sig level. <0.05. The results were obtained sig. 0.000 to H_0 minus. Thus, there is a difference in the average value in the variables of the experimental class and the control class. Thus, there is an influence of the podcast-assisted CRTT learning model and e-assessment on students' creativity and science literacy skills.

Table 13 Simultaneous hypothesis testing

Aspects	Sig.	Results	Conclusion
The influence of podcast-assisted CRTT learning models and e-assessments on students' creativity and science literacy abilities	0.000	H_0 Rejected	There is a significant influence

The Influence of the CRTT Learning Model with the Help of Podcasts and e-Assessments on Students' Creativity and Science Literacy Skills

The CRTT learning model is a constructivist learning model that links elements of local culture to the learning process so that it has the potential to develop scientific skills such as critical thinking, creativity, collaboration, and science literacy. Models CRTT consist of five stages, namely self-identification, cultural understanding, collaboration, critical reflection, and transformative construction (Fitriah et al., 2024). In previous research, the CRTT learning model was able to increase students' interest in chemistry learning because the learning process relates culture and phenomena experienced daily. The results of the literature study can confirm the effectiveness of the CRTT learning model in providing a conceptual student learning experience (Rahmawati et al., 2023).

The application of the CRTT model was assisted by podcasts and e-assessments on students' creativity abilities. Learning in the 21st century aims to train students' skills. 21st-century learning is no longer teacher-centric but rather student-centered to hone communication, collaboration, critical thinking, creativity, and problem-solving skills (Sofyan, 2025). CRTT would link local culture to learning that allows students to understand the material well. Cultural integration would help students process the material well. The culture raised in this study includes the process of making batik, the process of making palm sugar, making *uwuh wedang*, making ginger *wedang*, and making tiles related to reaction rate materials. Culture-based learning provides better students' creativity because the learning process is carried out by applying concept understanding in daily life (Rahmawati et al., 2020). Creativity is one of the important aspects associated with science literacy because it is in line with understanding concepts, applying knowledge in real life, and critical and innovative thinking skills. There are 4 (four) aspects of creativity, namely: 1) smoothness, 2) flexibility, 3) authenticity, and 4) detail (elaboration) (Utami, 2011).

Indicators are contained in Table 13 of the creativity skills that must be possessed by students who would be trained by the implementation of the CRTT learning model syntax.

Table 12. Indicators of students' creativity ability

Aspects	Indicator
Smoothness	Think of as many words as possible that are commonly used in chemistry
Flexibility	Creating variations and developing ideas
Authenticity	Thinking about the novelty and uniqueness of the idea to be written
Details (elaboration)	Thinking about the development and details of ideas

Self-Identification

The first phase of CRTT is to identify students' initial knowledge based on their respective cultures. The fluency aspect is characterized by the ability of students to think about words related to chemical materials, in this case, the reaction rate material, smoothly, coupled with the existence of a podcast video given before the learning process; this would help students to get closer to recognizing the culture around them. As a result, students who get the learning process with the CRTT learning model is better trained to criticize their creative abilities (Reggina & Wijayanti, 2025).

Cultural understanding

The second phase of CRTT is to construct cultural understanding related to science that has been obtained from various sources with the materials. In this phase, it also supports the aspect of fluency indicators where students would associate words that have been obtained from podcasts and various sources so that they have a cultural understanding related to the material to be studied. This is in accordance with the aspect of smoothness in capturing materials related to the culture (Saudarna, 2014).

Collaboration

In the third phase of CRTT, understanding is expanded through collaboration among student groups as they complete the provided worksheets. This aligns with the aspect of flexibility, in which students develop ideas and discover answers through cultural phenomena related to the topic of reaction rates. Through this phase, students would practice thinking rationally and contextually (Safitri et al., 2025).

Critical Reflection

The fourth aspect of CRTT is for students to be able to express their opinions and compare the results of the discussion with the theory given by the teacher. The aspect of authenticity is characterized by the ability of students to spark new ideas. In the fourth phase of CRTT, students would expand their understanding and come up with answers to the worksheet based on the concepts that have been built and learned (Rahmawati et al., 2020). Then, the teacher and the students would compare the results of the renewal of ideas from students with the theory that has been prepared by the teacher. Through this, students are trained to express opinions in their own language related to the reaction rate material that has been studied.

Transformative Construction

The fifth phase of CRTT is to present their understanding through the results of the worksheet that they have worked on; then they would detail the answers that have been obtained according to cultural phenomena (Rahmawati et al., 2023). Through this elaboration, it is characterized by the ability of students to solve problems and develop ideas in answers with creativity in their respective groups.

Based on the results of the data collection process, the results of students' creativity abilities were carried out in a pretest and posttest with five essay questions each using e-

assessment media. E-assessment in this study would help teachers to analyze the results obtained by students. E-assessment also makes it easier for students to find out the indicators of right and wrong in the test taken so that this e-assessment has feedback that can be accessed directly by students (Ashari et al., 2023). Then a prerequisite test for normality and homogeneity is carried out. Based on the results of the tests that have been carried out, the application of the CRTT learning model assisted by podcasts and e-assessments significantly affects students' creativity abilities. This is shown by the results of the hypothesis test with Mann-Whitney, with a score of 0.038 < 0.05, so H_0 is rejected. This means that there is a significant difference in students' creativity skills between the experimental class and the control class. The average score of creativity ability in the experimental class was 82.86, and in the control class, it was 74.72. The CRTT learning model is able to improve students' creativity skills.

The effect of the podcast-assisted CRTT learning model and e-assessment on science literacy. Science literacy is considered important because it includes critical thinking and skills in solving a scientific problem and applying science scientifically. In this study, science literacy includes 4 (four) aspects, namely, 1) content, 2) context, 3) Higher Order Learning Skills (HOLS), and 4) attitudes (Shwartz et al., 2006). The indicators contained in Table 14 science literacy, that must be possessed by students were trained with the implementation of the CRTT learning model syntax.

Table 14. Science literacy indicators

Aspects	Indicator
Contents	Have a general knowledge of chemistry and the main idea of chemistry, which aims to understand and relate chemistry to daily life.
Context	Be able to know the importance of chemistry in explaining phenomena in daily life.
Higher-Order Learning Skills (HOLS)	Able to identify scientific issues, seek understanding, and analyze problems that occur.
Attitude	Have an unbiased and realistic view of chemistry.

Self-Identification

The first phase of CRTT is to identify students' initial knowledge based on their respective cultures. The content aspect is characterized by the ability to have an idea of knowledge of chemistry in general and chemistry related to daily life, plus the existence of a podcast video given before the learning process; this would help students to get closer to recognizing the culture around them. As a result, students who get the CRTT learning process would be better trained to understand chemistry in general in the context of the local culture (Ramadani et al., 2020).

Cultural Understanding

The second phase of CRTT is to construct cultural understanding related to science that has been obtained from various sources with the materials. In this phase, it also supports the context aspect of this aspect, characterized by explaining the importance of cultural understanding associated with the material taught (Fatia, 2025). As a result, students would gain an understanding of materials related to culture based on the use of the CRTT learning model.

Collaboration

The third phase of CRTT is to expand understanding with collaboration carried out by completing the LKPD that has been given. This process can be attributed to the *Higher Order Learning Skills* (HOLS), where this aspect is characterized by the ability of students to analyze issues scientifically, seek understanding, and analyze problems that occur (Prayoga & Gading, 2023).

Critical Reflection

In the fourth phase of CRTT, students can express their opinions and compare the results of the discussion with the theory given by the teacher. It also supports aspects of higher-order learning skills (HOLS), characterized by students' ability to analyze problems (Reski et al., 2024) and compare the results that have been obtained from various sources with the material provided by the teacher.

Transformative Construction

In the fifth phase of CRTT, students can express their opinions and compare the results of the discussion with the theory given by the teacher. This also supports the aspect of attitude where students have an impartial view of the results that have been obtained realistically by comparing the teaching given by the teacher (Teguh Wibowo, 2020).

The data collection process was carried out using science literacy questions with a pretest and posttest using 15 multiple-choice questions each. Pretest and posttest treatment using e-assessment media. Then a prerequisite test for normality and homogeneity is carried out. Based on the results of the tests that have been conducted, the application of the podcast-assisted CRTT learning model and e-assessment significantly affects students' science literacy. It was shown by the results of the hypothesis test with the independent samples t-test because the data obtained was normal and homogeneous with a score of $0.000 < 0.05$; therefore, H_0 was rejected, indicating that there is a significant difference in science literacy between the experimental and control classes. The mean science literacy score for the experimental class was 87, while that for the control class was 78.05. Thus, the CRTT learning model is effective in improving science literacy.

It was found that the CRTT learning model, supported by podcasts and e-assessments, had a significant effect, as shown in the Kruskal-Wallis test in Table 15 with a significance value of $0.000 < 0.05$. Thus, there was a difference in the average scores of the variables between the experimental class and the control class.

CONCLUSION

Based on the results of the study, it can be concluded that there is a significant difference in students' creativity and science literacy abilities with the podcast-assisted CRTT learning model and e-assessment of reaction rate material in class XI. This comprehensive model includes conventional learning objectives and integrates cultural content, providing students with a broader and culturally contextual learning experience. The addition of podcast media can facilitate flexible learning and involve students in building knowledge; combined with an e-assessment-based assessment system, it makes it easier for teachers in the assessment process and students to get direct feedback. Essentially, the results of this study highlight the pedagogical approach in the creativity and science literacy skills of class XI. This approach is in line with education that highlights students' potential and provides student learning innovations that are relevant to the surrounding cultural relevance. Although the research results show significant findings, there are limitations: this study was conducted at only one school with a limited sample size, and the application of the CRTT learning model supported by podcasts and e-assessments was focused solely on reaction rate material. Future research could involve a broader and more diverse sample, both in terms of schools and student characteristics, to ensure the results are more representative. Additionally, this learning model should be tested on various other chemistry topics to determine the consistency of its effectiveness. Further research could also examine the long-term impact of implementing the podcast- and e-assessment-based CRTT model on students' 21st-century skills.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

The first author (PDNS) was responsible for the research, development, methodology, data collection through observation, data analysis, and preparation of the initial draft of the manuscript. The second author (SY) contributed to the refinement of the methodology, analysis of results, editing of the manuscript, and provision of academic guidance. The third, fourth, and fifth authors (AW, HRW, ASS) contributed to ensuring the consistency of the final manuscript. All authors have read and approved the final version of this article.

AI DISCLOSURE STATEMENT

This article was written using DeepL Translator to assist in translating the manuscript. The author reviewed the manuscript after using this tool/service. The author then thoroughly edited the content as needed and assumes full responsibility for the content of the published article. The authors also state that this research was designed, investigated, written, and edited without the use of artificial intelligence (AI).

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