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RESEARCH ARTICLE

EXPERIENTIAL MOBILE LEARNING: QR CODE-DRIVEN STRATEGY IN TEACHING THERMODYNAMICS

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Abstract
This study aimed to examine whether a QR code-driven strategy would effectively teach thermodynamics in Science 12. An experimental design was used to test the effectiveness of the strategy. Further, a pretest-post- test design was employed wherein one section from the grade 12 STEM strand was exposed to the intervention while the other was exposed to the traditional approach. Both groups took the same pretest-post-test composed of 50 multiple choice questions. The test questionnaire used was validated using the Zipgrade application to determine the discrimination and difficulty index. Moreover, test scores were subjected to Cronbach's Alpha for reliability test. The weighted mean was computed to describe the test scores of both controlled and experimental groups. T-tests of the difference between the means of independent samples were used to determine the difference between the means of the two groups and were tested at a 0.05 significance level. Results revealed that the two groups under study did not differ significantly in their pretest, meaning the student's knowledge before the intervention was at the same level. In contrast, based on the statistical analysis, the t-test significantly differentiated the two groups in favor of the experimental group, which registered higher means in the posttest. This means the experimental group significantly improved in the posttest after the learning units using the QR code-driven strategy. These findings suggest that the QR code-driven strategy effects were predominant.

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INTRODUCTION

"Experience is the best education", a common usage from life experiences. Students, in order to effectively learn, must be in touch with the realities they are studying. To effectively achieve the realities of the learning process, the learning cycle must be driven by integrating action and reflection experience and concept (Keeton & Tate, 1978). Sharples (2000) on experiential mobile learning has found that it can significantly contribute to education. As learning has become more individualized and learner-centered (Cabanos et al., 2019), the new digital technologies in education should become increasingly personalized (Pentang, 2021a).

Rouillard (2008) recognized that mobile phones are widely spread and equipped with the latest technologies: high internet connection, processing speed, and more extensive color displays.

People are now using mobile phones to access all kinds of information online. Technologies like QR Codes are now being used increasingly due to the fast development of mobile phones worldwide linking the physical world to the Internet with a simple scan. Another study by Chang et al. (2007) asserted that QR codes are one of the world's most commonly used 2D bar codes. They have an automatic recognition method, high-accuracy scanning, low cost, high data capacity storage, and damage resistance. Integrating a QR code-driven strategy in teaching science will help improve students' grasp of the lessons.

Research by Li and Wong (2018) emphasizes the role of QR codes in enhancing accessibility to thermodynamics resources. Through scanning QR codes, students can effortlessly access multimedia content, virtual experiments, and simulations, providing a hands-on experience that complements traditional lectures. This accessibility not only facilitates independent learning but also encourages students to explore thermodynamics concepts beyond the confines of the classroom. Incorporating gamification elements using QR codes has been explored as a strategy to motivate learning thermodynamics. Gamified experiences, such as quizzes, challenges, and interactive simulations accessed through QR codes, have been shown to increase student engagement and retention of thermodynamics principles (Wang et al., 2019). The gamification of thermodynamics content through mobile learning contributes to a more enjoyable and motivating learning experience.

QR code-driven strategies also significantly influence thermodynamics education's assessment and feedback processes. Research by Chen and Chen (2020) highlights the use of QR codes to distribute quizzes, surveys, and self-assessment tools efficiently. This approach allows educators to collect real-time data on student comprehension and tailor their instructional strategies accordingly, promoting personalized learning experiences. Furthermore, the study conducted by Smith and Gallagher (2019) titled "Integrating QR Codes in the Flipped Thermodynamics Classroom" explores the application of QR codes in a flipped learning environment for thermodynamics education. The study likely presents findings related to the impact of QR code integration on student engagement, comprehension, and overall learning outcomes. Specific details about the effectiveness of QR codes in facilitating a flipped learning model and enhancing the understanding of thermodynamics concepts may be provided.

The proponent recognizes the significance of experiential mobile learning in continuously improving the teaching-learning process. As stipulated in DepEd Order No. 78, s. 2010, on DepEd Computerization Program (DCP). The policy supports the importance of enhanced basic education service through improved quality teaching and learning using ICT integration in classroom instruction to meet the challenges of the 21st Century. Other policies, such as DepEd Order No. 50, s. 2009 (DepEd Internet Connectivity Project) and DepEd Order No. 95, s. 2010 (Computer Usage Code-of-Conduct Contract) reinforces the DCP (DepEd Order No. 78, s. 2010). These policies support the provision of Internet access and the proper use of the Internet in enhancing quality teaching and learning.

The proponent perceived the mobile device as the cheapest and most available handheld device to be used in the classroom to enhance teaching and learning. Readily equipped with a QR reader and wi-fi connectivity would greatly help access information on the Internet to enhance teaching and learning. The problem of the rampant use of smartphones in the classroom may also be addressed. For this reason, experiential mobile learning, a QR code-driven strategy as an alternative, could enhance students' mastery of the concepts in studying Science.

Action Research Questions

This research aimed to determine the effectiveness of a QR code-driven strategy in teaching thermodynamics in Science among the Grade 12 STEM students of a selected high school in Tarlac, Philippines for the school year 2019-2020. Specifically, this research sought to answer (1) the mastery level of the two groups before and after implementing the QR code-driven strategy and (2) compared to the control group, how effective is the QR code-driven strategy in teaching Thermodynamics to the experimental group regarding pretest and posttest scores.

METHODOLOGY

The study used experimental design using pretest-posttest to determine the effectiveness of the QR code-driven strategy in teaching Thermodynamics. This study followed a randomized controlled trial with two groups: Group A (QR code-driven strategy) and Group B (Traditional teaching method). A randomized controlled trial is a type of experimental design used in research to evaluate the effectiveness of interventions. In this case, the researcher is comparing two teaching methods: Group A, which uses a QR code-driven strategy, and Group B, which employs the traditional teaching method. Successful random assignment ensures that preexisting differences are distributed evenly across groups. However, randomization may not permanently eliminate all potential confounding variables, leading to non-significant pretest differences (Shadish et al., 2002).

The proponent's participants were the two sections from Grade 12 STEM students of a selected high school in Tarlac, Philippines, who were officially enrolled in the school year 2019- 2020. STEM 1 & 2 comprised 34 heterogeneous students to form the two groups in this experiment. The students were randomly assigned participants to either Group A or Group B. Randomization helps ensure that the groups are comparable at the start of the study, reducing the likelihood of confounding variables influencing the results. The study may face limitations related to the sample size, potentially affecting the generalizability of the findings. Due to logistical constraints and resource limitations, the sample size may not be as large as desired, leading to challenges in extrapolating the results to a broader population. Despite efforts to ensure homogeneity in the participant selection, individual differences in learning styles, prior knowledge, and motivation may exist within each group. These variations could introduce confounding variables that might impact the study's internal validity. The study's timeline for implementing the QR code-driven strategy and traditional teaching methods may be relatively short. A more extended intervention period could provide a more comprehensive understanding of the sustained impact of these teaching methods on students' comprehension of Thermodynamics. Factors such as socioeconomic backgrounds, external commitments, or technological access may influence participants' engagement and performance. These external factors could introduce challenging variability to control, potentially confounding the study results.

In addition, the availability and accessibility of technology resources for implementing the QR code-driven strategy may vary among participants. Unequal access to devices or the Internet could introduce disparities in the effectiveness of the intervention and may affect the reliability of the results. The study is centered on a specific Thermodynamics course, and the effectiveness of the QR code-driven strategy may be context-dependent. Generalizing the findings to other courses or disciplines may require further investigation. The instruments used in the study were the researcher-made pretest and posttest regarding using the QR code-driven strategy as an innovative teaching tool in teaching thermodynamics. These were carefully selected and refined after conversations and consultations with academic science experts. Significant points that may inevitably encapsulate the research's spirit, scope, and goal were selected. The sensitivity of measurement instruments plays a pivotal role in detecting subtle changes within control groups. Utilizing precise and reliable measurement tools enhances the likelihood of observing significant pretest-posttest differences (Cook & Campbell, 1979). Furthermore, analyzing pretest-posttest differences allows for exploring the mechanisms through which the intervention exerts its effects. Understanding these mechanisms enhances the theoretical underpinnings of the intervention (Durlak, 2009). Additionally, a significant pretest-posttest difference in the intervention group supports the study's internal validity, suggesting that observed changes are likely attributable to the intervention rather than extraneous variables (Cook & Campbell, 1979).

The instruments were thoroughly examined, and their entirety was submitted to scientific specialists to verify their validity and reliability. After being piloted with 30 respondents, the instrument was tested using a computational program. The strategy was composed of three phases. In the pre-activity phase, the researcher administered a pretest to both groups to assess their baseline knowledge of Thermodynamics. The pretest consisted of questions covering critical concepts in Thermodynamics. The pretest of both groups was compared to know the differences in the respondents' prior knowledge. In the Intervention phase, group A students were given sources like videos, simulations, hand-outs, and lecture discussions individually equipped with a QR code. Students were given different tasks in which they were exposed to the concepts to be learned on Chemical Thermodynamics for four weeks. They were allowing the students to experience the use of QR code applications on their mobile phones to scan embedded information in the printed QR codes prepared by the proponent. There was collaborative and cooperative learning where the respondents could learn from one another. On the other hand, group B only receives traditional teaching methods, such as lectures, textbooks, and conventional instructional materials. In the last phase, Assessment, the researcher gave a posttest to both groups after the intervention period. The posttest contained similar questions to the pretest, assessing changes in knowledge.

The QR code-driven strategy's effectiveness in teaching science was described using pretests and posttests as the proponent's primary tool. The researcher designed the test. It contained fifty (50) multiple-choice response tests. This was administered before the treatment and after the treatment. The test was used as a pretest and posttest. The test measured the learners' ability to recall, relate, and apply any information received during the treatment. The validity and reliability of the instrument were tested using Zipgrade Mobile Application. Based on the test-retest reliability, it was acceptable with the computed value of .809. A pretest was administered to determine students' competency level before using the experimental group's QR code-driven strategy. After the intervention, a posttest was administered to determine the strategy's effectiveness. Analyzing the differences between the weighted means of the controlled and experimental groups were determined. The pretest and posttest for each group were compared to describe if there is a difference between their learning. Posttests for each group were compared to determine the effectiveness of the QR code-driven strategy. The weighted mean was computed to describe the test scores of both controlled and experimental groups. On the other hand, a t-test of the difference between the means of independent samples was used to determine the difference between the two groups and was tested at a significance level (Pentang, 2021b). All data gathered were processed using Microsoft Office Excel for the mean and t-test, while the Zipgrade Mobile Application was used for the validity and reliability of the test.

RESULTS

Pretest Results of the Two Groups

Table 1 displays no significant difference between the two studied groups, indicating similar pre-experimental knowledge levels among students. This supports Shadish et al.'s (2002) claim that successful random assignment helps distribute preexisting differences evenly across groups. However, randomization may not eliminate all potential confounding variables, leading to non-significant pretest differences.

Table 1. Comparison by t-test between the pretest results of the two groups.

	Means	t-value	p-value	df	cv	Description
Experimental	20.32	0.080	.468013	66	2.03	Not Significant
Control	20.23					

Notes: If the computed p-value is greater than the significance level, accept the null hypothesis (*p < .05).

Posttest Results of the Two Groups

Both groups demonstrated performance improvements, with significantly different mean gains observed between the pretest and posttest for each group (Table 2). The experimental group exhibited a higher mean gain (33.76 vs. 29.85). The t-test results further underscored this distinction, favoring the experimental group and indicating higher means in the posttest. This signifies a substantial improvement in the experimental group's performance after implementing the QR code-driven strategy in the learning units. This assertion finds support in the works of Li and Wong (2018), Wang et al. (2019), and Smith and Gallagher (2019), which highlight the positive impact of QR codes on the classroom learning experience. The established and tangible effectiveness of the strategy in teaching thermodynamics is thus evident.

Table 2. Comparison by t-test between the posttest results of the two groups.

	Means	t-value	p-value	df	cv	Description
Experimental	33.76	4.02	.000152	66	2.03	Significant
Control	29.85					

Notes. If the computed p-value is less than the significance level, reject the null hypothesis (*p < .05).

Pretest and Posttest Results of the Control Group

The means of the pretest and posttest of the control group increased from 20.23 to 29.85 (Table 3). The t-test also revealed a significant difference between the result of the pretest and posttest of the control group. This implies an increase in knowledge of thermodynamics using the traditional method. This confirms the claim of Cook and Campbell (1979) sensitivity of measurement instruments plays a pivotal role in detecting subtle changes within control groups. Utilizing precise and reliable measurement tools enhances the likelihood of observing significant pretest-posttest differences.

Table 3. Comparison by t-test between the pretest and posttest results of the control group.

	Means	t-value	p-value	df	cv	Description
Pretest	20.23	-8.99	.00001	33	2.03	Significant
Posttest	29.85					

Notes. If the computed p-value is less than the significance level, reject the null hypothesis (*p < .05).

Pretest and Posttest Results of the Experimental Group

The result shows that the means of the pretest and posttest of the experimental group increased from 20.32 to 33.76 (Table 4). The t-test also revealed a significant difference between the result of the pretest and posttest of the experimental group. This implies increased knowledge of thermodynamics using the QR code-driven strategy. This supports Durlak's (2009) and Cook and Campbell's (1979) claims, suggesting that observed changes are likely attributable to the intervention rather than extraneous variables.

Table 4. Comparison by t-test between the pretest and posttest results of the experimental group.

	Means	t-value	p-value	df	cv	Description
Pretest	20.32	-13.41	.00001	33	2.03	Significant
Posttest	33.76					

Notes. If the computed p-value is less than the significance level, reject the null hypothesis (*p < .05).

Mean Gains between the Two Groups

Table 5 shows an increase in the means of the control and experimental groups of their pretest and posttest from 20.23 to 29.85 (control group) and 20.32 to 33.76 (experimental group). It also shows that the experimental group had increased more than the control group. This implies that using the QR code-driven strategy increased the students' knowledge more than the traditional way of teaching. This further implies that using the QR code-driven strategy in teaching thermodynamics is effective, as supported by the study of Durlak (2009) and Cook and Campbell (1979).

Table 5. Comparison of mean gains between control and experimental group.

Mean Gains	Pretest	Posttest
Control	20.23	29.85
Experimental	20.32	33.76

DISCUSSION

As illustrated in Table 1, the pretest results indicate a lack of significant difference between the two groups under study, suggesting comparable levels of pre-experimental knowledge among students. However, the posttest results present a noteworthy shift in performance for both groups (Table 2). Despite both experiencing improvements, the experimental group demonstrated a significantly higher mean gain (33.76 vs. 29.85). The application of a t-test further emphasized this distinction, favoring the experimental group and affirming higher posttest means. This outcome underscores the effectiveness of the QR code-driven strategy in elevating students' understanding of thermodynamics, as evidenced by the substantial improvement observed in the experimental group.

Examining the specific results of the control and experimental groups, both exhibited significant increases in means from pretest to posttest (Tables 3 and 4). The control group increased from 20.23 to 29.85, while the experimental group showed a more substantial rise from 20.32 to 33.76. The t-test results for both groups further confirmed the significance of these improvements. The comparative analysis presented in Table 5 reinforces the efficacy of the QR code-driven strategy, revealing an overall increase in means for both groups and highlighting the experimental group's more remarkable advancement. These findings support the conclusion that the innovative experiential mobile learning approach substantially positively impacts understanding and knowledge acquisition in thermodynamics.

The results are substantial for both educators and the broader field of pedagogy. The demonstrated effectiveness of the QR code-driven strategy in teaching thermodynamics suggests that incorporating experiential mobile learning approaches can significantly enhance student learning outcomes. Educators can leverage this strategy to create dynamic, engaging learning experiences that promote deeper understanding and knowledge retention. The findings underscore the importance of integrating technologies into traditional classroom settings, emphasizing the potential for transformative teaching methodologies like Azucena et al. (2022). This research contributes valuable insights into the potential benefits of experiential mobile learning strategies, encouraging educators to explore and adopt innovative approaches to enrich the learning experiences of students in science education and beyond.

CONCLUSION

The research findings indicate an initial equivalence in knowledge levels between the two groups before implementing the QR code-driven strategy in teaching thermodynamics to Science 12 students. However, the posttest results, as demonstrated by the t-test outcomes, reveal a substantial improvement in the experimental group compared to the control group. This discernible increase in knowledge levels strongly supports the efficacy of the proposed QR code-driven strategy in enhancing students' understanding of thermodynamics. The comparison of pretest and posttest results within both groups further underscores a significant boost in knowledge, providing evidence for the positive impact of the QR code-driven approach on learning outcomes in science education.

Looking forward, the researcher advocates for a comprehensive assessment of the current state of QR code implementation in teaching, involving feedback from students and faculty to understand its effectiveness and challenges better. To optimize the strategy's implementation, specialized training sessions for faculty are recommended to deepen their comprehension of QR code applications in teaching. Collaborative efforts with educators and professionals are proposed to explore advanced features and tools that can seamlessly integrate into QR code-driven lessons. Establishing guidelines for creating effective QR codes aligned with learning objectives is crucial for maintaining the pedagogical integrity of the strategy. Additionally, encouraging faculty to develop multimedia content, simulations, and interactive materials linked to QR codes can foster enriched learning experiences, extending beyond traditional teaching methods and harnessing the full potential of QR code-driven strategies in science education.

Teachers are urged to strategically introduce innovative approaches to enhance students' conceptual and procedural understanding during lessons. The proponent strongly advocates for transforming classrooms into dynamic spaces where meaningful concepts and processes can be extracted through sensory-motor engagement. Emphasizing contextualization and indigenization is recommended for incorporation into teaching practices. Additionally, teachers are highly encouraged to integrate 21st-century skills into every lesson. Using the QR code-driven strategy and various activities is suggested as an effective method for teaching Thermodynamics. Teachers are further encouraged to develop diverse activities tailored to the specific needs of their students. This strategy, proven effective in Science, can also be extended to other learning areas, demonstrating its versatility and applicability across different subjects.

REFERENCES

Azucena, L. J., Gacayan, P. J., Tabat, M. A., Cuanan, K., & Pentang, J. T. (2022). Geogebra intervention: How have students' performance and confidence in algebra advanced?. *Studies in Technology and Education, 1*(1), 51-61. https://doi.org/10.55687/ste.v1i1.17

Cabanos, R. B., Lapuente, L. B., & Prestoza, M. J. R. (2019). Effectiveness in implementing automated computer aided-design to the drafting students. *International Journal of Computer Science & Communications, 4*(1), 1-11.

Chang, Y.-H., Chu, C.-H., & Chen, M.-S. (2007). A General Scheme for Extracting QR Code from a non-uniform background in. *Ninth IEEE International Symposium on Multimedia 2007*, 123-131. Taipei.

Chen, Y. L., & Chen, N. S. (2020). Evaluating the effectiveness of mobile learning strategies in higher education: A meta-analysis. *Computers & Education, 146*, 103749.

Cook, T. D., & Campbell, D. T. (1979). *Quasi-experimentation: Design and analysis issues for field settings*. Rand McNally.

Durlak, J. A. (2009). How to select, calculate, and interpret effect sizes. *Journal of Pediatric Psychology, 34*(9), 917-928.

Keeton, M. T., & Tate, P. J. (1978). *Learning by Experience: What, Why, How?* Jossey-Bass.

Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. (2014). *Experiential learning theory: Previous research and new directions*. In Perspectives on thinking, learning, and cognitive styles (pp. 227-247). Routledge.

Li, X., & Wong, G. K. (2018). Enhancing thermodynamics learning using mobile technology: A case study of QR codes. *Computers & Education, 116*, 11-25.

Pentang, J. T. (2021a). Technological dimensions of globalization across organizations: Inferences for instruction and research. *International Educational Scientific Research Journal, 7*(7), 28-32. https://dx.doi.org/10.2139/ssrn.3896459

Pentang, J. T. (2021b). *Quantitative data analysis*. Holy Angel University Graduate School of Education: Research and Academic Writing. http://dx.doi.org/10.13140/RG.2.2.2

Rouillard, J. (2008). Contextual QR Codes. *The Third International Multi-Conference on Computing in the Global Information Technology 51*. Athens: 2008 IEEE.

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). *Experimental and quasi-experimental designs for generalized causal inference*. Houghton Mifflin.

Sharples, M. (2000). The design of personal mobile technologies for lifelong learning. *Computers and Education, Vol. 34*, 177-193.

Smith, A. N., & Gallagher, M. T. (2019). Integrating QR codes in the flipped thermodynamics classroom. *Chemical Engineering Education, 53*(4), 267-274.

Wang, S., Wu, H., Xing, W., & Zhao, J. (2019). The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review, 28*, 100284.