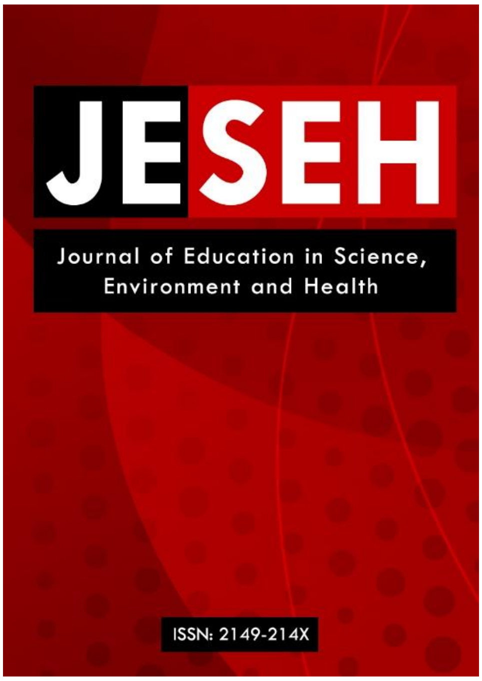

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The Effectiveness of Science Course Prepared According to Systematic Planning Model with ICT Integration: A Mixed Method Research

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The Effectiveness of Science Course Prepared According to Systematic Planning Model with ICT Integration: A Mixed Method Research

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Abstract

This study examined the impact of the 'Systematic Planning Model', an ICT integration model, on student achievement and perceptions in a 4th-grade primary school science course. The research aimed to determine whether there were significant differences in the achievement and retention scores between an experimental group, where a curriculum based on this model was implemented, and a control group, where it was not. Additionally, students' views on the model were explored. Using an explanatory mixed-method design, the study involved 45 students from a private school in Konya during the 2022–2023 academic year. Data were collected through an achievement test (reliability: 0.896) focused on the unit "Lighting and Sound Technologies from Past to Present" and semi-structured interviews. The findings revealed statistically significant improvements in the achievement and retention scores of the experimental group, while no significant changes were found in the control group's scores. Qualitative results showed that students responded positively to the model, particularly appreciating the use of technology and interactive activities. They described the lessons as enjoyable and educational. Furthermore, many students suggested that similar technology-supported activities be implemented in other subjects, underlining the effectiveness of engaging, tech-integrated learning environments.

Introduction

Technology has become an integral part of education today because it supports learning and teaching processes and enables faster and more permanent acquisition of knowledge. The intertwining of individuals are intertwined with technology in every field, especially, has contributed to the permanent place of technology in the teaching process (Cesur- Ozkara et al., 2018). Rapid developments in technology have led to radical changes in the field of education and transformed traditional learning methods. Technology integration in education is used as an important strategy to support modern learning approaches and prepare students for the needs of the future (Alan & Kırbag- Zengin, 2023; Koyuncuoglu, 2021). This integration aims to provide students with the skills required by the modern age by incorporating technological tools and resources into the learning process (Aslıyuksek et al., 2023). Thus, traditional classrooms can turn into more interactive and enriched learning environments. Learning can be made more meaningful and interesting with tools such as digital platforms, applications, simulations, virtual reality, and artificial intelligence.

Technology integration generally refers to the incorporation of information and communication technologies (ICT) into educational processes. In this context, emphasis is placed on the technological tools used to enhance students' learning experiences. important for the instructor to use technology effectively and to integrate technology into the curriculum in a holistic manner (Mazman & Kocak -Usluel, 2011). In these definitions, it is emphasized that the use of ICT will lead to permanent and sustainable changes that will enable the achievement of teaching goals (Belland, 2009; Hew & Brush, 2007; Lim, 2007; Vanderlinde & Van Braak, 2010; Wang & Woo, 2007). Today, science education, especially at the primary school level, aims to raise individuals who have the skills required by the age, adopt lifelong learning, use higher-order thinking and scientific process skills, have ethical and moral values, are entrepreneurial, and have achieved career awareness in science (MoNE, 2024). This goal necessitates the use of contemporary and innovative approaches in science teaching (Senturk, 2017).

Science is one of the most comprehensive disciplines that tries to explain everything that exists, arouses curiosity, and makes life easier with the solutions it offers (Obalı, 2009). Science education is a field that aims to understand and explore fundamental aspects of nature and the environment. This teaching aims to provide students with scientific thinking skills and enable them to use these skills in their daily lives. Science teaching, which includes disciplines such as biology, physics, chemistry, and astronomy, teaches scientific methods such as experimenting, observing, hypothesizing, and analyzing results (Tan & Temiz, 2003).

Science teaching can be enriched with interactive methods such as experiments, simulations, group work, project-based learning, and field studies. Thanks to technological developments, digital tools and artificial intelligence applications can also be integrated into teaching. In this process, students acquire basic skills such as critical thinking, problem solving, communication and collaboration, as well as scientific knowledge (Bakırcı & Kutlu, 2018). In this way, they are supported to grow up as individuals who not only consume knowledge but also produce it. The main purpose of science teaching is to enable students to better understand their environment and the events taking place in the universe (Guven- Yıldırım & Koklukaya, 2016). By stimulating their sense of curiosity, students are encouraged to develop an interest in science-related subjects. In this way, students gain a scientific perspective, understand the world more deeply, and develop the ability to use scientific methods.

The Science Curriculum for 2018-2024 includes skills such as communication in mother tongue and foreign languages, science and technology, mathematical and digital competencies, citizenship, learning to learn, taking initiative, entrepreneurship, and cultural awareness as basic perspectives (MoNE, 2018). The specific objectives of the program include raising individuals with knowledge about science and engineering applications, gaining scientific process skills, creating awareness of sustainable development, developing entrepreneurship and career awareness, adopting national and cultural values, and gaining scientific ethical principles. In line with these goals, the curriculum should be integrated with technology (MoNE, 2018).

For successful technology integration, it is important for teachers to develop the skills to use technology effectively and critically evaluate content (Atıs- Akyol & Askar, 2022). Integration is not just about the use of tools; it involves a strategic process that includes understanding student needs, lesson design, and assessment (Kaya & Yılayaz, 2013; McKnight et al., 2016). This process can increase students' motivation, deepen their learning and prepare them for the digital future. By using technology integration effectively, educators can ensure that students not only acquire knowledge but also develop learning as a lifelong skill.

Technology integration in education can be implemented through various models according to different learning needs and goals (Ince-Muslu & Erduran, 2020). These models guide teachers in the use of technology. *The TPACK Model (Technological Pedagogical Content Knowledge)* emphasizes the interaction between technology, pedagogical methods, and content knowledge (Koehler & Mishra, 2009). *The SAMR Model* is a framework for assessing the degree of integration of technology into educational processes and consists of four steps: Substitution, Augmentation, Modification, Redefinition, (Puentedura, 2023). *The Flipped Classroom Model* aims to spend more time on classroom practices by reversing traditional learning processes (Bishop & Verleger, 2013). *The 5W 1H Unified Integration Model* is structured with five main elements and one key component to support technology integration in the teaching process (Kuskaya-Mumcu et al., 2008).

The Systematic Planning Model developed by Wang and Woo (2007), which can realize ICT integration at three levels according to the content addressed. These are the curriculum (macro), the subject (meso), and the lesson (micro) level. At the *macro level*, the curriculum is integrated into ICT; at the *meso level*, ICT is used to support students' subject learning. At the *micro level*, ICT is used to better explain the subject in one or more lessons (Mazman & Kocak- Usluel, 2011).

At the macro level, the entire broad curriculum in a particular field, such as science, mathematics, physics, chemistry, biology, etc., is integrated (ICT). This usually means the widespread use of technology across courses in a discipline or a broad area of learning. This integration aims to strengthen interdisciplinary links by providing students with a broad perspective.

At the meso level, integrations are carried out for a specific learning area or topic within the curriculum. There is a focus on the use of ICT in lessons in a specific subject or learning area. This aims to provide students with an in-depth subject-based understanding and effective use of technology related to that subject.

At the micro level, integration is specific to a course and usually involves the use of ICT in teaching a particular subject or concept. For example, in a science course, interactive simulations, virtual experiments or other ICT tools can be used on a specific topic. Micro-level integration aims to provide students with a more in-depth experience of the topic.

The Systematic Planning Model is a preferred model in literature because the integration of technology into the environment takes place in stages, and each step of the evaluation processes is expressed in detail (Sevimli, 2020). The process in this model follows a logical flow; there is an interaction between all components. The development of each component depends on the completion of the preceding component. The model includes planning, implementation, and evaluation stages of the integration process and emphasizes that these stages are interconnected and form a continuous cycle. This process aims at careful planning implementation and continuous evaluation of the technology for its successful use in the educational environment.

The Systematic Planning model addresses the integration of technology and learning environments in seven stages:
1- Problem Statement: The process starts with defining the basic and current problem that needs to be addressed. It serves as the first step of integration. This realistic approach should also be feasible.
*2- Learning Objectives***:** The objectives to be achieved at the end of the process of integrating information and communication technologies into the learning environment should be consistent with the objectives in the curriculum of the relevant course.
3- Necessary Technologies: The technological materials needed to eliminate the problem situation mentioned in the first stage and for the goals expected to be achieved after the implementation of the method constitute this stage. The necessary material can be software, hardware, or any technological tool. One of the most important points is that such technological hardware or software should be compatible with the model in question and serve the learning objectives in terms of accessibility and applicability.
4- Rationale for Using Technology: Technology should be used to achieve learning objectives. For this reason, after determining the technology to be used during the design of the model, it is important to clearly identify the benefits that the technological materials will provide, the direction and extent to which they will support education, and most importantly, why they should be used.
5- Implementation Strategies: Teachers should integrate the preferred technology into subject teaching in an effective and meaningful way. At this point, an appropriate strategy should be determined regarding the methods and techniques of using technology in the classroom; the harmony and continuity between successive subjects should be ensured. Accordingly, while preparing lesson plans, technology-integrated plans should be designed to develop students' high-level thinking skills (critical thinking, creative thinking, reflective thinking, etc.).
6- Student Evaluation: At the end of the process, student assessment is carried out to determine how much learning has been realized, as a result of the implemented plan. The assessment takes into account how the students completed the learning activities or tasks; how they worked collaboratively with technology integration to reach the final product; written assignments; tasks completed through the online platform; and e-portfolios, which are used as assessment criteria (Theodosiadou & Konstantinidis, 2015).
7- Reflection: After the completion of integration, teachers need to reflect on their learning experiences in the teaching process. This reflection should focus on the appropriateness of the technology to the curriculum and its strengths and weaknesses. At this stage, teachers need to develop suggestions for other teachers to integrate technology into their fields, and students need to create learning outcomes that are appropriate for the curriculum (Wang & Woo, 2007).

The Systematic Planning Model was preferred because it focuses on the use of technology in line with goals and needs and on the process of evaluating learning outcomes (Izmirli, 2012; Wang & Woo, 2007). The model aims to ensure the effective use of technological tools, especially in science teaching, and guides teachers by addressing technology integration in the classroom context. Despite the emphasis on the use of ICT in current curricula, concrete examples of activities and lesson plans for technology integration in science teaching are limited (Bal, 2015; Kuskaya-Mumcu et al., 2008; Kuskaya-Mumcu, 2011).

Science teaching is a fundamental field of education that aims to improve students' ability to understand and discover the world (Ceylan, 2014). With technological advancements, there have been significant changes in teaching methods in this field, and a transition from traditional approaches to technology-supported, interactive, and visually rich learning environments has been achieved. This transition increases students' interest and contributes to a better understanding of the subjects. Modern instructional technologies include computers, tablets, interactive whiteboards, virtual and augmented reality tools. These technologies facilitate learning with audiovisual content. In particular, computer-based simulations allow students to reinforce their theoretical knowledge through experience. In courses such as chemistry and physics, these simulations are used to concretize abstract concepts. Virtual reality (VR) and augmented reality (AR) technologies offer students the potential to experience different environments outside the real world (Ozdemir, 2017).

Virtual reality (VR) technologies enable students to go beyond the physical world and better understand abstract, scientific concepts (Arıcı, 2013). VR technology offers students a visually and aurally rich learning experience thanks to its ability to create a virtual world (Yılmaz, 2023). This technology provides students with the opportunity to visually observing abstract science concepts (Sarıcam, 2019), having an interactive learning experience, moving around in a virtual world, examining objects and conducting experiments, transforming theoretical knowledge into practice, and exploring science topics in depth (Tepe et al., 2016). It supports students in increasing their motivation and developing scientific thinking skills (Cankaya & Girgin, 2018).

Augmented reality (AR) technology stands out as a powerful tool for transforming abstract scientific concepts into concrete and interactive learning experiences in science teaching (Altınpulluk, 2015; Law & Heintz, 2021). AR enriches the real world with virtual content, making students' learning processes more visual, auditory and interactive. Thanks to this technology, students can closely examine structures such as plant cells, see molecular models in three dimensions and conduct experiments in a virtual environment (Kına & Bicek, 2023; Taskın et al., 2023). Especially in units such as 'Solar System' or 'Let's Know Our Planet,' virtual excursions with AR technologies contribute to students' understanding of astronomy and geography subjects more effectively (Palmas & Klinker, 2020). In order to use this technology effectively in teaching, it is important that teachers have the necessary technical knowledge, technological infrastructure be provided, and equal access opportunities be provided to students (Chien, 2019; Lee, 2012; Sarıoglu, 2021).

Research on the effective integration of information technologies (ICT) in education provides important findings on teacher and student dimensions. *Kocak- Usluel et al. (2007)* reported that teachers preferred word processing and internet applications the most in ICT use, while they used desktop publishing and graphics programs the least. *Kuşkaya Mumcu (2011)* found that ICT education given to pre-service teachers significantly improved their technological pedagogical content knowledge. *Gunes (2015)* found that there were significant differences in the attitudes of administrators and teachers towards ICT. In studies on augmented reality (AR) applications, *Izgi - Onbasılı (2018)* found that these applications positively affected primary school students' motivation to learn science and their attitudes towards AR. Similarly, Dikkartın- Ovez and Sezginsoy- Seker (2022) found that AR-supported materials had significant effects on student achievement, attitude, and motivation. *Kaleci (2018)* stated that the in-service training program developed on the basis of the SAMR model positively affected teachers' beliefs and attitudes towards ICT. *Bayezit (2019)* developed an effective design process in mathematics teaching by combining ADDIE and Systematic Planning Models, and showed that teachers supported this process**.** *Gocen Kabaran (2020)* reported that an in-service training program aimed at increasing teachers' digital material development skills received positive feedback. *Simsek and Direkci (2021)* stated that Turkish teachers adopt technology in education and give importance to technology integration in teacher training processes. *Dundar and Unaldı (2023)* emphasized that an in-service training based on the TPACK model had positive effects on teaching processes and student achievement.

Chambers (2011) aimed to determine the effectiveness of ICT in a primary school. As a result of the research, he found that the use of ICT enhanced teaching efficiency and success and provided students with more effective learning opportunities. *Tak (2013)* aimed to determine the level of ICT usage of lecturers working in a higher education institution and their opinions on the subject. The research revealed that lecturers believe that the effectiveness of teaching will increase thanks to ICT integration. *Merillo and Domingo (2019)* aimed to examine teachers' views on the effectiveness of ICT integration in foreign language teaching. As a result of the research, they found that teachers believe the use of ICT will have very positive effects on language teaching. *Simonova and Kolesnichenko (2022)* aimed to determine the impact of the use of AR in higher education on foreign language teaching. As a result of the research, they found that AR applications were effective in increasing language learning levels and improving the quality of foreign language teaching.

Purpose of Research

In this study, although effective use of ICT in the science curriculum is necessary, there are limited examples of concrete applications, activities, and lesson plans on how to integrate technology into science teaching (Bal, 2015; Kuskaya-Mumcu et al., 2008; Kuskaya-Mumcu, 2011; Wang & Woo, 2007). In this context, the aim was to develop a sample instructional design on how ICT integration can be realized for science teaching and to evaluate the effectiveness of this design. The research provides a framework to guide teachers on how ICT can be used effectively in science teaching through the Systematic Planning Model. This is one of the ICT integration models and aims to integrate technology into disciplines in a regular and planned manner.

In the study, "Is there a significant difference between the achievement and retention scores of the students in the experimental group where the curriculum prepared based on the 'Systematic Planning Model', one of the ICT integration models, was applied in the 4th grade science course and the control group where it was not applied? What are the student views on the subject?" the study sought to answer. In this context, the hypotheses related to the experimental dimension of the research are presented below:

1. There is a significant difference between the achievement scores of the experimental group, in which the curriculum prepared based on the Systematic Planning Model was applied.

2. There is a significant difference between the achievement scores of the control group, in which the curriculum prepared based on the Systematic Planning Model was not applied (the current curriculum was applied).

3. There is a significant difference between the achievement scores of the experimental group in which a curriculum prepared based on the Systematic Planning Model was applied, and the control group in which it was not applied.

4. There is a significant difference between the retention scores of the experimental group in which the curriculum prepared based on the Systematic Planning Model was applied and the control group in which it was not applied.

The sub-problem related to the qualitative dimension of the research is presented below:

* What are the students' opinions about the practices in the curriculum prepared based on the 'Systematic Planning Model,' one of the ICT integration models, in the 4th grade science course in primary school?

Method

Research Design

In this study, mixed methods were used. The explanatory design, one of the mixed methods designs, was employed. First, quantitative data were collected; then qualitative data were collected to interpret, deepen, and enrich these data (Creswell & Plano Clark, 2007). Karasar (2014) defines mixed methods as a method that uses both types of data in the research process and contributes to making the results more meaningful. The mixed methods enable the research problem to be addressed from a broader perspective by using quantitative and qualitative data together. This approach increases the depth of the research through the mutual support of quantitative and qualitative findings (Creswell, 2017; Johnson et al., 2007; Sonmez & Alacapınar, 2019).

According to Karasar (2014), experimental research involves making comparisons. This comparison can be in the form of changes within a method or a comparison of two different methods. In this study, two methods applied in two different groups were compared. The pretest-posttest control group experimental design, a quantitative research design, was used. In this design, groups are naturally determined as experimental and control groups. In the model, groups are taken, as they are, in the institutions, in their existing structure. No assignment is made by selection or chance. A pretest is administered to both groups at the same time. Afterwards, the experimental procedure is used in the experimental group, but not in the control group. The test is given to both groups at the same time as a posttest. The pretest-posttest score differences of both groups were found and the results were compared (Sonmez & Alacapınar, 2019). In experimental studies, the population and sample are not determined, but the study groups are. It is important that these groups are balanced in terms of undesirable variables, not their size (Sonmez & Alacapınar, 2019).

In the qualitative dimension of the study, the case study model was preferred. A Case study enables the examination of various aspects of a particular phenomenon or situation from a holistic perspective (Yıldırım & Simsek, 2013). Qualitative data were obtained through a semi-structured interview form, and the descriptive analysis method was used to analyze the data. This method enables the data to be systematically defined, interpreted and organized in a certain order (Sonmez & Alacapınar, 2019). Thus, the findings of the study were supported by the combined use of quantitative and qualitative methods, and the study's validity was thereby increased.

Study Group

The study group of this research consisted of 45 students studying at the fourth-grade level of a private primary school in the Selcuklu district, in the Konya province. There are two main reasons for choosing fourth grade students in the study. Firstly, the current fourth grade science curriculum is thought to be the most suitable for technology integration practices compared to other grade levels. The second main reason is that fourth grade students are more suited to the age maturity required for technology integration, which necessitates the use of technological hardware and software, compared to other grade levels.

All 4th grade students studying in three branches of a private primary school were included in the study. The students in these three classes were treated as three naturally formed separate groups, and no random assignment was made to the groups. Then, from these two equivalent groups, class 4-A was designated as the experimental group and class 4-C as the control group. The distribution of the students in the experimental and control groups by grade and gender is given in Table 1 below.

Table 1. Distribution of students in experimental and control groups

Groups	Male		Female		Total	
	n	%	n	%	n	%
Experimental (4-A)	15	65,22	8	34,78	23	100
Control (4-C)	11	50	11	50	22	100
TOTAL	26	57,78	19	42,22	45	100

Table 1 shows that a total of 45 students from the experimental and control groups participated in the study. While 57.78% (n=26) of the students participating in the study were male, 42.22% (n=19) were female. However, 65.22% (n=15) of the 23 students in the experimental group were male and 34.78% (n=8) were female. In the control group, there were a total of 22 students, 50% (n=11) of whom were male and 50% (n=11) of whom were female.

The analyses made with the pre-test scores of the experimental and control group students in order to reveal their equivalence in terms of academic achievement levels in the unit of 'Lighting and Sound Technologies from Past to Present' in the science course are shown in Table 2.

Table 2. T-test results of students' pretest score averages according to groups

Groups	n	$\bar{x}$	SS	sd	t	p
Experimental	23	23,95	8,18	43	-1,595	0.118*
Control	22	27,27	5,42			

*p>0.05

When Table 2 is examined, it is seen that the mean pretest score of the experimental group was 23.95 and the mean pretest score of the control group was 27.27; there was no significant difference between the pretest scores of the groups [t (43) = -1.595, p=0.118, p>0.05]. The groups are equivalent in terms of pretest mean scores.

Data Collection Tools and Techniques

For the achievement and retention test to be applied to the experimental and control groups, the researcher prepared a test consisting of 50 multiple-choice questions targeting the achievements in the "Lighting and Sound Technologies from Past to Present" unit in the science course for 4th-grade primary school students in the 2022-2023 academic year. The questions of the test were prepared according to Bloom's taxonomy and the levels of knowledge, comprehension, and application. The test items were evaluated by 1 classroom teacher (head teacher), 1 science teacher (science expert), and 1 faculty member in terms of their effectiveness in measuring the intended behaviors. The agreement values between the experts' evaluations were calculated using a Miles & Huberman (1994) formula and determined as 0.87. At the end of the pilot application, the test, which was reduced to 40 items, was finalized. The reliability coefficient of the test was calculated as r=0.896 according to the KR-20 method. The calculated value has a level of reliability considered quite high for an achievement test (Salvucci et al., 1997).

To obtain data related to the qualitative dimension of the study, a semi-structured interview form consisting of three open-ended questions was prepared by the researcher. The questions in the interview form were evaluated by experts in the field of measurement and evaluation. In addition, an academician working in the field of basic education, and a language expert were consulted to evaluate the comprehensibility of the questions by fourth-grade primary school students. Since the students were at the primary school level, the interview form was prepared as semi-structured to determine the students' opinions and thoughts about the implementation process. To evaluate the reliability of the qualitative research, the reliability was calculated using the coder reliability method suggested by Miles and Huberman (1994) and found to be .93.

The questions in the form after the necessary corrections were made in line with the expert opinions: "What are your opinions about the studies we do in Science lessons? Do you think our studies are useful? Please state your reasons." Do you think using technology in science lessons is useful? In what way do you think the technological products we use (tablet computers, laptops, augmented reality applications, web tools, etc.) are beneficial or harmful? Please indicate with the reasons." "What are your suggestions for making our studies more useful and improving them?

Implementation Process and Data Collection

Two of the three 4th grade classes, in the private school where the experimental study would be conducted, were selected as the experimental and control groups. The experimental process was initiated while the academic achievement test was administered to the experimental and control groups simultaneously as a pretest. After the pretest application, the researcher conducted the research in the experimental and control groups over 7 weeks, with each group receiving 21 hours, starting in the same week. The reason the researcher took part in the experimental process as a teacher is that he is a classroom teacher, has expertise in the field of curriculum and instruction, and is familiar with the Systematic Planning Model. In addition, according to Creswell & Plano-Clark (2007), the aim of the researcher's proximity to the participants is to increase the validity of the research.

In the experimental process, the experimental group was taught according to a curriculum based on the Systematic Planning Model, while the control group was taught based on the existing curriculum with the resources and activities stipulated by the MoNE curriculum. An augmented reality application called Jigspace, an online presentation and information editing application called Visme, and an electronic classroom application called Google Classroom, were used to teach the topics in the curriculum. At the end of the course, the academic achievement test was given to both groups simultaneously as a posttest. At the end of the experimental process, a semi-structured interview form developed by the researcher was applied to the students in the experimental group. The form was delivered in printed form to the students in the experimental group, who were asked to answer three open-ended questions. The students expressed their opinions about the activities related to the experimental application in writing through printed forms during one 40-minute lesson allocated for this process. Four weeks after the posttest, the academic achievement test was given to both groups as a retention test. The experimental process of the research was completed.

Analysis of Data

The quantitative data obtained from the experimental and control groups were first recorded in Excel and transferred to IBM SPSS (Statistical Package for Social Sciences) 18 for the necessary analysis. In order to determine the appropriate statistical method to be used in analyzing the quantitative data, the homogeneity of variances and the normal distribution of the data were checked. The homogeneity of variances was determined by Levene's Test, and the normal distribution of the pretest, posttest, and retention test scores of the experimental and control groups were assessed using the Shapiro-Wilk test, Skewness-Kurtosis values, coefficients of variation, and histogram graphs. After testing the normal distribution of the data, the Dependent Sample t-Test, Independent Sample t-Test, Mann-Whitney U Test, and Wilcoxon Signed Rank Test were used for the measurements. The effect size of the significant difference between independent groups in the study was calculated using the "r" value, and the effect size of the significant difference between the results within groups was calculated using "Cohen's d" value formula. In this context, Cohen (1988) tried to classify the significance levels of Cohen's d value and r values to calculate the effect size in the model he developed. According to Cohen, the value found as effect size (r) can be interpreted as small if $r < 0.2$; moderate if $0.2 < r < 0.5$; strong if $0.5 < r < 0.8$, and very strong if $r > 0.8$.

In the qualitative dimension of the research, the data in the semi-structured interview forms developed by the researcher were carefully examined, organized, and analyzed. The descriptive analysis technique helped to identify the focal points and main themes of the research and enabled in-depth understanding of the data obtained. Descriptive analysis enabled the data to be evaluated within a broader context and facilitated a meaningful presentation of the main findings of the research. In this study, the analysis of the students' responses to the semi-structured interview questions was conducted independently by the researcher and a field expert.

Findings

Findings Related to the First Hypothesis

In order to test the first hypothesis of the study, researchers evaluated whether "there is a significant difference between the achievement scores of the experimental group in which the curriculum prepared based on the Systematic Planning Model was applied. Since the data showed a normal distribution, the paired sample t-test was used. The test results are given in Table 3.

Table 3. Comparison of pretest and posttest scores of experimental group students

Group	Test	*N*	$\bar{x}$	SD	*df*	t	*p*
Experimental Group	Pretest	23	23.956	8.182	22	-7.445	.001
	Posttest	23	34.565	5.106			

According to Table 3, the pretest scores for students in the experimental group were $\bar{x}$ pretest = 23.95±8.18, and the posttest scores were $\bar{x}$ posttest = 34.56±5.10. There was a statistically significant difference between the achievement scores of the experimental group ($t(22) = -7.445$, $p < 0.05$), $d = 1.63$. The curriculum prepared and implemented in accordance with the Systematic Planning Model, was effective in increasing the academic achievement of the experimental group students.

Findings Related to the Second Hypothesis

In order to test the second hypothesis of the study, the researchers postulated: "There is a significant difference between the achievement scores of the control group, in which the curriculum prepared based on the Systematic Planning Model was not applied (the current curriculum was applied). The Wilcoxon Signed Ranks Test was used since the data did not show normal distribution. The test results are given in Table 4.

Table 4. Comparison of pre-test and post-test scores of control group students

Group	Pretest-Posttest	N	Mean Rank	Rank Total	*Z*	p
Control Group	Negative Rank	5	11.90	59.50	-1.447	.148
	Positive Rank	14	9.32	130.50		
	Equal	3				

* Calculated based on negative ranks.

According to Table 4, it was determined that the difference between the achievement scores of the control group students ($z=-1.447$; $p=.148$), $d=0.15$, was not statistically significant and indicated a very small effect size (Cohen's d). It can be said that the program in force was not effective for improving the academic achievement of the control group students.

Findings Related to the Third Hypothesis

In order to test the third hypothesis of the study, "There is a significant difference between the achievement scores of the experimental group in which the curriculum prepared based on the Systematic Planning Model was applied and the control group in which it was not applied", Mann Whitney U test was used since the data did not show normal distribution. The test results are given in Table 5.

Table 5. Comparison of attainment scores of experimental and control group students

Group	N	Mean Rank	Rank Total	U	p
Experimental	23	33.33	766.50	14.500	.001
Control	22	12.20	268.50		

According to Table 5, it was determined that there was a statistically significant difference between the achievement scores of the experimental group students and the control group students ($U=14.500$; $p=.001$), with a Cohen's d of 1.94, indicating a very high effect size. The curriculum prepared based on the Systematic Planning Model is more effective than the current curriculum in determining students' achievement levels.

Findings Related to the Fourth Hypothesis

In order to test the fourth hypothesis of the study, "There is a significant difference between the retention scores of the experimental group to which the curriculum prepared based on the Systematic Planning Model was applied and the control group to which it was not applied," the Mann-Whitney U test was used, since the data did not show normal distribution. The test results are given in Table 6.

Table 6. Comparison of retention scores of experimental and control group students

Group	N	Mean Rank	Rank Total	U	p
Experimental	23	30.13	693.00	89.000	.001
Control	22	15.55	342.00		

According to Table 6, there was a statistically significant difference between the posttest retention scores of the experimental group students and the control group students (U=89.000; p=.001); the effect size value (Cohen's d) was d=1.81, which was quite high. It can be concluded that the curriculum prepared based on the 'Systematic Planning Model' is more effective than the current curriculum in determining students' retention levels.

Findings Related to the Qualitative Dimension of the Study

Student views on the achievement scores of the experimental group in which the curriculum prepared based on the Systematic Planning Model was applied

What are the students' opinions about the practices in the curriculum prepared based on the 'Systematic Planning Model', one of the ICT integration models, in the 4th grade science course in primary school? The opinions of the experimental group students about the implementation process were determined for the sub-problem.

In the qualitative dimension of the study, the views and opinions of the experimental group students about the implementation process were determined. The data obtained from the semi-structured interview form were subjected to content analysis and coded. The first question of the interview form was "What are your opinions about the studies we did in science lessons? Do you think that our studies are useful? Please state your reasons. A total of 59 codes were produced in 12 different categories from the answers given by 22 students in the experimental group. The codes were evaluated under two themes: "Positive Opinions" and "Negative Opinions". Among these codes under the "Positive Opinions" theme, the "fun" code ranked first in terms of frequency and percentage value with a frequency of 17. This code corresponds to 28.81% of the codes generated from all responses. It was determined that the code "useful" ranked second with 11 frequencies, and a value of 18.64%, and the code "instructive" ranked third with 10 frequencies and a value of 16.94%. The code "permanent" was ranked fourth with a frequency of 6 and a value of 10.16%. There were only two codes under the theme of "Negative Opinions. The first of these was "took a long time" with a frequency of 4 and a value of 6.78%. In the second row of the theme, "Temporary" was included with only 1 occurrence and a value of 1.69%. This situation indicates that the students found the practices and activities in the experimental process fun, useful, and instructive. The positive experiences of the students, observed by the researcher during the experimental process, were further corroborated by data collected through the interview form. Some of the answers given by the students are presented below, with the method of direct quotation.

S1: *"The studies we did in science class were useful. The educators encouraged playful activities because learning in a fun way was more permanent."*
S5: *"I think it was useful. We both had fun and learned as a class through comprehensive explanations. It was enjoyable and permanent. I want the lessons to be taught in this way."*
S8: *"It was useful. My curiosity was satisfied; it was fun and instructive. I liked it very much."*
S12: *"The lessons were very enjoyable, instructive, and informative."*
S16: *"I think it was useful because it was both fun and instructive."*

The second question of the interview form, "Do you think it is useful to use technology in science lessons? In what ways do you think the technological products we use (tablet computers, laptops, augmented reality applications, web tools, etc.) are beneficial or harmful? Please state with the reasons." It was observed that 55 codes were generated in 18 different categories from the answers given by students in the experimental group. The codes were evaluated under three themes: "Useful Aspects," "Harmful Aspects," and "Necessity and Importance. Among these codes within the scope of the first theme "Useful Aspects", the code "It is useful" ranked first by frequency and percentage, with a frequency of 17. This code corresponds to 30.90% of the codes generated from all responses. The code "It makes it fun" ranked second with 4 frequencies and 7.27%, and the code "It helps us learn better" ranked third with 3 frequencies and 5.45%. Within the scope of the second "Harmful Aspects" theme, the code "Using it for a long time causes harm" ranked first with a frequency of 9 and a value of 16.36%, while the code "It should be short" ranked second, with a frequency of 2 and a value of 3.63%. Thirdly, within the scope of the theme of "Necessity and Importance", the code "It should be used in all courses" ranked first with a frequency of 5, accounting for 9.09%. In this case, it can be said that students find technology-supported science education useful. However, the students also stated that using educational technologies for a long time would be harmful. Some of the students' answers to the second question are presented below using the direct quotation method.

S3: *"Yes, it is useful. It should be used in all courses."*
S10: *"Technology is necessary in science lessons. The harm caused by it leads to addiction. The benefit is that it helps us acquire knowledge."*
S14: *"It is useful for education because it enhances learning outcomes. The use of technology in science lessons enhances memory retention more effectively than traditional methods."*
S17: *"It is considered useful. Fast and practical learning. I think technology will be useful in every lesson."*
S20: *"The use of technology is beneficial. Technology is indispensable for obtaining useful information."*

In the third question of the interview form, "What are your suggestions for making our studies more useful and improving them?", 34 codes were generated from the answers given by the students in the experimental group, grouped into 8 different categories. The codes were evaluated under three themes: "In terms of quantity," "In terms of quality," and "Neutral. Among these codes within the scope of the first theme "In terms of Quantity", the code "It should be used in all courses" ranked first in terms of frequency with a frequency value of 14. This code corresponds to 41.17% of the codes generated from all answers. The code "The number of devices should be increased" ranked second with 3 frequencies and 8.82% while "It should be done more frequently" ranked third with 2 frequencies and 5.88%. Within the scope of the second theme, "In terms of quality", among the codes, the code "It should be shorter" ranked first with 11 frequencies, and a value of 32.35%. It was determined that the code "There is no need for improvement" which is the only code within the scope of "Neutral" as the third theme, has a frequency of 1 and a value of 2.94%. In this case, students demanded the widespread use of technology in all courses. However, as a criticism of the experimental process carried out within the scope of this research, they stated that technology-supported activities should be shorter and the amount of technological equipment was insufficient. Some of the students' answers to the third question, are presented below using the direct quotation method.

S2: *"I think the studies we did could have been shorter, and included in all lessons."*
S4: *"It could be shorter. It can be applied to every lesson."*
S7: *"It should be used in every lesson; tablets should be given to every student."*
S19: *"It may be beneficial to integrate technology into science lessons. Augmented reality should be considered for implementation in all lessons."*
S22: *"I think it is good; however, it takes too long. It can be accelerated. It should be used in all lessons."*

Student views on the retention scores of the experimental group in which the curriculum prepared based on the Systematic Planning Model was applied

In the study, the data obtained from the students' views on the effect of the course taught using the systematic planning model on retention were analyzed by content analysis. As a result of the analysis of the answers given by the students about retention, three themes and codes related to these themes were determined. When the findings were examined, the main themes were determined as "Retention and Recall", "Embodiment and Understanding" and "Motivation and Increased Interest". The majority of the students stated that the retention of information increased in the lessons taught in line with the systematic planning model. In particular, it was observed that visual and experiential learning provided by the technological elements used in the lessons contributed to the long-term recall of the information learned. In this context, the prominent codes were determined as "keeping the information in mind for a long time", "retention of visual elements in memory", "learning through experience is not forgotten", "learning becomes fun". Students emphasized that especially abstract concepts became more concrete and understandable thanks to the technologies used in the lessons. Supporting difficult-to-learn concepts with three-dimensional virtual models and visual content facilitated understanding and contributed to the retention of learning. In addition, the different and fun structure of the augmented reality application used in the lesson made it easier for students to pay attention, which had a positive impact on the learning process. Some of the student responses are presented below by direct quotation method.

S1: *"The things we learn in this course stay in my mind because it is as if I discovered them myself."*
S3: *"I have a lot of fun and the information stays in my mind because the things we only see pictures of in the book appear three-dimensional and moving thanks to the application we use on the tablet computer."*

S6: *"When I took this lesson, I felt like I was on an adventure, not in a lesson, so I can say that everything I learned was engraved in my brain."*
S9: *"Thanks to these lessons, I can visualize even abstract things. When I see and do it, it stays in my mind, I didn't understand much when I just listened to it."*
S11: *"Normally, the subjects in science class were difficult for me. But now I understand better and what I have learned stays in my mind."*
S18: *"Since this method is very different, I now listen to the lessons more carefully and remember what I have learned for longer."*
S21: *"We both had fun and never forgot what we learned."*

As a result of the analysis of the data collected for the qualitative dimension of the research, it was determined that the students in the experimental group expressed positive opinions about the activities and lessons taught within the scope of the curriculum prepared based on the 'Systematic Planning Model'. They stated that they found the lessons fun and useful, that the hardware and software used facilitated their learning, that what they learned was permanent, that they remembered for a long time, and that although the activities took a long time, they should be used in every lesson. It was also observed that the students thought that the number of equipment was insufficient and the activities took a long time, and that the students made various suggestions for the development of the curriculum.

Discussion and Conclusion

In line with the findings, the results of the research were determined. The effectiveness of the curriculum prepared based on the Systematic Planning Model in the Primary School 4th Grade Science course was discussed, and suggestions were made. When the findings related to the first hypothesis of the research were examined, it was revealed that the curriculum prepared and implemented in accordance with the Systematic Planning Model was effective in increasing students' academic achievement. These findings coincide with the studies in the existing literature. Ghavifekr and Rosdy (2015) found that teachers' preparation and implementation of technology-supported curricula equipped with ICT tools and facilities are effective in learning and increase achievement. Tak (2013) found that ICT integration of instructors increases effectiveness in teaching. Bayezit (2019) developed an instructional design that integrated the ADDIE model and the Systematic Planning Model in mathematics education. Teachers supported this program. Kul (2019) determined that augmented reality applications increased students' academic achievement and motivation towards science learning. Sevimli (2020) reported that that the online teaching module developed according to the ADDIE model and Systematic Planning Model created a significant difference in favor of the experimental group after the application, and that the participants' beliefs about the use of ICT changed positively. Omurtak and Zeybek (2022) revealed that augmented reality-based activities increased student achievement and motivation in biology courses.

The findings related to the second hypothesis of the study show that the activities based on the current program are not effective in increasing students' academic achievement. The control group data revealed that the current program was insufficient to increase achievement, therefore, this hypothesis was not confirmed. These results coincide with Chambers' (2011) study in which he found that the use of ICT in a primary school increased efficiency and achievement in teaching. It also coincides with the results of Dikkartın Ovez's and Sezginsoy Seker's (2022) research in which they found that activities designed for the application of AR-supported materials significantly increased the achievement of experimental group students in social studies and mathematics courses.

Regarding the third hypothesis, it was determined that the achievement scores of the experimental group were significantly higher than those of the control group. This shows that the experimental process was effective in increasing the students' learning levels. This result coincides with the findings of Donmus's (2012) study, which found that activities supported by educational computer games significantly increased students' achievement levels, and Piper et al.'s (2015) study, in which teachers' use of tablet computers and students' use of e-book readers had positive effects on learning outcomes.

The findings obtained within the scope of the fourth hypothesis, showed that the retention scores of the students in the experimental group were significantly higher compared to the control group. These results are similar to the results of Ozgur (2016) and Kıyıcı (2018) and Gurbuz et al.(n.d.). The results of Turksoy's (2019) study, which determined that the use of AR in science courses increased students' academic achievement and retention of knowledge, and Simonova & Kolesnichenko's (2022) study, which showed that using AR applications had a positive effect on learning outcomes, were found to be similar to the results of Ozgur (2016) and Kıyıcı (2018) and Gürbüz et al. (n.d.).

In line with the qualitative findings of the study, according to the achievement and retention scores of the experimental group, the majority of the students stated that they found the in-class activities fun and useful, and some of them stated that the duration of the activities was long. The students expressed their desire for similar activities to be used in other lessons. These findings are similar to the results of Izgi- Onbasılı's (2018) study, which found that lessons taught with AR applications increased students' motivation; Purbudak and Usta's (2019) study, which found that the use of digital stories positively affected students' attitudes towards the course; and Tak's (2013) study, in which instructors believed that effectiveness in teaching would increase as a result of their ICT usage levels and their opinions on the subject. In addition, it was determined that most of the students stated that the applied method increased their retention levels. In this context, the results of the study overlap with the findings of Simsek and Hamzaoglu's (2020) study in which Simsek and Hamzaoglu (2020) determined that teaching enriched with models in science teaching increased the retention level and Tekdal and Taskın's (2021) study in which Tekdal and Taskın (2021) determined that dynamic and interactive computer-aided science and technology teaching increased the retention level.

As a result, it was concluded that the lessons taught in line with the technology-supported curriculum implemented in the research were found to be fun and useful by the students, facilitated the learning process. It was also concluded that similar applications should be carried out in different courses. This supports the quantitative findings of the study. While quantitative data revealed that there was a significant increase in the academic achievement of the experimental group, qualitative data showed that students developed positive views towards the course and were satisfied with the experimental practices that facilitated learning. The findings reveal that systematic planning based on technology integration is effective in increasing both students' achievement and their motivation in the course.

Recommendations

In line with the research findings, planned and model-based approaches to technology integration in education are observed to have positive effects on student achievement and learning motivation. In this framework, it is important to consider theoretically based integration models such as the Systematic Planning Model in the design of curricula. Considering that technology integration, especially at the meso level, supports students' in-depth comprehension and permanent learning of subjects, teachers should be encouraged to combine content and pedagogy with digital tools in a structured way.

The qualitative findings show that students developed positive attitudes towards technology-supported learning activities, reflecting their increasing interest in the lessons. In this context, technology integration should be planned to create student-centered, interactive and experience-oriented learning environments without reducing it to the use of tools. Based on the students' views, it can be suggested that technology-supported activities should be expanded not only in science but also in other courses. Making such activities routine in the teaching process will allow students to experience multiple ways of learning and contribute to their cognitive development.

The study was limited to the application of the Systematic Planning Model at the meso (subject) level. The applicability of this model at the micro (in-class implementation) and macro (integration across the curriculum) levels can also be examined in future research. In particular, in-class strategies, material use, and student-technology interaction can be analyzed in detail through course-based (micro-level) applications. At the macro level, more holistic integration approaches can be developed by establishing interdisciplinary connections.

In addition, similar studies can be conducted at different grade levels, in different disciplines, and in educational institutions with various technological infrastructure in order to increase the traceability of the effect of the research. It is recommended that ICT integration models be included in pre-service and in-service training programs in order to improve pre-service teachers' knowledge and skills for technology integration. In addition, longitudinal studies should be conducted to monitor the sustainability of student achievement and learning quality in the longer term.

Declaration of Scientific Ethics

* The authors declare that the scientific, ethical, and legal responsibility of this article published in the JESEH journal belongs to them.

* The ethics committee report from Necmettin Erbakan University, assessing the ethical appropriateness of this

study, was obtained dated 08.07.2022 and numbered 2022/292.

Conflict of Interest

* The authors declare that they have no conflict of interest.

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