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# Effects of Electronic Strategic Intervention Material on Elementary Students' Motivation in Learning Plant and Animal Cells

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**ABSTRACT**

**Purpose of the study:** This study aimed to develop and validate a Self-Determination Theory-based Electronic Strategic Intervention Material (E-SIM) designed to enhance students' intrinsic motivation in learning about plant and animal cells. The E-SIM was anchored on the Department of Education's Most Essential Learning Competencies (MELCs) to ensure curriculum alignment and contextual relevance.

**Methodology**: A descriptive-developmental design was employed for material validation, and a one-group pretest posttest design (n = 39) was used to evaluate its effectiveness. Data were collected through expert and student validation checklists, as well as the Intrinsic Motivation Inventory (IMI). Quantitative analyses included the Shapiro–Wilk test for normality and the Wilcoxon signed-rank test to determine significant changes in motivation levels.

**Main Findings:** Expert validators rated the E-SIM "Very Satisfactory" in content, instructional, and technical quality, while student evaluators rated it "Excellent" in content and "Very Good" in format. The Wilcoxon signed-rank test revealed a significant increase in intrinsic motivation after E-SIM implementation ($p < .05$; $r = 0.84$), particularly in Interest/Enjoyment and Value/Usefulness subscales, alongside a notable decrease in Pressure/Tension.

**Novelty/Originality of this study**: This study introduces a technology-enhanced, game-based E-SIM developed through Microsoft PowerPoint with integrated narration, animations, and interactive feedback mechanisms. Grounded in Self Determination Theory, the E-SIM promotes autonomy, competence, and enjoyment demonstrating its potential as an engaging, low-cost, and scalable alternative to traditional instruction in fostering students' motivation and learning in biology.



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## 1. INTRODUCTION

The rapidly changing world of the 21st century continues to transform the educational landscape. Educators are increasingly seeking innovative approaches to address the evolving needs of students in the digital era. Likewise, learners at the forefront of education are expected to acquire skills that align with the demands of a knowledge-based, technology-driven society [1]. Recent studies emphasize that educational transformation requires self-directed, technology-enhanced, and motivational tools that promote learner autonomy, engagement, and adaptability in the digital age [2], [3].

Despite these demands, the Philippines continues to lag behind other countries in the quality of education, particularly in science education [4]. Based on the Trends in International Mathematics and Science Study

(TIMSS, 2019), the Philippines ranked 70th out of 144 participating countries, scoring 297 in Mathematics and 249 in Science [5], [6]. Similarly, the 2018 Programme for International Student Assessment (PISA) revealed that the country ranked second lowest among 78 nations, with only about 1% of junior high school students achieving proficiency in Science [7]. The persistent underperformance of Filipino learners in science has been attributed to the ineffective use of instructional materials that often fail to address the target learning competencies [4], [8].

To improve the quality of science learning, the integration of technology-based intervention materials has been regarded as a viable strategy for inclusive, high-quality education [1]. Such materials are designed to meet learners' current needs and promote the development of 21st-century skills, enabling students to progress at their own pace through diverse and engaging learning activities. In this context, the department of education (DepEd) introduced the Electronic Strategic Intervention Material (E-SIM) a digital remediation tool aimed at improving learners' performance in least-mastered competencies and addressing learning gaps within the K–12 curriculum [9].

Electronic Strategic Intervention Materials are systematically designed to spark students' curiosity, improve comprehension, and facilitate mastery of content knowledge [10]. As technology-embedded instructional tools, E-SIMs bridge the gap between traditional and modern learning by combining interactivity, feedback, and engagement. Prior studies demonstrate that interactive and multimedia-rich environments significantly enhance students' motivation, conceptual understanding, and participation when grounded in strong pedagogical principles [11], [12]. This is consistent with Dandan [13], who found that E-SIMs have a positive impact on learners' performance, being both highly acceptable and effective in promoting knowledge acquisition. Similarly, the use of digital, self-directed, and game-based materials—such as E-SelfIMo and Game-Based Activities (GBAs) in science instruction has been shown to improve conceptual understanding and intrinsic motivation among elementary students [14], [15]. These results align with the assertion that the integration of technology in science lessons promotes deeper learning and strengthens learner persistence [16].

Motivation plays a vital role in shaping students' engagement and achievement. It reflects the degree to which learners invest effort, maintain interest, and sustain attention during learning [17]. According to Self-Determination Theory (SDT), intrinsic motivation flourishes when learners experience autonomy, competence, and relatedness psychological needs that can be supported through feedback-rich, choice-driven, and interactive learning environments [18], [19]. Motivated learners generally demonstrate better engagement and retention of scientific knowledge [20]. Within this framework, digital materials like E-SIMs are effective because they can integrate multimedia design and learner control, satisfying these basic motivational needs. Furthermore, mayer's cognitive theory of multimedia learning (2009) supports that combining visual and auditory elements helps learners build meaningful mental models, leading to more effective knowledge construction.

Motivation is especially critical in science domains such as biology, which helps students understand the living world and their place within it. Tokan and Imakulata [21] emphasized that intrinsic motivation directly influences students' learning behavior and academic achievement in biology. However, misconceptions persist in several biological concepts most notably the structure and functions of plant and animal cells [22]. The cell, though fundamental, is a complex and abstract topic that students often find difficult to conceptualize. Saygın, Atılboz, and Sayman [23], as cited in Çeliker [24], noted that cellular structures and organelles are among the most challenging concepts for learners to grasp. In addition, declining motivation toward science learning continues to impede students' development of conceptual understanding and scientific thinking [17].

Despite substantial evidence showing that technology-enhanced, game-based, and electronic instructional materials improve students' academic performance, conceptual understanding, and engagement in science learning [13]-[15], most prior studies have primarily focused on achievement outcomes, acceptability, or material validation rather than motivation as a theoretically grounded construct. In particular, Philippine-based studies on Electronic Strategic Intervention Materials (E-SIMs) have emphasized learner performance and usability, with limited quantitative examination of intrinsic motivation using validated psychological instruments. Moreover, although Self-Determination Theory (SDT) has been widely cited to explain motivational processes in learning, few local studies have explicitly operationalized SDT to examine how digital intervention materials support autonomy, competence, and perceived value—especially in teaching abstract and conceptually challenging biology topics such as plant and animal cells. This gap suggests a need for empirical research that moves beyond performance metrics to systematically investigate the motivational mechanisms underlying the effectiveness of E-SIMs in elementary science education.

Responding to this gap, the present study is novel in that it develops and evaluates a Self-Determination Theory–based Electronic Strategic Intervention Material and quantitatively examines its effects on elementary students' intrinsic motivation using the Intrinsic Motivation Inventory (IMI), a validated motivational measure seldom employed in Philippine basic education research. Unlike previous studies that focus mainly on learning outcomes or material acceptability, this research foregrounds motivation as a central educational outcome, offering empirical evidence on how E-SIMs support enjoyment, competence, autonomy, and perceived value in science learning. The urgency of this investigation is underscored by persistent national and international assessments (TIMSS and PISA) indicating low science performance and engagement among Filipino learners, as well as documented difficulties in understanding cell biology concepts. By producing a low-cost, curriculum-aligned, and scalable digital intervention, this study responds to the immediate need for motivationally supportive instructional materials that can help address declining interest in science and strengthen foundational learning in elementary biology.

## 2. RESEARCH METHOD

### 2.1. Research design

This study examined whether the use of the Electronic Strategic Intervention Material (E-SIM) significantly influenced elementary students' intrinsic motivation to learn about plant and animal cells. A descriptive-developmental design was adopted to guide the design, validation, and empirical testing of the material. The developmental phase involved the systematic creation, expert validation, and refinement of the E-SIM following the ADDIE model (analysis, design, development, implementation, and evaluation), consistent with approaches used in recent e-learning module studies in the Philippines [26].

The design of the E-SIM was anchored on Mayer's Cognitive Theory of Multimedia Learning and Self-Determination Theory [18] to ensure that the material satisfied learners' needs for autonomy, competence, and engagement through interactive, feedback-driven experiences. The descriptive component analyzed expert and student validation data, while the quasi-experimental component a one-group pretest posttest design examined the E-SIM's effect on students' intrinsic motivation.

To minimize internal validity threats common to one-group designs (e.g., history, maturation, testing effects), both pretest and posttest were administered within the same week under identical conditions by the same teacher. This controlled delivery approach aligns with classroom-based intervention protocols recommended in similar Philippine educational experiments [27].

### 2.2. Sampling procedures and respondents

The study was conducted in one public basic education institution in Sorsogon, Philippines, during the 2022–2023 school year. Three distinct participant sources were involved, namely: expert validators (n = 5), pilot-test students (n = 36), and implementation participants (n = 39).

For the validation phase, five (5) expert validators were purposively selected based on the following criteria: (1) professional expertise in science education or curriculum development, (2) prior experience in evaluating instructional or digital learning materials, and (3) a minimum of five years of teaching experience aligned with Department of Education (DepEd) standards. These criteria ensured that content, instructional design, and technical quality were evaluated by qualified specialists.

For the pilot-testing phase, thirty-six (36) Grade 6 elementary students were purposively selected from an intact class in the same school. Selection was based on availability, regular class attendance, and prior exposure to digital learning materials, allowing students to provide informed feedback on the E-SIM's usability, clarity, and engagement features. Feedback from this group guided the final revisions of the material prior to implementation.

For the implementation phase, thirty-nine (39) Grade 6 elementary students from a different intact class in the same institution participated in the one-group pretest–posttest design. The class was treated as a cluster sample, a common and appropriate approach in classroom-based educational research where random assignment is not feasible and ecological validity is prioritized [26][27]. Inclusion criteria for participation were regular enrollment in Grade 6 science, parental consent, and student assent. All participants joined voluntarily.

Although modest, the sample size for implementation (n = 39) satisfies the minimum recommended threshold for detecting large effect sizes ($d \geq 0.80$) at 80% statistical power in educational quasi-experimental studies [28]. Basic demographic variables, including gender and prior academic performance, were recorded to ensure there were no significant baseline disparities among participants.

### 2.3. Research instrument

Three validated instruments were utilized: the DepEd Learning Resources Management and Development System (LRMDS) Evaluation Tool, a Student Validation Checklist, and the Intrinsic Motivation Inventory (IMI). The deped lrmds assessment and evaluation tool for non-print materials, as described in [29], was used for expert validation, evaluating content, instructional, and technical quality, as well as conceptual and typographical accuracy. Scores were normalized to a 4-point scale (3.50–4.00 = Excellent; 2.50–3.49 = Very Satisfactory; 1.50–2.49 = Satisfactory; 1.00–1.49 = Needs Improvement) and analyzed using weighted means.

The Student Validation Checklist, adapted from interactive module validation frameworks [14], assessed the E-SIM's format, visual appeal, and content accuracy on a 5-point Likert scale. Interpretation followed established descriptors ranging from "Strongly Disagree" (1.00–1.80) to "Strongly Agree" (4.21–5.00).

To assess students' intrinsic motivation, the Intrinsic Motivation Inventory (IMI) [11], [18] was administered before and after implementation. Six subscales were included: interest/enjoyment, perceived competence, effort/importance, value/usefulness, pressure/tension, and perceived choice. The relatedness subscale was excluded as it was beyond the scope of this study. The IMI was adapted to a 5-point scale for accessibility among junior high students. Reliability analysis revealed Cronbach's α ranging from 0.78 to 0.91, indicating high internal consistency [30].

### 2.4. Data Collection

Data collection occurred in three stages: validation, pilot testing, and implementation. Validation Stage: After obtaining formal approval from the Schools Division Office and the school principal, the E-SIM and validation instruments were distributed to expert validators for a five-day evaluation. Pilot Testing Stage: The revised E-SIM was evaluated by 36 students who completed the validation checklist and provided written feedback. This informed the final version used in implementation. Implementation Stage: The 39 elementary student-participants completed the IMI pretest, used the E-SIM over three weeks (approximately four hours per week), and then completed the IMI posttest. The timeline corresponded to DepEd's recommended pacing for the "Structure and Functions of Plant and Animal Cells" lesson. The same teacher facilitated all sessions to ensure procedural consistency and fidelity. All ethical standards were adhered to, including obtaining informed consent, ensuring voluntary participation, and maintaining data confidentiality, in accordance with institutional research guidelines.

### 2.5 Data Analysis

The DepEd Learning Resources Management and Development System (LRMDS) served as the primary analytical framework for evaluating the E-SIM's quality. Validation data from experts and students were analyzed using weighted-mean analysis, following the DepEd guidelines for evaluating non-print learning resources [29]. Weighted-mean analysis was likewise used in module validation studies to determine content, instructional, and technical quality [3]. Both raw and normalized mean scores were compared with the prescribed thresholds to establish the material's validity and acceptability.

For implementation data, descriptive statistics were computed to summarize the pretest and posttest scores obtained from the Intrinsic Motivation Inventory (IMI). The Wilcoxon signed-rank test was employed to determine significant differences in students' motivation levels before and after the intervention, given the ordinal nature of IMI scores and the modest sample size [31]. The Wilcoxon test is recommended for classroom-based research using small, non-normal samples and ordinal motivation data [32].

To control for inflated Type I error rates across multiple IMI subscales, the Holm correction [33] was applied at an $\alpha = 0.05$ significance level, a standard adjustment in educational-psychology studies (Field, 2018). Practical significance was assessed using effect-size estimates ($r = |Z| / \sqrt{N}$), interpreted according to [34] thresholds for minor (0.10), medium (0.30), and large (0.50) effects. Hodges supplemented these–Lehmann median difference estimates with 95% confidence intervals to provide a robust interpretation of magnitude, consistent with procedures used in motivation-based e-learning studies [3] [11].

In interpreting the results, motivational enhancement was inferred only when the positively oriented IMI subscales—Interest/Enjoyment, Perceived Competence, Effort/Importance, Value/Usefulness, and Perceived Choice—showed significant increases, while the negatively oriented Pressure/Tension subscale decreased. This interpretation follows Self-Determination Theory (SDT), which posits that intrinsic motivation improves when autonomy, competence, and value are supported [18], [35], [36].

### 2.5. Ethical considerations

Because the study involved minors, strict ethical protocols were observed in accordance with international and national guidelines for research with children and adolescents [37], [38]. Written parental consent and student assent were obtained prior to participation, consistent with ethical frameworks that emphasise guardian permission and child assent for studies involving vulnerable populations [39]. Students were informed of the voluntary nature of their participation and their right to withdraw at any time without academic penalty, as recommended by research ethics guidelines in educational settings [40]. All responses were treated confidentially, and no personally identifiable information was recorded. In line with best practices for child-centred research, all data were anonymised using coded identifiers and stored securely in password-protected files accessible only to the researchers [41].

## 3. RESULTS AND DISCUSSION

### 3.1. The Development of electronic strategic intervention material

The researchers developed an Electronic Strategic Intervention Material (E-SIM) intended to enhance students' intrinsic motivation in learning *plant and animal cells*. The development of the E-SIM was anchored on the department of education's most essential learning competencies (MELCs) for elementary Biology in the second quarter [25], specifically focusing on the topic "structures and functions of plant and animal cells." accordingly, two separate e-sims were designed: (1) "the cell adventure: part 1," which includes lessons on the structure, parts, and functions of plant and animal cells and their differences; and (2) "the cell adventure: part 2," which discusses the discovery of the cell, the cell theory postulates, and the two major types of cells.

The development process followed the ADDIE instructional design model (analysis, design, development, implementation, and evaluation), ensuring that each phase of the e-sim aligned with learner needs, content standards, and contextual realities. The design was also informed by mayer's cognitive theory of multimedia learning and self-determination theory [18], both of which emphasize that learning materials should promote cognitive engagement, autonomy, and intrinsic motivation. To further align with 21st-century learning outcomes, the E-SIM development drew on the partnership for 21st century learning framework [42] and deped's k–12 reform goals, which advocate for critical thinking, collaboration, communication, and creativity. Each E-SIM was designed with four key features immediate feedback system, student-centered learning, development of 21st-century skills, and informative enhancement as shown in Table 1.

Table 1. Matrix of the developed E-SIM, highlighting the four features

| Developed E-SIM | FEATURES | | | |
|---|---|---|---|---|
| | Immediate Feedback System | Student Centered | Develop 21st Century Skills | Informative |
| The Cell Adventure Part 1 and 2 | • Each level contains different sets of activities and each activities have an immediate result after the students answer it.<br>• The students will be able to know if they got the correct answer. | The students can use and manipulate the E-SIM all by themselves. This helps develop students to become independent learners. | • It can enhance students' collaboration skills as it can also be played by pairs or by small groups. • The ESIM enhances the critical thinking skills of the students as it contains activities that will boost the students' mental capacity. | • The ESIM contains additional information at every level. In every correct or wrong answer of the students, there is information and trivia that will pop up on their screen. |

The E-SIM was developed using Microsoft PowerPoint 2019 as the authoring platform, selected for its accessibility and compatibility across devices. The researchers integrated hyperlinks, action buttons, embedded audio narration, animations, and interactive triggers to create a dynamic and responsive learning environment. These features enabled learners to receive immediate, automated feedback, navigate lessons non-linearly, and engage in interactive tasks that sustain motivation and cognitive focus. The material's offline accessibility ensures equitable use across varying technological contexts, allowing students to operate it on laptops or mobile devices without requiring an internet connection.

Moreover, the E-SIM was intentionally designed to promote student-centered and constructivist learning, where students actively construct understanding through interaction and exploration rather than passive reception. Its accessibility and interactivity allow learners to study at their own pace, thereby cultivating autonomy and competencetwo psychological needs central to intrinsic motivation under Self-Determination Theory. The integration of collaborative tasks and challenge-based activities likewise supports the development of 21st-century learning skills as defined by the P21 framework.

Finally, the developed E-SIMs were subjected to expert validation following the department of education's learning resources management and development system (LRMDS) criteria, assessing content accuracy, instructional effectiveness, and technical soundness. This validation ensured that the materials met DepEd's standards for high-quality, accessible, and pedagogically appropriate digital learning resources prior to implementation.

**3.2 Experts' validation of the developed E-SIM**

The developed Electronic Strategic Intervention Material (E-SIM) underwent expert review using the Department of Education's Learning Resources Management and Development System (LRMDS) evaluation framework for non-print materials [29]. The LRMDS provides standardized quality assurance procedures for learning resources in terms of content, instructional quality, technical quality, and other aspects, including conceptual, grammatical, and typographical accuracy. Five science education experts with at least 10 years of experience handling science subjects and with a Master's Degree served as validators, using a 4-point descriptive scale (4 = Very Satisfactory, 3 = Satisfactory, 2 = Poor, 1 = Not Satisfactory). Weighted means were computed for each dimension to establish overall validity indices; qualitative comments and recommendations were also addressed in successive revisions of the materials. This process aligns with established practices in Philippine instructional-material development, such as the work of [43], [44] who validated modules and materials against LRMDS criteria.

Table 2. Expert's evaluation results in validating the developed E-SIM

| Factors | Total Weighted Mean | Descriptive Rating |
|---|---|---|
| a. Content Quality | 3.74 | Very Satisfactory |
| b. Instructional Quality | 3.76 | Very Satisfactory |
| c. Technical Quality | 3.75 | Very Satisfactory |
| d. Other Findings | 3.7 | Present but very minor, and must be fixed |

The validation results indicate that the E-SIM achieved high quality across all evaluated criteria: content quality (m = 3.74), instructional quality (m = 3.76), and technical quality (m = 3.75) are rated "very satisfactory," while other findings (m = 3.70) identified only minor typographical items to be corrected. the high rating for content quality suggests that the material presents accurate, relevant, and well-organized scientific information aligned with the elementary biology curriculum. The strong score in Instructional Quality reflects design features that promote learner autonomy, engagement, and motivation, in line with Self-Determination Theory [18] and multimedia learning principles [45]. The technical robustness, as indicated by the technical quality score, attests to the material's usability, accessibility, and multimedia integration essential considerations in philippine classroom contexts, where offline or low-connectivity conditions are common. These findings mirror other Philippine studies that achieved high validity under LRMDS-based criteria [7], [14] [44]. The minor issues flagged under Other Findings were addressed prior to pilot implementation. Overall, the validation affirms that the developed E-SIM meets national standards for instructional materials and is pedagogically and technically suitable for classroom deployment.

**3.3. Students' validation of the developed E-SIM**

This study tests the validity of the E-SIM from students' perspectives using the Students' Evaluation Checklist adapted from the study [22]. The mentioned evaluation tool is a 5-point Likert scale composed of two parts: Format and Content. Students' perspective on instructional material plays a significant role in the further improvement of the E-SIM.

Table 3. Validity of the E-SIM in terms of its Format

| I.FORMAT | | |
|---|---|---|
| Items | Weighted Mean | Descriptive Rating |
| 1. The layout of the E-SIM is arranged in a logical and sequential order | 4.4 | Very Good |
| 2. The instructions on each level of the E-SIM are clear and well-emphasized. | 4.8 | Excellent |
| 3. The font size and font style are readable | 4.9 | Excellent |
| 4. The symbol (if there is is) used is well designed. | 4.2 | Very Good |
| 5. Key points and key concepts are well highlighted to focus attention while playing and using the E-SIM. | 4.5 | Excellent |
| 6. Illustrations, pictures, and captions used in E-SIM are clearly defined. | 4.4 | Very Good |
| 7. The language used is easy to understand. | 4.6 | Excellent |
| 8. The language used is clear, concise, and motivating. | 4.4 | Very Good |
| 9. The audio narration is clear and easy to understand. | 4 | Very Good |
| Total Weighted Mean | 4.46 | Very Good |

It can be interpreted from Table 3 that the E-SIM obtained a passing rate in terms of its format with a weighted mean of 4.46, described as very good. Thus, based on the result and comments of the student validators, the researchers had done some minor revisions in some parts of the E-SIM.

As such, the lowest weighted mean obtained is 4.0, which is described as *Very Good.* The item that gained this rating was item number *9.)* The audio narration is clear and easy to understand. This means that there are some minor issues with the audio narration and specific audio effects in the E-SIM. Meanwhile, in item number 4, the symbol (if used) is well-designed, achieving a weighted mean of 4.2 with a descriptive rating of Very Good. This implies that the symbol used in the E-SIM was well-received by the students. Moreover, the researchers made some minor revisions to improve the product. As such, three (3) items gained a weighted mean of 4.4, characterized as Very Good. These are 1) The layout of the E-SIM is arranged in a logical and sequential order, 6) Illustrations, pictures, and captions used in E-SIM are clearly defined, and 8) The language used is clear, concise, and motivating.

In addition, a weighted mean of 4.5, described as *Excellent*, has been obtained in item number *5.* Key points and key concepts are well highlighted to focus attention while playing and using the E-SIM. The result showed that the students were able to maintain attention by the points and key concepts provided in the E-SIM. This indicates that the E-SIM had a positive impact on the students when they used the material.

Likewise, item number 7) The language used is easy to understand, obtained a weighted mean of 4.6, described as Very Satisfactory. Accordingly, the process of sharing ideas, skills, knowledge, and abilities between the learners and the teacher is involved in the instructional language [26]. This means that the language used in the ESIM was excellent, which helped the students to comprehend better the information contained in the topic. Moreover, a weighted mean of 4,8 described as Excellent, was obtained in item number 2. The instructions in each level of the E-SIM are clear and well-emphasized. The results showed that the instructions given in the E-SIM were clear and well-emphasized, guiding users on how to use the E-SIM. Lastly, the highest weighted mean gained was 4.9, described as Excellent. The item that obtained this rating was 3) The font size and font style are readable.

Table 4. Validity of the E-SIM in terms of its Content

| II. CONTENT | | |
|---|---|---|
| Items | Weighted Mean | Descriptive Rating |
| 1. The learning objectives of the E-SIM are easily understandable. | 4.5 | Excellent |
| 2. The instructions in every level are easily understandable | 4.3 | Very Good |
| 3. The E-SIM can motivate students to finish the game | 4.8 | Excellent |
| 4. The ideas and concepts of the E-SIM are understandable | 4.5 | Excellent |

| | | | |
|---|---|---|---|
| 5. | The illustrations /captions can help in understanding the content of the E-SIM. | 4.6 | Excellent |
| 6. | The E-SIM could help students fully understand the lessons | 4.5 | Excellent |
| 7. | The styles of illustrations and written expressions are appreciable. | 4.5 | Excellent |
| 8. | Accomplishing each level found in the E-SIM is enjoyable | 4.7 | Excellent |
| 9. | It is easier to study plant and animal cell topics using the ESIM. | 4.7 | Excellent |
| 10. | The lesson is enjoyable until the end. | 4.8 | Excellent |
| Total Weighted Mean | | 4.59 | Excellent |

Based on the result of the student's validation process, the total weighted mean obtained in terms of the content of the E-SIM was 4.59. This means that the material has a descriptive rating of excellent. As such, the lowest weighted mean obtained in the items under the content part of the E-SIM was 4.3, described as very good. Item number 2) The instructions in every level are easily understandable gained the mentioned rating. This means that the instructions given in the E-SIM need to be improved to provide more convenient guidance to the students.

Meanwhile, four (4) items gained a weighted mean of 4.5, described as excellent. These are the following: 1) The learning objectives of the E-SIM are easily understandable, 4) The ideas and concepts of the E-SIM are understandable, 6) The E-SIM could help students fully understand the lessons, and 7) The styles of illustrations and written expressions are appreciable. This implies that the learning objectives stated in the E-SIM were clear and the concept was easily understandable. Likewise, item number 5) The illustrations /captions can help in understanding the content of the E-SIM, obtained a weighted mean of 4.6, described as Excellent. The result shows that the illustrations/captions provided in the E-SIM have a positive relation with the way the students understand the concept in the material.

Moreover, two (2) items have a weighted mean of 4.7 with a descriptive rating of Excellent. These are: 8) Accomplishing each level found in the E-SIM is enjoyable, and 9) It is easier to study plant and animal cell topics using the E-SIM. Accordingly, high learning motivation of students results in the desire and drive to learn [27], which shows that there is no need to revise the E-SIM in terms of the given aspects and that the developed material shows relevance with the topic since the students were able to appreciate the lesson through the E-SIM.

Lastly, the highest weighted mean obtained was 4.8, described as Excellent. The items that gained this rating were the following: 3) The E-SIM can motivate students to finish the game, and 10) The lesson is enjoyable until the end. As such, this implies that the student validators were motivated by using the E-SIM and felt enjoyment about the lesson.

With regards to the ratings provided, it can be interpreted that there is no total revision needed. The developed E-SIM was validated by the students and is valid to be used for the implementation of the research study.

Table 5. Student's evaluation results in validating the developed E-SIM

| Part | Total Weighted Mean | Descriptive Rating |
|---|---|---|
| Format | 4.46 | Very Good |
| Content | 4.59 | Excellent |

From the table, it can be inferred that the developed E-SIM is valid for testing its effect on students' intrinsic motivation in learning about Plant and Animal Cells. Moreover, the researchers incorporated the comments and suggestions of the student validators into the revision process to further improve the material.

**3.4. Results of the wilcoxon signed-rank analysis on students' intrinsic motivation**

To determine the impact of the developed and validated electronic strategic intervention material (E-SIM) on students' intrinsic motivation, pre- and post-test scores across six subscales of the intrinsic motivation inventory (IMI) were analyzed. A shapiro wilk test confirmed that the data deviated from normality ($p < .05$), thus warranting the use of the non-parametric wilcoxon signed-rank test. effect sizes were also calculated to assess the magnitude of the change. The results, summarized in table 6, reveal meaningful improvements in most motivational subscales particularly interest/enjoyment, perceived competence, perceived choice, and value/usefulness alongside a reduction in pressure/tension, indicating a positive motivational shift following exposure to the E-SIM.

Table 6: Wilcoxon signed-rank test results comparing pre- and post-test scores across the six IMI subscales

| SUBSCALE | n | PRE-TEST | | | POST-TEST | | | P-Value | Wilcoxon r | Interpretation |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean | SD | Interpretation | Mean | SD | Interpretation | | | |
| Interest/ Enjoyment | 39 | 3.28 | 0.67 | N | 3.54 | 0.74 | A | 0.001 | 0.84 | L |
| Perceived Competence | 39 | 3.11 | 0.84 | N | 3.26 | 0.71 | N | 0.001 | 0.70 | L |
| Effort/ Importance | 39 | 3.53 | 0.17 | A | 3.57 | 0.24 | A | 0.297 | 0.233 | S |
| Pressure/ Tension | 39 | 2.95 | 0.22 | N | 2.56 | 0.20 | D | 0.001 | 0.88 | L |
| Perceived Choice | 39 | 2.99 | 0.42 | N | 3.11 | 0.44 | N | 0.001 | 0.84 | L |
| Value/ Usefulness | 39 | 3.79 | 0.77 | A | 3.95 | 0.51 | A | 0.004 | 0.52 | L |

Notes: SA = strongly agree; A=agree; N=neutral; D=disagree; SD=strongly disagree; L=large; M=moderate S = small, r = wilcoxon effect size; thresholds: small (<0.30), moderate (0.30–0.49), large (≥0.50). interest/enjoyment. The mean score for interest/enjoyment increased from 3.28 (SD = 0.67) to 3.54 (SD = 0.74), shifting the interpretation from neutral to agree (p = .001, r = 0.84), indicating heightened engagement and satisfaction when interacting with the E-SIM. Consistent with self-determination theory, intrinsic motivation rises when learning activities are experienced as enjoyable, meaningful, and autonomy-supportive [18], [46]. The E-SIM's gamified and interactive features plausibly nurtured this enjoyment; meta-analytic and systematic reviews show that gamification and technology-enhanced learning generally yield positive, though small-to-moderate, gains in motivation, interest, and engagement particularly in science learning contexts.

Perceived Competence: Students' perceived competence rose from 3.11 (SD = 0.84) to 3.26 (SD = 0.71), with a statistically significant difference (p = .001, r = 0.70). Although both means fell within the Neutral interpretation range, the large effect size implies a meaningful confidence gain. This supports previous findings that feedback-rich and autonomy-supportive environments enhance learners' self-efficacy and perceived mastery [35], [36]. The E-SIM's immediate feedback and scaffolded design appear to help students monitor progress and correct misconceptionsa k ey mechanism for strengthening perceived competence in digital learning contexts.

Effort/Importance: For Effort/Importance, the mean scores remained stable 3.53 (SD = 0.17) pretest and 3.57 (SD = 0.24) posttest showing no significant change (p = .297, r = 0.23). This stability may indicate that students already valued the lesson and exerted effort even before the intervention, likely because the content on plant and animal cells is foundational in biology [46]. This suggests that E-SIMs may be more influential in enhancing motivation when baseline engagement is low or content is perceived as abstract or challenging.

Pressure/Tension: A notable finding emerged in the Pressure/Tension subscale, which decreased from 2.95 (SD = 0.22) to 2.56 (SD = 0.20), indicating a reduction in anxiety levels (p < .001, r = 0.88). The large effect size suggests that the E-SIM alleviated academic stress and performance pressure conditions known to hinder intrinsic motivation [47]. The interactive, self-paced format allowed learners to engage without fear of error or social comparison, consistent with evidence that digital tools promoting autonomy and formative feedback reduce cognitive load and test anxiety [48]. Reduced tension, therefore, signals a crucial affective benefit: learners may become more willing to explore, reflect, and persist in scientific inquiry.

Perceived Choice: Perceived Choice improved modestly from 2.99 (SD = 0.42) to 3.11 (SD = 0.44) (p = .001, r = 0.84). Though both means were within the Neutral range, the large effect size suggests that students felt a greater sense of autonomy in navigating and controlling their learning. Autonomy-supportive digital environments—where learners can select activities, control pacing, or receive adaptive feedback—are empirically linked to sustained intrinsic motivation [49]. The E-SIM's flexible, learner-paced structure appears to satisfy this psychological need, implying that even modest increases in perceived choice can translate to greater engagement over time.

Value/Usefulness: The value/usefulness subscale demonstrated a significant improvement, increasing from 3.79 (SD = 0.77) to 3.95 (SD = 0.51) (p = .004, r = 0.52). This indicates that students recognized the E-SIM as a relevant and beneficial learning resource. When learners perceive instructional content as personally meaningful, they exhibit higher persistence and cognitive investment [58]. The E-SIM's contextualized activities aligned with deped's melcs likely reinforced students' understanding of the topic's real-world applications, further supporting its educational value.

Overall, the E-SIM intervention demonstrated statistically and practically significant improvements in multiple motivational dimensions, underscoring its promise as an engaging and autonomy supportive digital learning tool for science education. These results align with broader literature on technology enhanced interventions that promote active engagement, self regulation, and enjoyment in STEM contexts [50], [51].

However, this study's one-group pretest–posttest design inherently limits causal interpretation due to possible confounding variables such as maturation, test familiarity, and novelty effects. The short intervention duration and limited sample size (n = 39) also restrict generalizability. Future studies employing randomized controlled designs, larger and more diverse samples, and longitudinal tracking are recommended to validate and extend these findings.

## 4. CONCLUSION

Based on the findings of this study, several conclusions can be drawn. The developed Electronic Strategic Intervention Material (E-SIM), created using microsoft powerpoint with integrated multimedia and interactive features, was successfully aligned with the department of education's most essential learning competencies (MELCs) for elementary science, with specific emphasis on plant and animal cells. Expert validation confirmed that the E-SIM attained very satisfactory ratings across content, instructional, and technical dimensions under the deped learning resources management and development system (LRMDS) framework, indicating its pedagogical soundness and usability for classroom application. Minor revisions were implemented in response to expert feedback to further enhance clarity, navigation, and technical design. From the learners' perspective, the E-SIM demonstrated high acceptability, receiving excellent ratings in terms of content and very good ratings in format. These findings suggest that the material is engaging, learner-friendly, and appropriate for the cognitive level of elementary students.

Based on the conclusions drawn, several recommendations are proposed. First, elementary science teachers are encouraged to integrate validated Electronic Strategic Intervention Materials as supplementary instructional tools, particularly when teaching abstract and least-mastered concepts such as plant and animal cells, to enhance students' intrinsic motivation and engagement. Second, school administrators and curriculum planners may consider providing institutional support for the development, validation, and dissemination of teacher-designed digital intervention materials aligned with melcs and deped standards. Third, future researchers are encouraged to employ randomized or quasi-experimental designs with larger and more diverse samples to strengthen causal claims and improve generalizability. Longitudinal studies may also be conducted to examine the sustained effects of E-SIM use on motivation, conceptual understanding, and academic performance. Finally, investigating the dose–response relationship between frequency of E-SIM use and learner outcomes may offer valuable insights into its optimal implementation in science education.

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