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DEVELOPMENT AND VALIDATION OF LOCALIZED COMIC-BASED MODULES IN GRADE 7 CHEMISTRY

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ABSTRACT

The MATATAG Curriculum promotes learner-centered and contextualized materials to enhance learners' science skills and understanding. However, Grade 7 learners' mastery of fundamental chemistry concepts, particularly scientific investigation and changes of state, remains a concern, as reflected in the Index of Mastery and Item Analysis of Grade 7 assessment results in the first quarter of School Year 2025–2026. This study developed localized comic-based modules in Grade 7 chemistry, validated them through expert evaluation and user acceptability ratings, and tested their effectiveness in enhancing learners' performance. A Research and Development (R&D) approach guided by the ADDIE instructional design model was employed. Five experts (three science experts and two professional illustrators) validated the modules using the Department of Education's Evaluation Rating Sheet for New Print Resources, and 40 Grade 7 learners assessed their acceptability using a rating sheet adapted from Chichioco (2023). Effectiveness was determined through a quasi-experimental pretest–posttest control group design with 80 Grade 7 learners from Gerona Junior College (40 per group). Data were analyzed using descriptive statistics, weighted means, paired-samples and independent-samples *t*-tests, and Cohen's *d*; validators' qualitative feedback was analyzed thematically. The modules were rated Very Satisfactory in content, format, presentation, and organization, and were judged accurate, current, and up to date; all four factors met the passing criteria. End users rated the modules Outstanding in acceptability (means = 4.53–4.88). Both groups improved significantly from pretest to posttest, but gains were significantly greater in the experimental group than in the control group in Module 1 (mean gain = 2.33 vs. 0.75; Welch's $t(73.30) = 5.01$, $p < .001$, $d = 1.12$) and in Module 2 (mean gain = 2.92 vs. 0.68; $t(78) = 8.13$, $p < .001$). The comic-based modules were valid, acceptable, and effective as supplementary instructional materials. Their localized contexts, visual storytelling, and learner-centered activities enhanced learners' engagement and academic performance. The modules are recommended for use in Grade 7 chemistry, with further development of comic-based materials for other science disciplines and grade levels.

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INTRODUCTION

Background of the Study

As science education evolves, the focus is shifting toward student-centered approaches that enable learners to construct their own understanding actively. This shift is particularly important in chemistry, a field that relies heavily on symbols, abstract concepts, and specialized terminology. Empirical evidence indicates that learners often struggle to grasp chemistry concepts because classroom instructional materials lack context and fail to connect with students' lived experiences (Romarate et al., 2023). Consequently, instructional resources need to move away from teacher-oriented designs toward designs that are learner-centered, context-driven, and cognitively supportive.

Philippine laws and policies provide a clear basis for producing contextualized and localized learning resources. The Enhanced Basic Education Act of 2013 (Republic Act No. 10533) allows curriculum flexibility through localization and contextualization (Section 5). Under DepEd Order No. 35, s. 2016, the development of learning resources at the local level that are aligned with curriculum competencies is facilitated through the Learning Resources Management and Development System (LRMDS). DepEd Order No. 42, s. 2016 (Policy Guidelines on Daily Lesson Preparation) emphasizes the proper and contextually relevant use of instructional materials, which calls on teachers to develop and modify learning materials so that learning becomes meaningful and relevant to learners. Likewise, DepEd Order No. 21, s. 2019 (Policy Guidelines on the K to 12 Basic Education Program) highlights the need for contextualization to improve teaching and learning, and directs that assessment results be used as the basis for supportive instruction and for context-appropriate learning resources that target the least-mastered competencies. The MATATAG Curriculum also stresses the use of flexible materials that give learners opportunities to master key concepts, particularly in difficult competency areas. Taken together, these policies make the creation of localized, comic-based modules to support Grade 7 learners in chemistry an appropriate intervention.

Instructional materials help all students learn and are particularly effective in science, where abstract concepts pose additional challenges to learners. Locally appropriate materials are especially valuable in science because they are likely to yield positive learning outcomes. Bautista and Ocampo (2019) reported that context-based instructional materials in junior high school science helped students learn more science concepts than textbook materials did and made learning more interesting for them. Localization therefore tends to increase students' understanding of, and interest in, science, and the available evidence supports the use of local instructional materials in the discipline.

Beyond providing context, instructional design also influences how learners process scientific information. Mayer (2020) indicates that learners learn better from materials that integrate text and visuals than from text alone. In chemistry, linking narrative text to pictures and structured activities helps learners form a mental image of chemical processes and phenomena. This principle underlies the use of comics, which combine narrative, images, and scientific explanation. Comics can also support comprehension in science lessons that require literacy integration. Science reading comprehension is closely tied to the complex scientific texts that learners read, and science materials that use narratives and comics reduce learners' extraneous cognitive effort and help them understand more (Mayer, 2020). In science and literacy learning, a narrative-based approach stimulates students to understand, recall, and participate in reading activities and enhances their reading motivation (Arindya, 2024).

Validation, in turn, strengthens confidence in instructional materials. Current design-research practice emphasizes expert validation and user validation to ensure the accuracy of content, ease of use, and learner acceptance (McKenney & Reeves, 2018). Peer experts judge scientific soundness and pedagogical appropriateness, whereas users (learners and teachers) judge clarity, engagement, and practical classroom design. DepEd provides Evaluation Rating Sheets to assess the quality of locally produced instructional materials in terms of content, form, and technical aspects (DepEd, 2021).

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A private school is likely to hold numerous learning resources of varying quality. For such schools, localized and narrative-based teaching is a promising option, because resources that engage students and deepen comprehension are what make science instruction effective, and because such resources allow the scope and sequence of lesson plans to be developed more easily. The distinctive character of comics, which appeal to both the minds and the hearts of readers, makes them well suited to differentiated instruction and to promoting equitable learning among diverse groups of learners.

Classroom assessment data from Gerona Junior College indicate difficulty in the Grade 7 Chemistry competencies of the MATATAG Curriculum, specifically Competency 3 (to explain the difference in particle arrangement and energy changes that account for changes of state) and Competency 5 (to apply the steps of scientific investigation). Item analysis and the Index of Mastery (IM) from the first-quarter examination of School Year 2025–2026 showed that these were the least-learned concepts. These results reveal persistent gaps in beginning chemistry concepts that are prerequisites for advanced science understanding, and they call for innovative, appropriate instructional resources that address the least-learned competencies.

Literature on comic-based learning materials in science and chemistry is growing, but it remains largely limited to senior high school and general chemistry. Most studies do not target the least-learned competencies of the MATATAG Curriculum, and few have examined localized comic-based modules for the low-mastery competencies of Grade 7 learners in Philippine private schools. Validated instructional materials that use comic-based modules to address changes of state and scientific investigation are still lacking. This study aims to fill that gap by developing and testing localized, comic-based modules for the least-learned Grade 7 chemistry competencies in the context of a Philippine private school.

Review of Related Literature

Teacher-Developed Instructional Materials and Their Impact on Learning

Teacher-made materials are useful in science, where concepts become increasingly abstract and difficult for textbooks to explain. According to Camuyong and Sam (2023), such materials are more contextualized because they are created to meet classroom needs and are grounded in learners' experiences. A Philippine development study found that instructor-made course materials were adequate and valid and that students' posttest performance improved significantly after using them, indicating that teacher-developed materials positively affect learning outcomes and support deep learning (Camuyong & Sam, 2023). Kabilito (2024) found that diverse and interesting instructional materials can improve students' learning achievement. Ahmed et al. (2024) likewise reported that teaching–learning materials affected students' academic performance in government primary schools in Pakistan, supporting concept understanding, retention, and examination performance, which is consistent with Umar et al. (2019), who reported better performance among students taught with instructional materials.

Grana (2024) developed contextualized instructional materials for Senior High School Technical-Vocational-Livelihood (TVL) students; the materials facilitated students' understanding of the topic, and students and teachers found them user-friendly, appropriate, meaningful, and target-oriented. The results show that materials relevant to students' context are significant, and that teacher-made materials can be adapted to close curriculum gaps and learner-background gaps. Similarly, Anzures (2022) found that developed and validated learning materials were highly accepted by students and were accompanied by improved student performance. These studies support the use of locally produced, comic-based modules as new instructional materials in chemistry.

Amos et al. (2022) observed that instructional materials improve students' cognitive ability and encourage critical thinking, which in turn stimulates interest in biology lessons, and they noted that the selection and presentation of materials are central to a productive teaching–learning process. Jibililu (2024) highlighted the importance of

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instructional materials in shaping learning outcomes in social studies and argued that traditional and modern materials should both be used. This suggests that helping teachers develop or select materials can reshape learning environments and reduce reliance on lecture-based teaching.

Teacher-made materials can also address learners' motivation and participation. Studies on science teaching materials show that teachers' use of models, displays, and computer-based materials increases students' interest and participation (Ayodele, 2025). Belisario and Paglinawan (2025) found a strong positive correlation between science instructional materials and the engagement of Grade 10 students in a rural area in the Philippines, indicating that good and diverse science teaching materials stimulate interest and involvement in science.

Advantages and Applications of Illustrated Instructional Materials

Learners process information through two channels. Diagrams, infographics, and similar materials help students build their reasoning by pairing visual input with verbal explanation (Mayer, 2020), and this principle has been supported in many contexts, providing a sound reason for using visuals in science education. Pantaleo (2021) investigated how the visual design elements and medium-specific conventions of graphic novels support science reading comprehension among elementary students. Science graphic novels introduce and simplify abstract concepts and help learners construct mental models of ideas that are difficult to convey in plain language. In science classrooms, visuals such as concept maps, models, and sequenced illustrations act as cognitive anchors and can also be used to differentiate instruction for students of varying abilities.

Gurung and Herrboldt (2024) compared how well students recalled instructions presented as text only or as text with supporting illustrations and infographics; illustrated instructions produced higher quiz scores, indicating that illustrations support cognitive processing and understanding. Lule (2022) similarly noted that picture illustrations improve comprehension and recall and can support problem solving, and that diagrams and graphics help learners process a wealth of information concisely; illustrations can also help learners think critically and learn meaningfully. Zsidó et al. (2026) reported that relevant images in a presentation can "elaborate and enhance" the content and help participants understand abstract concepts. Hosler and Boomer (2016) found that college students scored higher than average on a post-comic reading test in biology and expressed significantly more positive science-related attitudes, which reinforces that comics can improve both conceptual understanding and interest in learning.

Research on digital comics further indicates that they can serve as an interest booster and as a tool for enhancing scientific literacy among elementary students. Haris, Akmaluddin, and Putra (2024) developed comic-based integrated science materials for fifth-grade students that experts in materials, language, and media validated with high scores. Higher engagement and posttest scores among students exposed to digital comics, compared with students who were not, show that illustrations and narration can help students achieve cognitive and affective outcomes (Fitria, 2023). Although illustrations matter, simple and clear designs are equally important: Saunders and Wong (2020) emphasize that the simplest, cleanest, and easiest instructional materials are the most effective, and that removing unnecessary words and images helps learners avoid cognitive overload and focus on the main points.

Continued Relevance of Comics and Manga Among Contemporary Learners

Recent studies and readership surveys indicate that comics, manga, and graphic novels remain relevant and appealing reading materials for children and adolescents despite the growing availability of digital entertainment. The National Literacy Trust (2026) reported that 45.7% of children and young people in the United Kingdom read comics or graphic novels in their free time at least once a month, the highest level of engagement recorded since 2017, and that 59.8% of comic readers preferred printed comics. Similarly, the National Literacy Trust (2024) found that approximately two in five children and adolescents aged 8–18 read comics or graphic novels at least monthly, and that comic readers

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showed greater enjoyment of reading, more frequent reading, and more positive perceptions of their reading ability than non-comic readers.

In the Philippine context, the National Book Development Board (2023) reported that comics remain among the preferred reading materials of Filipino children: in its national readership survey, 20% of child readers aged 12–15 identified printed comic books, and 11% identified digital comics, among their preferred reading materials. These findings are particularly relevant to Grade 7 learners, whose ages generally fall within this range. In the United States, the School Library Journal (2023) reported that 61% of surveyed school libraries observed a significant increase in young people's interest in graphic novels and manga, and that manga was identified as the most popular type of graphic novel among teenagers by 51% of responding middle school libraries and 65% of high school libraries. Collectively, the literature establishes that comics and manga remain relevant forms of reading among contemporary learners, supporting their consideration as instructional materials. The continued readership of comics thus provides a rationale for developing localized comic-based modules in Grade 7 chemistry, where illustrations, sequential storytelling, and familiar situations can be integrated to present scientific concepts in an engaging and accessible manner.

Comics in Education: Conceptual Foundations

Illustrated materials are useful in several ways, but comics offer something further: they employ sequential art to tell stories. Akcanca (2020) argues that comics can "concretize abstract concepts," especially in science lessons, through their ability to combine text and images. A meta-analysis of 31 studies of comics-based learning conducted across Europe, Asia (South Korea, Indonesia, Taiwan, and the Philippines), and the United States found that comics-based learning is more effective than text-only learning aids and has a positive impact on both cognitive and affective outcomes (Jungbluth et al., 2024). This aligns with the Cognitive Theory of Multimedia Learning, which holds that narratives paired with text provide pathways that activate learning, so that information is easier to understand and is retained longer (Mayer, 2020). Sequential images can therefore support the learning of abstract concepts and motivate students to learn science.

It is essential that junior high school science students be actively involved in learning. Overly wordy textbooks do not hold students' attention, especially among those born in the digital age (OECD, 2018). Comics present main ideas and information as a series of pictures rather than as lengthy explanations, and science comics encourage students to take part in learning activities and tasks. They can engage students intellectually and emotionally with science, especially when phenomena are abstract and microscopic, as they are in chemistry. Comics can also help novice science students become scientifically literate: Farinella (2018) states that comics are a form of visual storytelling that organizes and simplifies concepts and so helps readers understand information, which can make chemistry accessible to Grade 7 students who are learning it for the first time.

Comics can also elicit positive interest in science. Participants in Tatalovic's (2019) study who encountered science comics reported increased interest and decreased anxiety toward the subject, and interest formed at the start of secondary school encourages students to pursue STEM beyond school. Moreover, knowledge construction through active learning resembles constructivism: a comic story requires prediction, inference, and synthesis of information, so teaching with comics is an effective active-learning model (Matuk et al., 2019).

Comics in Science Education

Comics can enhance engagement, understanding, and literacy across the sciences. A broad review by Nan et al. (2024) of comic-based learning in science reported that comics are interactive and innovative educational tools and that positive changes in motivation, and particularly in cognitive and higher-order thinking skills, were found across all levels and disciplines. A mixed-method study of comic-based materials for integrated science (Haris et al., 2025)

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reported high validation scores for material quality, language, and media design, and found that most students showed high academic performance after implementation. Enteria and Casumpang (2019) found that comic strips presenting a science concept (waste generation and management) improved students' science process skills and posttest scores relative to pretest scores, and students appreciated the material. Sung, Hwang, and Yen (2018) reported that comic-based learning resources improved participation in science classrooms, since interactive and narrative materials motivate students to engage in lessons and to respond and ask questions. Research on the use of science comics in Philippine elementary classrooms likewise showed improved academic achievement; in a study where pupils created and labeled weather images and instruments, performance rose after exposure to comics, and the researchers attributed the improvement to the comics' visual and narrative components (Fabillar et al., 2024). These findings show that comic-based materials can enhance learning and classroom interest and should be used in science.

Hosler and Boomer (2016) found that students using a biology concept comic book performed as well as, or better than, students using a traditional textbook. Sequential art and storytelling help learners comprehend and visualize abstract ideas. Yu and Sumayao (2022) created a localized comic on cell division that was reviewed by biology teachers, was consistent with the biology curriculum, and led to better student comprehension of the concept, along with greater interest and creativity. Naimnule et al. (2024) created digital comic-based e-modules in Canva for senior high school biology; material and media validations found the e-modules feasible, and teacher and learner evaluations indicated that they were effective for teaching and learning.

In physics, Cadorna and Molina (2025) developed a comic-based learning module for Grade 11 Filipino students; teachers observed that the content was accurate and the materials were organized, and achievement and attitude toward physics improved. Badeo and Ong (2025) found that integrating a comic-based learning module into Mechanics positively influenced the conceptual knowledge and each motivational component (intrinsic, self-efficacy, self-determination, and grade motivation) of Grade 8 students. Degorio and Langub (2025) similarly concluded that comics in physics education positively influenced achievement from pretest to posttest and were perceived by students as engaging and effective. In addition, an ADDIE-based design and testing of a comics-based module on vibrations and waves was judged highly successful: students and teachers responded positively to its practicality, and a test of effectiveness showed a medium increase in students' critical thinking skills (Putri, Ain, & Pranata, 2022).

Comics can also support inclusive learning by letting different learners learn through several modalities, including visual representation, which can enhance the reading comprehension of students with different reading abilities (Fisher & Frey, 2019). This is applicable in most private schools, which have mixed-ability classrooms. Students can also learn at their own pace with comics, because the multi-panel structure allows readers to return to and carefully reread each panel and dialogue, which facilitates understanding and reflection. On the basis of these studies, exploring comics as a means of helping students learn chemistry is justified.

Comics in Chemistry Education

Research and development studies in chemistry show that comic-based instructional materials can be developed through systematic instructional models such as ADDIE to achieve validity, usability, and relevance for learners. For example, comic-based electronic modules on the periodic system created with Canva were rated positively by material and media experts, and positive feedback from students and instructors on module-based learning models has shown them to be viable and effective resources for learning difficult chemistry concepts (Riau et al., 2023). Halawa et al. (2022) created acid–base electronic chemistry comic media that field experts, teachers, and students evaluated as viable and suitable for senior high school chemistry. A systematic R&D process can thus be used to assess the relevance and feasibility of comic-based modules for constructing chemistry concepts and instructional materials.

Cha et al. (2021) investigated how teaching socio-scientific issues (SSIs) and education for sustainable development (ESD) through comic drawing affected engagement among first-year undergraduate organic chemistry students. The

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students created comics on organic-chemistry SSIs, linked them to scientific concepts, and placed them in contexts such as environmental pollution and sustainability. Students' involvement made them more aware of SSIs and engaged them with more complex chemistry concepts than traditional lectures did; they were highly satisfied and showed better understanding in their reflective essays. Compared with general textbooks, the informational graphics used in comics and closely related formats have been found in numerous chemistry-teaching studies to be more interesting and effective. Cook and van Hest (2025) studied comic zines in high school chemistry and found that quiz performance and engagement, as shown by student surveys, improved when curriculum content was presented in visually appealing zines. Agussalim et al. (2025) found that the narrative and visual structure of educational comics can support student motivation, initial understanding, and readiness to learn. Gumonan and Bug-os (2021) reported that experts found graphic novel materials on chemical bonding suitable and effective, noting that narratives and comics can convey molecular, structural, and bonding interactions that text alone cannot; this approach is pedagogically sound, especially for students who learn through narratives.

Nisa et al. (2022) developed a comic-based chemistry medium on chemical bonding using a problem-based learning approach and the ADDIE model. Experts scored it favorably on content, presentation, language, and graphic quality, and teacher and student focus groups reported high satisfaction; the comics appealed aesthetically, were simple to understand, and were a good assistive tool for simplifying difficult concepts. Beyond understanding, comics can yield positive affective outcomes such as greater interest, motivation, and engagement. Nabila and Lutfi (2025) found that ADDIE-based comic media on reaction rates increased student interest and improved posttest over pretest performance. Van Dulmen et al. (2023), who explored context-based chemistry learning resources, showed that such materials inspired students, enhanced their knowledge, and encouraged teachers' professional growth; resources based on real-world examples and grounded in research exemplars can increase engagement and understanding in chemistry. A positive effect on motivation and conceptual comprehension has also been found with comic-based instruction in high school chemistry, which the authors explained by the gradual development of the elements of a scientific process in narrative form, helping students move from the abstract to the concrete. Wayne et al. (2024) likewise observed a positive attitude change toward science after high school students read a chemistry comic.

A quasi-experimental study of 11th-grade science students in Indonesia showed that electronic comics used within a discovery-learning approach improved attitudes and academic performance in hydrocarbons; the experimental group scored better on the posttest and showed greater gains in attitude and learning outcomes than the control group, suggesting that comics can ease the mastery of abstract chemical concepts (Rahmawati et al., 2025). Design research on comics for Grade 10 general chemistry found that students and teachers favored the comics for their scientific correctness, attractiveness, interest, and integration into lessons (Thi Thuy et al., 2025). This corroborates research on digital comic media showing that comics can increase conceptual understanding and scientific application, such as for the rate of chemical reactions and the structure of hydrocarbons (Amala & Dwiningsih, 2025). Yunita et al. (2023) used an ADDIE-based R&D process to develop Canva-based comic electronic modules on the periodic system to counter students' loss of motivation in understanding abstract chemistry; validation by two material experts and one media expert found the modules valid, interesting, and sufficient for use as teaching materials.

Cotiangco et al. (2024) tested the teaching of chemical bonding through audio-visual comics on an Android platform with Grade 9 students. In a pretest–posttest design, students using the comic-based application improved significantly more than students taught with conventional PowerPoint-based instruction; the study also drew on learners' intrinsic motivation, self-efficacy, and self-determination, and engagement and motivation were enhanced. Aringer, Wallner, and Berglund (2025) created an evolutionary biology comic for 4th–6th graders and found that students often described the comic's narrative and images when explaining key concepts (variation, selection, heredity), showing that the comic enabled meaningful learning. Asmiarsih and Rusmini (2019) developed high school acid–base comic modules (Chemtoon) with high validity in expert review; in trials, 95.2% of students responded positively to the comics and 80% reached mastery of the topic. Sari (2021) used an ADDIE-based R&D design to create a reaction-

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rate comic that addressed low student interest and poor learning results in chemistry; after analyzing student needs and building plots, characters, and situations specific to the topic, the content was verified by professionals and tested in a senior high school science class, where the comic made learning more interesting and substantially improved learning outcomes.

Although these results are encouraging, literature on localized, curriculum-based, comic-based modules in chemistry remains sparse, particularly in the K–12 context. Numerous studies implement comic modules in senior high school or general science courses without a clear fit to a prescribed curriculum such as the Philippine MATATAG framework, and evidence on their usefulness at the lower secondary level, such as Grade 7, is lacking. Although studies such as those of Riau et al. (2023) and Halawa et al. (2022) demonstrate validity and feasibility at senior levels, few focus on the effects of comic-based modules on learning outcomes, curriculum alignment, and engagement specifically in Grade 7 chemistry. This gap points to the value of developing and testing localized comic-based modules that are instructional and also culturally sensitive, competency-based, and responsive to the pedagogical needs of this age group. Closing it would provide evidence-based support for innovative instructional resources that increase accessibility, understanding, and interest in basic chemistry education.

Localized and Contextualized Instructional Materials

Science education research has consistently emphasized the importance of contextualizing instruction to make learning meaningful. Localized learning materials relate subject matter to the immediate, cultural, and life experiences of learners to improve understanding and relevance. UNESCO (2017) asserts that contextualized learning materials help students link science concepts to their environment, enabling deep learning and long-term retention. Localization is important for conceptual clarity in subjects such as chemistry, which may be perceived as abstract; it is the process of adapting instructional content to learners' cultural context, everyday experiences, and community so that it becomes more relevant and engaging. A Philippine study on contextualization in science instruction showed that students taught with contextualized materials improved significantly more than students taught with traditional instruction, particularly on the topic of gas laws in chemistry (Rivera & Sanchez, 2020).

With contextualization, learners can link abstract ideas to familiar circumstances, making academic concepts more concrete. Dizon and David (2021) likewise found that localized instructional materials contributed to students' achievement and motivation in science. These findings underline the importance of instructional resources that reflect students' experiences and circumstances to keep them engaged and improve academic outcomes, and they are sufficient grounds for producing materials, such as comics, that are interesting and both culturally and contextually relevant.

Modular instructional design has also been linked to advances in instructional practice. Natarajan and Charles (2024) describe an "instructional modular approach" for science teachers that is compatible with teacher competencies, involves hands-on science, and offers a self-paced approach. Modules are carefully written and updated to address learners' needs and may be amended to reflect local examples and language where necessary; the format is flexible and permits culturally relevant content. Each module is scaffolded and integrated with its local context, so teachers can cater to different learning styles and settings.

To address contextual variation among schools, the Department of Education has consistently promoted the creation of locally produced learning resources (Department of Education, 2022). Locally developed materials can meet learners' varied needs while ensuring that national curriculum requirements are met, and this policy direction supports localized comic books relevant to the MATATAG Curriculum. Localized materials also correspond to curriculum changes such as the MATATAG framework, which focuses on context and learner-centered teaching. A comic-based Grade 7 chemistry resource that incorporates local examples, language, and cultural references can therefore be more relatable and effective for learners.

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Development and Validation of Instructional Materials

Steiner (2024) noted that instructional materials are integral to education and that their quality directly affects teaching and learning. This underscores the need for modules that are rigorous and easy for learners to use, which localized comic-based modules aligned with learners' needs and curriculum standards can provide, as in the present study. Designing materials involves converting learning objectives into learning content and forms, and designing them through systematic design models has been shown to yield more coherent and effective materials (Molenda, 2017). Applying the ADDIE model to comic-based modules helps ensure that module content, visuals, and stories complement one another. ADDIE, which comprises Analysis, Design, Development, Implementation, and Evaluation, is a sound, well-known, and effective model for developing theoretically and empirically based instructional materials (Branch, 2016), and its iterative and systematic design is widely used in science instructional design research.

Validation plays a vital role in developing educational resources because it helps ensure the quality, accuracy, and usability of materials. Gall, Gall, and Borg (2020) stated that the purpose of expert validation is to establish the validity of instructional materials in terms of content and educational needs; for science materials, the accuracy and currency of information are critical. As an example of validating instructional comics through expert evaluation of content, Philippine physics comics were found to meet quality criteria for learning materials, including content accuracy, format quality, presentation, and overall organization, which helped increase student understanding of and attitude toward physics (Molina & Cadorna, 2024). Asmiarsih and Rusmini's (2019) chemistry comic was also sent to experts for validation and showed greater than 80% validity in content and presentation. These validation techniques align with national standards such as DepEd's LRMDS evaluation tools, which emphasize accuracy in checking content, format, presentation, and accuracy of information (DepEd, 2022).

Modules used in chemistry settings have also drawn on expert and teacher responses to improve them. Researchers who created a general chemistry module in the Philippines found that experts and teachers considered the modules acceptable in various categories and gave feedback for improvement (Dela Mines, 2024). User evaluation determines the acceptability and practicality of content; when users find material acceptable, research shows that it will be used efficiently in the classroom (Reeves & McKenney, 2018). Acceptability evaluation can establish whether material is clear, attractive, and easy to read, and whether lessons or modules fit curriculum goals and meet pedagogical requirements.

Curriculum Alignment of Instructional Materials

Curriculum alignment is crucial when developing instructional materials. The Philippine MATATAG Curriculum specifically emphasizes foundational competencies, contextualized instruction, and student-centered learning, and lessons with localized comic-based modules aligned with the curriculum ensure that learners receive coherent instruction and assessment. Studies have found improved instruction–assessment coherence when educators used materials aligned with their curriculum (Polikoff et al., 2020). All instructional materials in this study were designed to align with MATATAG Chemistry competencies.

Private schools usually have more room to experiment with learning materials while remaining compliant with curriculum standards, and schools that adopted such an approach produced quality instruction because they could customize materials to their learners and contexts (Bernardo et al., 2018). This flexibility allows private-school chemistry teachers to develop comics that teach MATATAG competencies and also match students' interests, so that learners can dive deeper into science concepts. Comics used in science also help learners relate to learning modules if they are "aligned with curriculum objectives and intentionally designed for learners" (Ismiyanto et al., 2025). Developing comics that tackle Grade 7 chemistry topics while integrating Filipino culture and curricular competencies can therefore help learners relate science to their daily lives. Incorporating the curriculum into comic development

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ensures that comics teach targeted competencies rather than serve only for amusement, and mapping comic lessons to specific competencies, such as concept mastery and scientific reasoning, supports instructional alignment.

Least-Learned Competencies

Mapping changes of state onto ideas about particle arrangement and energy is among the most basic yet difficult ideas to learn in chemistry. Students must relate observable processes such as melting or evaporation to descriptions of particle motion and energy transfer, and multiple studies show that students have difficulty with these representational forms. Students "often do not learn how to construct correct chains of scientific reasoning even after they have been taught because their thought process relies on intuition rather than scientific models" (Gousopoulos, 2023). They continue to make mistakes and give incomplete explanations of phenomena involving processes that cannot be seen, such as particle motion and energy transfer.

Like Tejero (2025), Sutisnawati et al. (2025) found that students learned competencies requiring the explanation of processes poorly, which they attributed to students' lack of opportunity to observe and engage in activities that would let them discover processes. Students excelled in tasks requiring observation but fared poorly when they had to explain processes such as particle-level changes and energy transfer. This agrees with the assertion that competencies requiring explanations of processes, such as changes of state, are among the least learned, since it is hard for learners to explain processes they cannot observe. Pozuelo-Muñoz et al. (2023) further showed that explaining phenomena requires higher-order thinking and conceptual understanding, and concluded that students fail to develop scientific skills when they are not given inquiry-based learning experiences. This supports the proposed solution to the least-learned science competencies: modules with comic strips that allow students to "see" chemical processes. In addition, a meta-analysis by Ahzari et al. (2026) found that modules and structured learning materials significantly helped students develop higher-order thinking skills and understand science concepts, with high effect sizes for both critical thinking and conceptual understanding, implying that learning materials play a large role in helping students master difficult science competencies.

The second least-learned competency requires students to follow the appropriate steps of scientific investigation, such as identifying problems, designing procedures, collecting data, and drawing conclusions. The ability to investigate scientifically is a basic foundation of scientific literacy, yet studies show that students are weak in this area. Tejero (2025) found that students had poor science process skills at the pretest, with data interpretation the lowest, but their skills developed greatly after investigatory-project instruction; students thus appear to have poor investigation skills by default and need guidance or specific instruction to develop them. Sutisnawati et al. (2025) also found that planning and conducting an investigation were the lowest-displayed science process skills and that students were less engaged and performed poorly in investigation-related activities, which ties in with the MATATAG competency on following appropriate steps of scientific investigation. Ignacio and Yabut (2023) found that Filipino students were weak in higher-order integrated science process skills and struggled to interpret results and design experiments, which concurs with the concern raised by local and international science educators about learners' scientific proficiency. Inquiry-based learning studies also report that scientific investigation develops science process skills; Lai et al. (2020) found that students who actively participated in scientific investigations improved their application of science processes. This gives reason to provide students with comic-strip modules that require them to actually investigate.

Synthesis and Research Gap

Research confirms what teachers know about developing their own materials to support learning: educational comics can lower cognitive load, boost engagement, and promote the learning of science concepts, and research across science topics, with early work in chemistry, confirms that visuals tell a story that students remember. Words paired with graphics promote dual processing, limit cognitive load, and are associated with better science understanding and reading comprehension (Mayer, 2020). Resources created by teachers with reference to learners' context also lead to

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better achievement, motivation, and engagement, and several studies report favorable results for locally produced educational materials in Philippine schools (Alvarez et al., 2022; Bautista & Ocampo, 2019; Camuyong & Sam, 2023). Findings on comics as learning media show their usefulness in making difficult chemistry concepts more understandable, and graphic novels and comic-based instruction have been associated with higher quiz scores, better learning attitudes, and good content quality (Gumonan & Bug-os, 2021; Lin et al., 2020; van Dulmen et al., 2023).

Nevertheless, evaluations of contextualized, standards-based comic modules for Grade 7 chemistry are limited, particularly in private-school settings and aligned with the MATATAG Curriculum. Other studies implemented comic-based instruction in general science or in subjects other than chemistry, and only a few focused on competencies required by Philippine chemistry curricula. The literature suggests a demand for MATATAG-appropriate comics that can fill learning gaps in private-school settings (Alvarez et al., 2022; Dizon & David, 2021), and the validation of such modules could support equity-driven science learning. This sheds light on the need for development and validation studies, like the present one, so that comic-based modules can be used as conventional instructional media.

Theoretical Framework

This study is anchored on two learning theories: the Cognitive Theory of Multimedia Learning of Richard E. Mayer and Roxana Moreno, and Situated Learning Theory. According to Mayer (2020), individuals learn better when words and pictures are presented meaningfully together than when presented alone, because this limits cognitive load. Comics integrate words and pictures to present information with a specific organization. The modules developed in this study presented chemistry lessons as comic strips to help students understand abstract concepts and ideas through meaningful information.

The study is also anchored on Situated Learning Theory, which states that learning occurs in real and authentic situations. Learners understand science lessons better when these are situated in their real-life environment (Dizon & David, 2021). The modules helped learners relate chemistry concepts to their community and everyday experiences because the instructional materials were localized, and the contextualization of information gave significance to the lessons delivered to Grade 7 learners.

Together, these theories guided the development, validation, and implementation of the localized comic-based chemistry modules, on the assumption that student learning is enhanced when learning is presented in a situated context, is visually supported, and tells meaningful stories.

Conceptual Framework

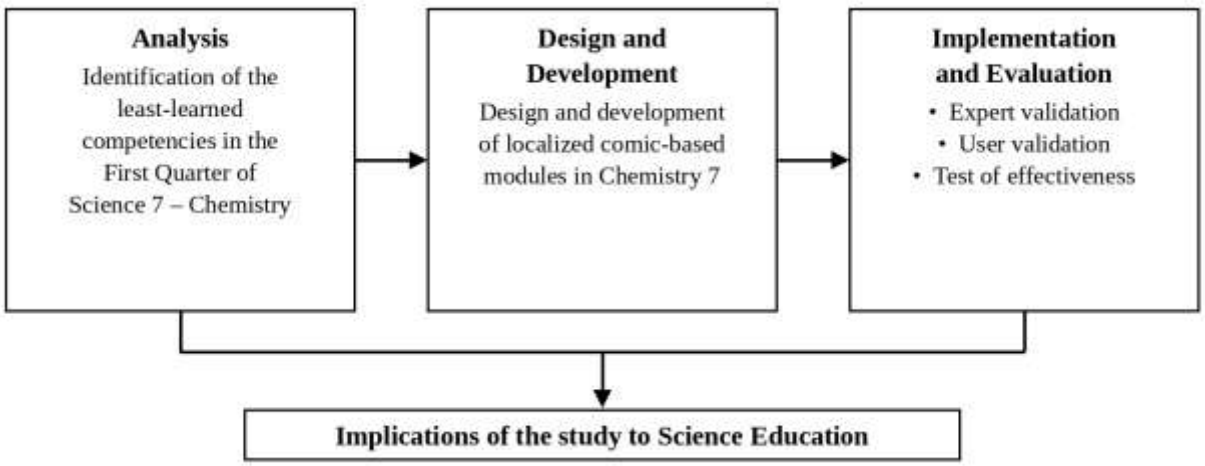
The paradigm of this study is based on a linear sequential model of developmental research (Figure 1) whose steps follow one another over time. The study begins with Analysis, in which the researcher determines the objectives that students learned least in the first quarter of Science 7 Chemistry; this deficiency serves as the basis of the study. Using the data from the analysis stage, the study moves to Design and Development, in which the inadequately mastered competencies become the foundational outline for developing localized comic-based modules for Chemistry 7. This stage converts conceptual scientific ideas into meaningful, illustrated modules suited to seventh graders.

After the materials are developed, they move to Implementation and Evaluation, in which the materials pass through a validation pipeline of three steps: expert review of content and pedagogical accuracy, user review of readability and acceptability, and a test of effectiveness in the classroom in increasing student mastery. The straight-line path leads to an integration block, indicated by the downward arrow, in which all information gathered and results found feed into the implications of the study for science teaching and learning, by providing data-driven suggestions for educational planning, curriculum development, and chemistry teaching.

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Figure 1. **Paradigm of the Study**



Objectives of the Study

This study developed and validated Localized Comic-Based Modules for Grade 7 Chemistry. Specifically, it sought to:

1. develop localized comic-based modules in chemistry following the least-learned competencies of the MATATAG Curriculum;
2. validate the localized comic-based modules in chemistry through evaluation (2.1) by experts in terms of content, format, presentation, and organization, and accuracy and up-to-datedness of information; (2.2) by users in terms of acceptability; and (2.3) of the effectiveness of the modules; and
3. draw implications of the study for science education.

Hypothesis

The study tested the null hypothesis that there is no significant difference between the pretest and posttest scores of the control and experimental groups. This was operationalized as (a) no significant difference between the pretest and posttest scores within each group, and (b) no significant difference between the control and experimental groups in their gain scores (posttest minus pretest). The level of significance was set at $\alpha = .05$.

Significance of the Study

The results of this research are useful to the following groups.

- **Curriculum developers and writers of instructional materials.** The study provides empirical evidence on incorporating storytelling and localization in science instructional materials. The authenticated modules can guide the creation of effective, curriculum-based resources and innovative teaching materials in privately owned educational institutions.
- **School administrators and school heads.** The study offers useful information on the effectiveness of localized, comic-based modules for teaching Grade 7 chemistry. The validated teaching and learning materials are a basis for informed decisions on adopting innovative, learner-centered materials aligned with

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the MATATAG Curriculum, which can improve the quality of curriculum delivery and the performance of private schools.

- **Science teachers.** Teachers gain a better understanding of how to design and implement localized comic-based modules to deliver abstract chemistry concepts and enhance student engagement. The modules can be instructive to other science teachers, who can adapt their lesson strategies to diverse students in private schools and use the modules as a flexible resource for other fields of science.
- **Students.** Students are provided with lesson materials that are interesting, age-relevant, and grounded in local situations and in concepts related to changes of state and scientific inquiry. Comic-based modules are likely to enhance learners' understanding and retention of chemistry topics, improve academic performance, and improve attitudes toward learning science.
- **Parents.** Parents can see how effective and engaging chemistry teaching can influence their children's learning through greater interest in and understanding of chemistry, which can lead to better performance and attitudes, evident in children's classroom behavior and school progress reports.
- **The community.** Because the modules are localized, the community may benefit from possible partnerships between schools and other establishments or organizations that stimulate community investment.
- **Future researchers.** The study provides a reference base for developing and validating narrative-based, localized instructional materials, and a foundation for a framework that enables similar research at other levels, in other subjects, and in other schools.

Scope and Delimitations

This research designed and tested localized comic-based modules in Grade 7 chemistry under the MATATAG Curriculum. The materials were implemented and used only during the first term of School Year 2026–2027, the term in which chemistry is introduced at this grade level. The instructional resources were built on topics under the least-learned competencies of the MATATAG Curriculum: "Follow appropriate steps of a scientific investigation which includes: (a) Aim or problem, (b) Materials and equipment, (c) Method or procedures, (d) Results including data, and (e) Conclusion," and "Explain the changes of state in terms of particle arrangement and energy changes: a. solid → liquid → vapor, and b. vapor → liquid → solid." The Index of Mastery and Item Analysis of Grade 7 written outputs and examination papers from the first quarter of School Year 2025–2026 were used to identify these competencies. The content, activities, and illustrations of the modules were localized to include familiar contexts and experiences of Grade 7 learners.

Only two of the seven Grade 7 sections of Gerona Junior College were used. The control group comprised 40 students, and the experimental section had 42 students, of whom 40 had parental consent; the print modules were therefore provided only to those 40 students. The 80 students (40 per group) took the pretest and posttest used to determine the effects of the instructional materials on their comprehension of the selected chemistry concepts. Only one private school in Gerona, Tarlac, was involved, and no other schools or grade levels were included.

Three science experts evaluated the modules in terms of content, format, presentation and organization, and accuracy and up-to-datedness, and two professional illustrators reviewed the format, specifically the illustrations. Both groups of validators used the Department of Education's Evaluation Rating Sheet for New Print Resources. The acceptability rating sheet given to the experimental group was adapted from Chichioco (2023). The modules were developed and validated only as printed versions; no digital versions or other instructional formats were produced. The research was limited to the process of development, validation, and short-term effectiveness of the modules, and did not examine

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long-term retention, long-term attitudes toward or interest in science, or any outcomes other than those of the designed instructional materials.

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METHODS

Research Design

The study used a Research and Development (R&D) design to develop and test localized comic-based modules as supplemental learning materials for Grade 7 chemistry lessons under the MATATAG Curriculum. R&D designs are used in educational research whenever the emphasis is on creating, developing, and validating learning products for educational settings (Branch, 2016). The design allowed the researcher to bring together curriculum standards, instructional theory, and classroom application in a tool that also generates scientific evidence about the resource's quality, and it is particularly suited to instructional materials because it focuses on what students learn (Akker et al., 2016). Development followed the ADDIE instructional design model (Analysis, Design, Development, Implementation, and Evaluation; Branch, 2016).

The final stage of the R&D process was validation of the product by experts and by students as user validators. The student validators were Grade 7 learners who were involved in testing the modules, and their input helped ensure that the modules were pedagogically relevant, contextual, informed by national curriculum expectations, and sensitive to the classroom users' point of view. The effectiveness of the modules was determined through a quasi-experimental pretest–posttest control group design in which one Grade 7 section used the modules (experimental group) and another received conventional instruction (control group). The R&D approach establishes procedures for systematically developing, testing, analyzing, and evaluating instructional materials, and it allows future researchers to replicate how needs were analyzed, materials designed and developed, and implementation and evaluation carried out. It can thus serve as a guide for those who wish to create, test, and revise their own instructional materials according to learners' needs and curriculum requirements.

Locale of the Study

The study was conducted at Gerona Junior College, a private school located in Poblacion 3, Gerona, Tarlac (Figure 2). Formerly known as Gerona Vocational School (GVS), it was founded in 1946 by Mr. Bernabe T. Cardona and has served the community for eighty years. The school currently offers Junior High School and Senior High School programs, namely Science, Technology, Engineering, and Mathematics (STEM); Accountancy and Business Management (ABM); and Humanities and Social Sciences (HUMSS). It is the first high school in Gerona, Tarlac, to offer Teacher Education courses and, this year, became the first private school in the Schools Division Office (SDO) of Tarlac to offer the Science, Technology, and Engineering (STE) Program. The school's background and curricular offerings make it an appropriate site for validating localized comic-based chemistry modules.

Figure 2. **Map of the Study Location**



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Participants and Sampling

The study had two categories of participants: expert validators and Grade 7 student participants. They were selected through purposive and random sampling, depending on their roles, consistent with R&D studies in which instructional materials are validated by integrating expert or teacher judgment with users' feedback (Akker et al., 2016; Branch, 2016).

Expert validators

Five expert validators were selected through purposive sampling on the basis of their educational background and professional experience in instructional material development (Table 1). Three were science experts (a College Research Department Head; a Science and Mathematics Coordinator who is also the STE Coordinator; and a science teacher, formerly an Academic Coordinator), and two were expert illustrators (a College Student Council Adviser of the College of Architecture and Fine Arts and a Fine Arts faculty member).

Table 1. **Expert-Validators' Profile**

Expert	School/Office	Department	Designation	Education	Years in Service
E1	Tarlac State University	College of Education – BSEd Sciences Department	College Research Department Head	Doctor of Education major in Educational Management (Dissertation Writing)	16
E2	Gerona Junior College	Science and Mathematics Department	Science and Mathematics Coordinator; Science, Technology, and Engineering (STE) Coordinator	Doctor of Education major in Educational Management (Dissertation Writing)	14
E3	Aldersgate Institute, Inc.	Senior High School	Science Teacher	Master of Arts in Education major in Science Education	6
E4	Tarlac State University	College of Architecture and Fine Arts – Fine Arts Department	College Student Council Adviser	Doctor of Philosophy in Multimedia Arts (12 units)	5
E5	Tarlac State University	College of Architecture and Fine Arts – Fine Arts Department	Faculty	Master of Fine Arts (27 units)	3

Note. E1–E3 = science experts; E4–E5 = professional illustrators.

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Student participants

The student participants came from two Grade 7 sections enrolled at Gerona Junior College (GJC) in School Year 2026–2027. The sections were chosen through the fishbowl technique (simple random sampling), so that every Grade 7 section had a fair chance of being selected. One section served as the control group (40 students) and the other as the experimental group. The experimental section had 42 students, but only 40 had parental permission to participate, so each group had 40 participants (N = 80). The 40 experimental-group learners also served as the end-user validators who rated the acceptability of the modules.

Development of the Localized Comic-Based Modules

Analysis. The Grade 7 Chemistry competencies of the MATATAG Curriculum were examined to identify the least-learned competencies. The competencies were selected on the basis of the Index of Mastery (IM) computed from learners' written outputs and the item analysis of the Grade 7 first-quarter examination of School Year 2025–2026. This ensured that the materials addressed topics on which students scored lowest (Bautista & Ocampo, 2019; Dizon & David, 2021). Branch (2016) notes that analysis identifies the specific gaps in students' learning and the extent and focus that learning materials need, which provides a foundation for the later stages.

Design. The layout, structure, format, and instructional strategies of the modules were conceptualized following the Elements and Technical Specifications of a Learning Resource (LR) Module in Regional Memorandum No. 91, s. 2020: front outside cover page; preliminary pages (copyright page, preface, acknowledgment, table of contents); introduction; pre-assessment; lesson proper; generalization/summary of learning; application; post-assessment; additional activity; answer key; references; and back outside cover. Following Mayer's Cognitive Theory of Multimedia Learning, in which learners construct knowledge effectively when words and visuals complement or integrate with each other, the comic modules were arranged so as not to overload the learner while sustaining interest.

Development. The modules were created through a comics approach that included writing stories, making illustrations, and assembling the required content using Microsoft Word and Canva, following the LR module specifications for the least-learned competencies under the lead researcher's guidance. The development process incorporated curriculum-related content, localization, comic storylines, illustrations, learning activities, assessments, digital tools (QR codes), and learner support. Illustrations were created for the modules by a professional illustrator.

Implementation. The validated modules were used by the student participants during the first month of the first term of School Year 2026–2027. Pretest scores were obtained before exposure to the modules and posttest scores after their use, a standard practice when localized instructional materials are tested (Dizon & David, 2021). This stage tested whether the materials work in the actual setting in which they will be used.

Evaluation. Evaluation determined the quality of the modules and their effect on students' learning outcomes. Results of expert validation, user acceptability ratings, and students' pretest–posttest scores were analyzed. In the ADDIE model, evaluation serves both formative and summative purposes: formative evaluation allows improvement of the instructional material, and summative evaluation permits evidence-based conclusions about the material as instruction (Branch, 2016).

Research Instruments

Three kinds of instruments were used: an expert validation rating sheet, a user acceptability rating sheet, and researcher-made pretests and posttests. Development studies that produce classroom learning resources typically use expert-based and user-based evaluation instruments to test instructional soundness and classroom suitability (Akker et al., 2016; Branch, 2016).

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Expert validation rating sheet

The expert validation instrument was the Evaluation Rating Sheet for New Print Resources from the Department of Education's Evaluation Rating Sheets for Locally Developed Learning Resources (Division Memorandum No. 441, s. 2019; see Appendix B). The researcher used this validated national instrument as the basis for expert evaluation of the modules. It rates the material on four factors: (1) content (7 indicators; maximum 28 points; passing score ≥ 21), (2) format (18 indicators covering prints, illustrations, design and layout, paper and binding, and size and weight; maximum 72 points; passing score ≥ 54), (3) presentation and organization (5 indicators; maximum 20 points; passing score ≥ 15), and (4) accuracy and up-to-datedness of information (6 error indicators; maximum 24 points; passing score 24). Each indicator is rated on a four-point scale (4 = Very Satisfactory, 3 = Satisfactory, 2 = Poor, 1 = Not Satisfactory; for Factor 4, 4 = error not present, 3 = present but very minor and must be fixed, 2 = present and requires major redevelopment, 1 = poor, do not evaluate further). Mean ratings were interpreted as 3.25–4.00 = Very Satisfactory, 2.50–3.24 = Satisfactory, 1.75–2.49 = Poor, and 1.00–1.74 = Not Satisfactory. The tool allowed validators to judge whether the modules were scientifically and technically accurate, instructionally correct, culturally appropriate, age-appropriate in their visuals, and aligned with the Grade 7 chemistry competencies of the MATATAG Curriculum. Qualitative comments and recommendations were also collected through the instrument and used to guide revisions. Expert validation is critical to ensuring alignment among learning objectives, content accuracy, and instructional strategies (Branch, 2016).

User acceptability rating sheet

The acceptability rating sheet was adapted from Chichioco (2023) and answered by the Grade 7 student participants. Its Likert-type items were grounded in instructional design and multimedia learning principles (Mayer, 2020). Responses were rated on a five-point scale (5 = Outstanding, 4 = Very Satisfactory, 3 = Satisfactory, 2 = Fair, 1 = Poor), with mean ratings interpreted as 4.21–5.00 = Outstanding, 3.41–4.20 = Very Satisfactory, 2.61–3.40 = Satisfactory, 1.81–2.60 = Fair, and 1.00–1.80 = Poor. Acceptability data are important in instructional development studies because they show how the instruction works from the learner's perspective (Molenda, 2017). The rating sheet also invited comments and suggestions.

Pretests and posttests

Student learning was measured with researcher-made pretests and posttests for each module: Module 1 (Scientific Investigation) and Module 2 (Phase Changes). Each test consisted of 15 four-option multiple-choice items (maximum score = 15), in line with the 15-item pre- and post-assessment range prescribed for Key Stage 3 learning modules in the LR module specifications. The pretest and posttest for each module were alternate forms with different items covering the same competency. The Module 1 tests assessed the identification of the aim or problem, materials and equipment, procedure, results or data, and conclusion of a scientific investigation. The Module 2 tests assessed particle arrangement and motion in solids, liquids, and gases; the terminology of the changes of state (melting, freezing, evaporation, condensation); and the energy changes involved. The researcher ensured that the items were age-appropriate, reflected the MATATAG competencies, and did not unfairly disadvantage students.

Data Gathering Procedure

Data were gathered after the localized comic-based modules were developed for Grade 7 chemistry, on the basis of the least-learned MATATAG competencies identified through the Index of Mastery and item analysis. Before data gathering, the researcher secured approval from the principal of Gerona Junior College and obtained all necessary permissions to ensure that ethical considerations in educational research were upheld. Participants and their parents were asked for consent before the study began, and their responses were kept confidential.

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Data were collected through three processes. First, the modules were evaluated by experts. Copies of the instructional materials and the Expert Validation Rating Sheet were made available to the selected experts, who rated the modules in terms of content, format, presentation and organization, and accuracy and up-to-datedness of information; the completed forms were returned to the researcher.

Second, after the two Grade 7 sections had been identified by the fishbowl technique, the researcher implemented the modules during the first term of the school year, when chemistry is taught in Grade 7. The modules covered the least-learned competencies finalized before implementation and were used in regular classes to maintain the authenticity of lessons. The control group was taught the same chemistry topics through conventional lecture-based instruction without the comic-based modules. Both groups took the pretest before and the posttest after instruction in each module.

Third, after exposure to the modules, the student participants answered the Student Acceptability Rating Sheet within the classroom. The researcher explained clearly how to answer the instrument so that students understood the items, asked them to answer on the basis of their own experience with the modules, and gave them ample time to avoid hasty responses. All completed instruments were retrieved immediately after implementation to prevent loss of data and to confirm that they were complete. The data were then organized and tabulated for analysis, and the results served as the basis for judging the validity, acceptability, and effectiveness of the modules and for drawing implications for science education.

Data Analysis

Responses from the students and the expert validators were arranged, tabulated, and coded for analysis. Descriptive statistics were used to present and describe the numerical data, as is common in studies on instructional material validation and educational development (Creswell & Creswell, 2018; Fraenkel et al., 2019). Mean ratings were computed for each indicator and, for expert ratings, summed into total scores that were compared with the passing criteria of the rating sheet; weighted means were used to interpret the users' acceptability ratings. Likert-scale analysis and weighted means are frequently used and recommended for assessing the acceptability and quality of instruction from users' perspectives (Branch & Kopcha, 2019; Mertler, 2020).

Learning outcomes were measured through the researcher-made pretests and posttests. Frequency distributions of scores, means, and standard deviations were computed, and gain scores (posttest minus pretest) were obtained for each student. Pretest–posttest analysis with a control group is sufficient for determining learning effects in classroom instructional development research (Fraenkel et al., 2019; Johnson & Christensen, 2020). An independent-samples *t*-test on pretest scores tested baseline equivalence of the groups; paired-samples *t*-tests tested pretest–posttest differences within each group; and independent-samples *t*-tests on gain scores tested differences between the groups. Where Levene's test showed unequal variances, Welch's *t*-test was used instead of Student's *t*-test. All tests were two-tailed at $\alpha = .05$. In addition, Cohen's *d* was computed and interpreted using Cohen's (1988) criteria (Table 2) to establish the practical significance and magnitude of the intervention's effect beyond statistical significance.

Table 2. Interpretation Matrix for Cohen's d Effect Size Thresholds

Effect Size Value (d)	Descriptor	Practical Meaning in Education
0.00 to < 0.20	Negligible / Less than small	There is no discernible effect on student performance.
0.20 to < 0.50	Small	The intervention leads to a minor, yet noticeable, alteration in student scores.

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0.50 to < 0.80	Medium	The intervention results in a clear, moderate educational improvement.
0.80 or greater	Large	The intervention exerts a powerful, highly meaningful impact on learning.

Note. Adapted from *Statistical Power Analysis for the Behavioral Sciences* (2nd ed.), by J. Cohen, 1988, Lawrence Erlbaum Associates.

Qualitative data from the comments and suggestions of validators and student users were coded using thematic analysis. Responses were read, coded, and sorted into themes illustrating how participants perceived the strengths and weaknesses of the modules and what they recommended for improvement. Thematic analysis helps researchers discover patterns in qualitative data and is often used to supplement and explain quantitative findings in educational research (Braun & Clarke, 2021; Miles et al., 2020). The qualitative data guided decisions to edit and improve the material during the evaluation phase of the ADDIE model, as recommended by Branch and Kopcha (2019). In sum, quantitative methods (descriptive statistics, *t*-tests, and Cohen's *d*) and qualitative coding procedures were used together to draw conclusions about the quality and efficacy of the developed modules.

Ethical Considerations

The study adhered to ethical principles throughout the research and development process so that participants' rights, welfare, and dignity were safeguarded. Because the participants included Grade 7 students and expert raters, informed consent, voluntariness, confidentiality, and data storage were addressed following ethical procedures in educational research (Fraenkel et al., 2019; Johnson & Christensen, 2020).

- **Informed consent.** Permission was requested from Gerona Junior College officials, the Grade 7 science teacher, and the principal before data were gathered from students. Written informed consent was obtained from parents or guardians, and assent from the student participants themselves. Expert validators were informed of the details of their involvement and gave consent before appraising the modules. Sample letters and consent forms were prepared for the principal, science experts, expert illustrators, parents or guardians, student participants, the Grade 7 science teacher, and the comic illustrator.
- **Voluntary participation.** Students were neither forced nor pressured by superiors to take part. Expert validators participated of their own will. Refusal carried no penalty, and no student was dropped from class for not participating.
- **Confidentiality.** The privacy of student participants and expert validators was not revealed in any process of the study. No names were used in documenting data, and students were assigned codes or pseudonyms in data processing. All data are kept in a safe place by the researcher alone.
- **Assessment instruments.** The researcher ensured that the pretests and posttests were age-appropriate, reflected the competencies needed in the MATATAG Curriculum, and did not contain items that might disadvantage or unfairly test students.
- **Expert validation.** The professional opinions of the experts were respected and used only to improve and validate the modules. The researcher did not falsify or selectively report the experts' evaluations.
- **Academic integrity.** Sources used in creating the modules, the research instruments, and the written report are acknowledged in the references. Images in the modules were either created by the researcher or used with permission, to prevent plagiarism and copyright infringement (American Educational Research Association

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[AERA], 2016). Images in one module activity that were generated with Canva AI are labeled with a disclaimer in the module.

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RESULTS

The findings are presented in line with the objectives of the study: (1) the development of the localized comic-based modules, (2) their validation by experts and users, including their effectiveness, and (3) the implications for science education, which are taken up in the Discussion.

Development of the Localized Comic-Based Modules

Analysis of the learning gaps

The modules were created to address the lowest-learned concepts in the first quarter of School Year 2025–2026. The Grade 7 Chemistry competencies of the MATATAG Curriculum were reviewed during the analysis phase, and the Index of Mastery from learners' written outputs and the item analysis of the Grade 7 tests administered in the first quarter of School Year 2025–2026 identified two least-learned competencies: (1) "Explain the changes of state in terms of particle arrangement and energy changes: a. solid → liquid → vapor, and b. vapor → liquid → solid," and (2) "Follow appropriate steps of a scientific investigation which includes: (a) Aim or problem, (b) Materials and equipment, (c) Method or procedures, (d) Results including data, and (e) Conclusion." Two modules were developed accordingly: Module 1 (Scientific Investigation) and Module 2 (Phase Changes).

Features of the developed modules

The two modules follow the structure prescribed by the Elements and Technical Specifications of an LR Module (Regional Memorandum No. 91, s. 2020). Their covers are shown in Figure 3. The modules are titled "The Sukang Tubo Secret: The Fermentation Challenge" (Module 1) and "Youth in Action: Super Typhoon Uwan Relief Program" (Module 2) in the user rating sheet.

Figure 3. **Cover Pages of Modules 1 and 2**



(A) **(B)**

Localization was one of the important features of the modules, as shown in Figure 4: scientific concepts are linked to local situations, experiences, and contexts, for example, the Science Detective's Guide to Investigations, the Cellphone

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Battery Mystery, the Viral Challenge Disaster, the puto (rice cake) baking activity, and, in Module 2, evaporation of water in containers left in the sun and wet clothes drying in a Tarlac barangay setting. Each module uses its comic as an instructional tool rather than as decoration: the comic strips (Figure 5) set out the storylines of the modules, including a sugarcane and vinegar-making contest set in Gerona (Module 1) and a typhoon relief program (Module 2). Instructional design for the modules also considered typography and color. Both modules use Times New Roman for body text and Franklin Gothic Demi Cond for headings and certain display elements, and color is used to distinguish sections, emphasize elements, and keep the modules visually consistent.

Figure 4. **Samples of Localization and Contextualization in the Learning Modules**



Mini Lesson

The Science Detective's Guide to Investigations

Have you ever wondered why wet clothes dry faster on a sunny day? Or why some plants grow better than others? Scientists ask questions like these all the time! To find answers, they follow a process called a **scientific investigation**.

Think of yourself as a **Science Detective**. Every investigation follows five important steps to solve a mystery!

The Cellphone Battery Mystery: A Scientific Investigation

Have you ever noticed that your cellphone battery drains faster at certain times? Maybe when you're watching videos or playing games? Let's investigate this like real scientists!

(A)



Independent Assessment

Activity Title: The Viral Challenge Disaster

Type: Individual Written Activity

Objective: By the end of this activity, you will be able to identify the steps of a scientific investigation such as a.) aim/problem; b.) materials and equipment; c.) method/procedure; d.) results/data; and e.) conclusion based on a given scenario.

Directions: Read the story carefully then read each question carefully. Identify the correct part of the scientific investigation described in the story.

One weekend, a new online challenge became very popular among Grade 7 students. The challenge involved making colorful "super slime" using different household ingredients and posting the results online.

Excited to join the trend, best friends Nico, Bea, and Jam made slime after watching several videos online. They mixed glue, detergent, glitter, food coloring, and a large amount of

(B)

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ADDITIONAL ACTIVITY



Activity Title: The Puto Fluff Experiment

Directions: Follow the given procedures carefully in preparing and steaming the two batches of puto, ensuring that only the amount of baking powder is changed, and then record your observations and answer the guide questions based on the results of your investigation.

Aim or Problem: To determine the effect of different amounts of baking powder on the texture, height, and fluffiness of puto.

Materials and Ingredients (for BOTH batches)

Ingredients (same for both batches)

- 1 cup rice flour
- ½ cup granulated white sugar
- 1 cup water
- ¼ cup evaporated milk

(C)



Guided/ Controlled Assessment

Activity Title: Everyday Phase Change Analyzer

Type: Pair Activity

Objective: Students will work by pair to match the pictures to the situations and identify and explain phase changes in everyday situations using particle arrangement and energy changes.
Disclaimer: The images in this activity were generated by Canva AI.



A



B

(D)

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APPLICATION CHALLENGE

Activity Title: Evaporation Investigation: Where Does the Water Go?

Objective: Apply knowledge of phase changes and energy transfer by measuring how heat from the environment affects evaporation.

Type: Individual, Pair or Small Group Activity

Context: In many communities in Tarlac, people store water in containers for washing plants, cleaning, or during water interruptions. However, when containers are left open under the sun, the water level slowly decreases even when no one uses it.

Materials:

- 2 small containers or cups
- Water
- Permanent marker or tape
- Ruler
- Notebook

(E)

Figure 5. Samples of Comic Strips



(A)



(B)

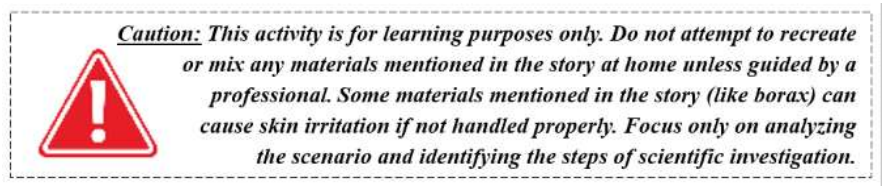
Safety was built into the instructional design for every activity involving hazardous materials, heat, sharp tools, or dry ice, so that the design considered not only the cognitive aspect of an activity but also the environment in which learners

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would carry it out (Figure 6). In addition, response spaces, tables, and QR codes were included to help learners organize information; the QR codes in the printed modules link the physical modules to digital media, such as an online simulation, for additional practice (Figure 7).

Figure 6. **Safety Precautions in the Modules**



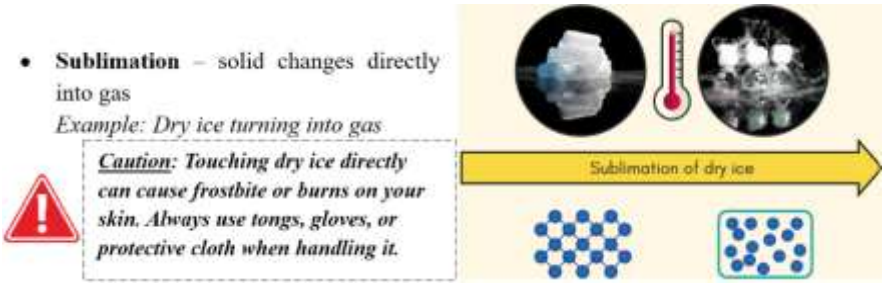
(A)



(B)



(C)



(D)

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Figure 7. Response Spaces, Tables, and QR Codes in the Modules

Station 4

Task: Answering the following questions by analyzing the results/ data

Plant	Water given	Growth
A	Regular	5 cm
B	Irregular	1 cm
C	No water	0 cm

Guide Questions:

1. Which plant grew the most? _____
2. What factors affected growth? _____
3. What does the data show? _____

Station 5

Task: Complete the conclusion:

Based on the investigation, we conclude that _____ affects plant growth because _____.

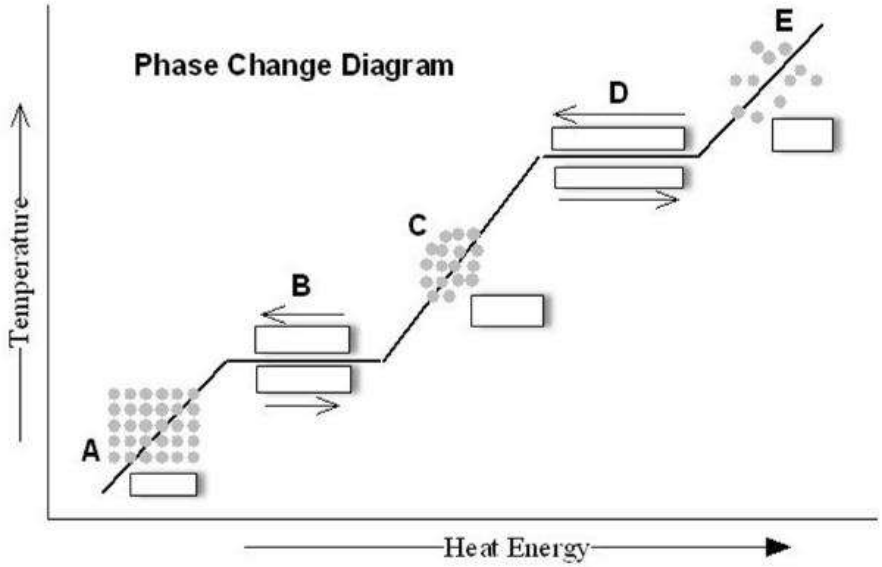
(A)

Situation	Phase Change	Particle Arrangement	Energy Change
Example: *__A__Steam from freshly cooked rice forms droplets on the pot lid*	*Condensation*	*Far apart to closer together*	*Energy decreases*
_____ 1. Ice placed in a cooler during a barangay basketball game slowly melts under the afternoon heat.			
_____ 2. After washing clothes in the morning, the wet school uniforms dry under the hot sun.			
_____ 3. While cooking pancit at home with the help of his mom, Ernesto notice steam rising from the boiling water in the pot.			

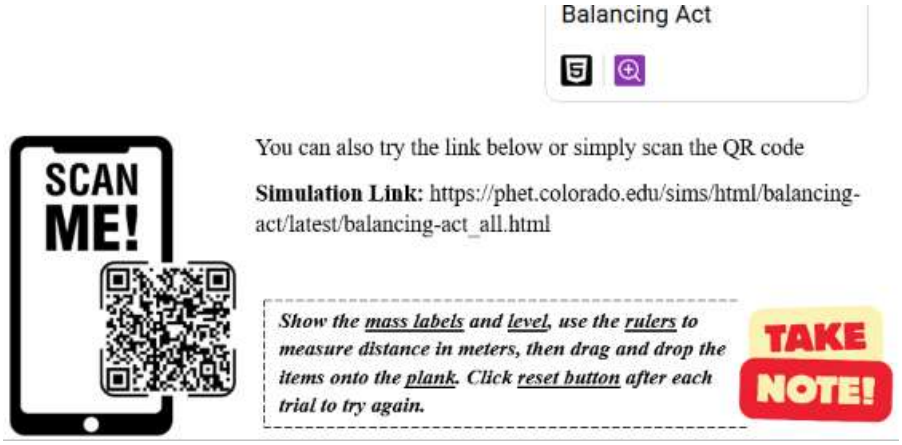
(B)

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(C)



(D)

Validation of the Modules by Experts

The modules were validated by five experts (Table 1) using the Department of Education Evaluation Rating Sheet for New Print Resources.

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Content

Table 3. Experts' Validation on the Modules' Content

Parameter	Mean	Description
1. Content is suitable to the student's level of development.	4.00	Very Satisfactory
2. Material contributes to the achievement of specific objectives of the subject area and grade/year level for which it is intended.	4.00	Very Satisfactory
3. Material provides for the development of higher cognitive skills such as critical thinking, creativity, learning by doing, inquiry, problem solving, etc.	3.67	Very Satisfactory
4. Material is free of ideological, cultural, religious, racial, and gender biases and prejudices.	3.67	Very Satisfactory
5. Material enhances the development of desirable values and traits.	4.00	Very Satisfactory
6. Material has the potential to arouse the interest of the target reader.	4.00	Very Satisfactory
7. Adequate warning/cautionary notes are provided in topics and activities where safety and health are of concern.	4.00	Very Satisfactory
Total points	**27.34**	**Passed**

Note. Rating scale: 3.25–4.00 = Very Satisfactory; 2.50–3.24 = Satisfactory; 1.75–2.49 = Poor; 1.00–1.74 = Not Satisfactory. Passing criterion: ≥ 21 of 28 points = Passed; 0–20 = Failed.

All seven content indicators received mean ratings between 3.67 and 4.00 (Very Satisfactory), and the total score of 27.34 points falls within the Passed range (21–28 points). Content suited to learners' level of development, alignment with the learning objectives, promotion of desirable values and traits, potential to arouse interest, and adequate safety and cautionary notes each received the highest possible mean of 4.00. The experts thus agreed that the modules provide age-appropriate, curriculum-aligned, engaging, and safe content for learning Grade 7 chemistry. The indicators on developing higher-order thinking skills and on freedom from ideological, cultural, religious, racial, and gender bias received means of 3.67, still Very Satisfactory.

The validators also made recommendations. Although the modules include the concepts stated in the learning objectives, they could include more concepts, such as particle arrangement, in the comic dialogue; assessment questions should be answerable directly from the comic presentation; an introduction should precede the comic; the characters, settings, and themes of the comic should be integrated into the rest of the module; and images should be culturally relevant and appropriate to learners. These recommendations point to opportunities for a better flow of instruction, contextualization, and alignment of objectives with activities, materials, and assessment.

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Format

Table 4. Experts' Validation on the Modules' Format

Parameter	Mean	Description
1. Prints		
1.1 Size of letters is appropriate to the intended user.	4.00	Very Satisfactory
1.2 Spaces between letters and words facilitate reading.	4.00	Very Satisfactory
1.3 Font is easy to read.	4.00	Very Satisfactory
1.4 Printing is of good quality (i.e., no broken letters, even density, correct alignment, properly placed screen registration).	4.00	Very Satisfactory
2. Illustrations		
2.1 Simple and easily recognizable.	4.00	Very Satisfactory
2.2 Clarify and supplement the text.	3.80	Very Satisfactory
2.3 Properly labeled or captioned (if applicable).	3.60	Very Satisfactory
2.4 Realistic/appropriate colors.	3.80	Very Satisfactory
2.5 Attractive and appealing.	3.80	Very Satisfactory
2.6 Culturally relevant.	3.80	Very Satisfactory
3. Design and Layout		
3.1 Attractive and pleasing to look at.	4.00	Very Satisfactory
3.2 Simple (i.e., does not distract the attention of the reader).	3.67	Very Satisfactory
3.3 Adequate illustration in relation to text.	3.67	Very Satisfactory
3.4 Harmonious blending of elements (e.g., illustrations and text).	4.00	Very Satisfactory
4. Paper and Binding		
4.1 Paper used contributes to easy reading.	4.00	Very Satisfactory
4.2 Durable binding to withstand frequent use.	4.00	Very Satisfactory
5. Size and Weight of Resource		
5.1 Easy to handle.	4.00	Very Satisfactory
5.2 Relatively light.	4.00	Very Satisfactory
Total points	**70.13**	**Passed**

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Note. Rating scale as in Table 3. Passing criterion: ≥ 54 of 72 points = Passed; 0–53 = Failed. The total is the sum of the 18 indicator means (unrounded).

The modules passed the format criterion; all 18 indicators obtained mean ratings between 3.60 and 4.00 (Very Satisfactory), which indicates that the physical appearance and visual design of the modules are suitable for quality learning resources and classroom use. Under Prints, all indicators (letter size, spacing between letters and words, font readability, and print quality) received the highest mean rating of 4.00, as did all indicators for Paper and Binding and for Size and Weight, suggesting that the modules are readable, durable, easy to handle, and not bulky.

Under Illustrations, "simple and easily recognizable" received 4.00; "clarify and supplement the text," "realistic/appropriate colors," "attractive and appealing," and "culturally relevant" received 3.80; and "properly labeled or captioned" received 3.60. Under Design and Layout, "attractive and pleasing to look at" and "harmonious blending of elements" each received 4.00, while "simple (does not distract the reader)" and "adequate illustration in relation to text" each received 3.67. Although all indicators were Very Satisfactory, the lower ratings identify areas where the visual and layout quality could be improved further.

Qualitative comments from the illustrators supported these results. They remarked that both comic strips were aesthetically pleasing and complemented the colors and character designs, which reinforced the message. They suggested greater consistency in text layout and font size, which relates to the quantitative findings on text–illustration integration and print quality. The validators also recommended carrying the characters, setting, and color scheme of the comic into other parts of the module to ensure consistency and continuity across sections, adding culturally relevant and familiar images, and ensuring consistency in labeling and text presentation (font and arrangement).

Presentation and organization

Table 5. Experts' Validation on the Modules' Presentation and Organization

Parameter	Mean	Description
1. Presentation is engaging, interesting, and understandable.	4.00	Very Satisfactory
2. There is a logical and smooth flow of ideas.	4.00	Very Satisfactory
3. Vocabulary level is adapted to the target reader's likely experience and level of understanding.	4.00	Very Satisfactory
4. Length of sentences is suited to the comprehension level of the target reader.	3.67	Very Satisfactory
5. Sentences and paragraph structures are varied and interesting to the target reader.	3.67	Very Satisfactory
Total points	**19.33**	**Passed**

Note. Rating scale as in Table 3. Passing criterion: ≥ 15 of 20 points = Passed; 0–14 = Failed.

Mean ratings for the five indicators ranged from 3.67 to 4.00 (Very Satisfactory), and the total of 19.33 points falls within the Passed range (15–20 points). The experts thus validated the modules as presentable, logically organized, and written in language suited to learners' comprehension. Engaging and understandable presentation, logical and smooth flow of ideas, and vocabulary adapted to the target readers each received 4.00, whereas sentence length and variety of sentence and paragraph structure each received 3.67. Experts recommended adding space between multiple-choice items to improve readability. This comment concerned the look of the modules, not the quality of their content.

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Accuracy and up-to-datedness of information

Table 6. Experts' Evaluation on the Modules' Accuracy and Up-to-Datedness

Parameter	Mean	Description
1. Conceptual errors.	4.00	Not present
2. Factual errors.	4.00	Not present
3. Grammatical errors.	4.00	Not present
4. Computational errors.	4.00	Not present
5. Obsolete information.	4.00	Not present
6. Typographical and other minor errors (e.g., inappropriate or unclear illustrations, missing labels, wrong captions, etc.).	4.00	Not present
Total points	**24.00**	**Passed**

Note. Rating scale: 3.25–4.00 = Not present; 2.50–3.24 = Present but very minor and must be fixed; 1.75–2.49 = Present and requires major redevelopment; 1.00–1.74 = Poor, do not evaluate further. Passing criterion: 24 of 24 points = Passed.

All six indicators received a mean of 4.00, meaning that the experts observed no errors. The total of 24.00 points is the highest possible rating and corresponds to an overall interpretation of Passed. The modules were thus viewed as technically precise, grammatically correct, scientifically accurate, and current, with no typographical errors, missing labels, inappropriate illustrations, or incorrect captions.

Validation of the Modules by End Users: Acceptability

Table 7. End Users' Validation of the Modules in Terms of Acceptability

Criterion	Mean	Description
1. The learning resource makes learning science interesting and easy.	4.78	Outstanding
2. The discussion of topics is appropriate to our level of cognition.	4.58	Outstanding
3. The lessons are compatible with the background of knowledge and level of us learners.	4.65	Outstanding
4. The learning resource is sensitive to the cultural background of us learners.	4.88	Outstanding
5. The learning resource uses appropriate language for better and meaningful learning.	4.53	Outstanding
Overall mean	**4.68**	**Outstanding**

Note. Rating scale: 4.21–5.00 = Outstanding; 3.41–4.20 = Very Satisfactory; 2.61–3.40 = Satisfactory; 1.81–2.60 = Fair; 1.00–1.80 = Poor. n = 40. The overall mean is the average of the five indicator means.

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The Grade 7 learners found the modules acceptable. All five indicators received mean ratings from 4.53 to 4.88, each interpreted as Outstanding (overall mean = 4.68), indicating that the learners viewed the modules positively as engaging, appropriate, culturally sensitive, and easy to understand. "The learning resource is sensitive to the cultural background of us learners" received the highest mean (4.88), followed by "makes learning science interesting and easy" (4.78), compatibility with learners' background knowledge (4.65), and appropriateness to learners' level of cognition (4.58). "The learning resource uses appropriate language for better and meaningful learning" received the lowest mean (4.53), although this is still Outstanding.

Validation of the Effectiveness of the Localized Comic-Based Modules

The effectiveness of the modules was examined by comparing the performance of the control and experimental groups on each module. An independent-samples *t*-test on pretest scores first tested whether the groups had similar prior knowledge of Grade 7 chemistry. Paired-samples *t*-tests then tested pretest–posttest changes within each group, and independent-samples *t*-tests on gain scores tested differences in learning gains between the groups.

Module 1: Scientific Investigation

Table 8. Pretest and Posttest Scores of the Control Group in Module 1 (Scientific Investigation)

Score Range	f	%	Score Range	f	%
0–3	0	0.00	0–3	0	0.00
4–7	7	17.50	4–7	2	5.00
8–11	27	67.50	8–11	29	72.50
12–15	6	15.00	12–15	9	22.50
Mean	**9.43**		**Mean**	**10.18**	

Note. Left panel = pretest performance; right panel = posttest performance. Maximum score = 15; *n* = 40 per group.

Most learners in the control group scored within the 8–11 range in both assessments (67.50% on the pretest and 72.50% on the posttest). The share of learners in the highest interval (12–15) rose from 15.00% to 22.50%, while the share scoring 4–7 fell from 17.50% to 5.00%. The mean score increased from 9.43 to 10.18, a mean gain of 0.75 points, a modest improvement following conventional instruction.

Table 9. Pretest and Posttest Scores of the Experimental Group in Module 1 (Scientific Investigation)

Score Range	f	%	Score Range	f	%
0–3	0	0.00	0–3	0	0.00
4–7	6	15.00	4–7	0	0.00
8–11	30	75.00	8–11	18	45.00
12–15	4	10.00	12–15	22	55.00
Mean	**9.32**		**Mean**	**11.65**	

Note. Left panel = pretest performance; right panel = posttest performance. Maximum score = 15; *n* = 40 per group.

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In the experimental group, most learners (75.00%) scored 8–11 on the pretest and only 10.00% scored 12–15. After using the comic-based module, the share in the highest interval rose substantially to 55.00%, and no learner remained in the 4–7 interval. The mean score increased from 9.32 to 11.65, a mean gain of 2.33 points, which is a notable improvement in performance.

Table 10. **Independent Samples t-Test for Baseline Pretest Performance Between Groups for Module 1 (Scientific Investigation)**

Variable	Control M	Control SD	Exp. M	Exp. SD	t	df	p
Pretest	9.43	2.00	9.32	1.73	0.24	78	.812

Note. Control group $n = 40$; experimental group $n = 40$. Exp. = experimental. H_a: $\mu_{control} \neq \mu_{experimental}$.

The control group had a pretest mean of 9.43 (SD = 2.00) and the experimental group an almost identical mean of 9.32 (SD = 1.73), $t(78) = 0.24$, $p = .812$. Because p is greater than .05, there was no significant difference between the groups' baseline scores, so the two sets of Grade 7 students had equivalent prior knowledge of the topic before the introduction of Module 1.

Table 11. **Paired Samples t-Test Comparison of Pretest and Posttest Scores of the Control and Experimental Groups in Module 1 (Scientific Investigation)**

Group	Assessment	n	M	SD	t	df	p	Cohen's d
Control	Pretest	40	9.43	2.00	3.91	39	<.001	0.62
	Posttest	40	10.18	1.85				
Experimental	Pretest	40	9.32	1.73	9.33	39	<.001	1.48
	Posttest	40	11.65	2.08				

Note. H_a: $\mu_{Measure\ 1 - Measure\ 2} \neq 0$.

Both groups improved significantly from pretest to posttest. The control group, which received conventional lecture instruction, increased from 9.43 (SD = 2.00) to 10.18 (SD = 1.85), $t(39) = 3.91$, $p < .001$, with a medium effect size (Cohen's $d = 0.62$). The experimental group, which used the localized comic-based module, increased from 9.32 (SD = 1.73) to 11.65 (SD = 2.08), $t(39) = 9.33$, $p < .001$, with a large effect size ($d = 1.48$).

Table 12. **Independent Samples Welch t-Test Comparison of Gain Scores Between Groups in Module 1 (Scientific Investigation)**

Group	n	M gain	SD	t	df	p	Cohen's d
Experimental	40	2.33	1.58	5.01	73.30	<.001	1.12
Control	40	0.75	1.21				

Note. H_a: $\mu_{experimental} \neq \mu_{control}$. Levene's test was significant ($p < .05$), indicating unequal variances; Welch's t-test is therefore used instead of Student's t-test. Mean difference = 1.58.

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Gain scores show how much each student progressed during the module. The experimental group had a mean gain of 2.33 (SD = 1.58), significantly higher than the control group's mean gain of 0.75 (SD = 1.21; mean difference = 1.58), Welch's $t(73.30) = 5.01$, $p < .001$, with a large effect size (Cohen's $d = 1.12$).

Module 2: Phase Changes

Table 13. **Pretest and Posttest Scores of the Control Group in Module 2 (Phase Changes)**

Score Range	f	%	Score Range	f	%
0–3	0	0.00	0–3	0	0.00
4–7	9	22.50	4–7	4	10.00
8–11	29	72.50	8–11	28	70.00
12–15	2	5.00	12–15	8	20.00
Mean	**8.93**		**Mean**	**9.60**	

Note. Left panel = pretest performance; right panel = posttest performance. Maximum score = 15; $n = 40$ per group.

In Module 2, most control-group learners (72.50%) scored 8–11 on the pretest, 22.50% scored 4–7, and only 5.00% scored 12–15. After conventional instruction, the share in the highest interval rose to 20.00%, and the share scoring 4–7 fell to 10.00%. The mean score rose from 8.93 to 9.60, a mean gain of about 0.68 points (0.67 when computed from the rounded means shown), a modest improvement in understanding changes of state of matter.

Table 14. **Pretest and Posttest Scores of the Experimental Group in Module 2 (Phase Changes)**

Score Range	f	%	Score Range	f	%
0–3	0	0.00	0–3	0	0.00
4–7	10	25.00	4–7	0	0.00
8–11	26	65.00	8–11	17	42.50
12–15	4	10.00	12–15	23	57.50
Mean	**8.93**		**Mean**	**11.85**	

Note. Left panel = pretest performance; right panel = posttest performance. Maximum score = 15; $n = 40$ per group.

In the experimental group, most learners (65.00%) scored 8–11 on the pretest, 25.00% scored 4–7, and only 10.00% scored 12–15. After the intervention, 57.50% scored 12–15, and no learner remained in the 4–7 interval. The mean score rose from 8.93 to 11.85, a mean gain of about 2.92 points, a considerable descriptive improvement in performance.

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Table 15. Independent Samples t-Test for Baseline Pretest Performance Between Groups for Module 2 (Phase Changes)

Variable	Control M	Control SD	Exp. M	Exp. SD	t	df	p
Pretest	8.93	1.75	8.93	1.69	0.00	78	1.000

Note. Control group $n = 40$; experimental group $n = 40$. Exp. = experimental. H_a: $\mu_{experimental} \neq \mu_{control}$.

The control group's pretest mean was 8.93 (SD = 1.75), exactly the same as the experimental group's mean of 8.93 (SD = 1.69), $t(78) = 0.00$, $p = 1.000$. The difference between the groups was not statistically significant, indicating equivalent baseline knowledge, so that the Grade 7 students in both groups had the same prior knowledge of phase changes before instruction.

Table 16. Paired Samples t-Test Comparison of Pretest and Posttest Scores of the Control and Experimental Groups in Module 2 (Phase Changes)

Group	Assessment	n	M	SD	t	df	p	Cohen's d
Control	Pretest	40	8.93	1.75	3.60	39	<.001	0.57
	Posttest	40	9.60	1.82				
Experimental	Pretest	40	8.93	1.69	14.40	39	<.001	2.27
	Posttest	40	11.85	1.59				

Note. H_a: $\mu_{Measure\ 1 - Measure\ 2} \neq 0$.

Both groups again showed significant pretest–posttest gains. The control group improved slightly, from 8.93 (SD = 1.75) to 9.60 (SD = 1.82), $t(39) = 3.60$, $p < .001$, with a medium effect size ($d = 0.57$). The experimental group improved from 8.93 (SD = 1.69) to 11.85 (SD = 1.59), $t(39) = 14.40$, $p < .001$, with a large effect size ($d = 2.27$).

Table 17. Independent Samples t-Test Comparison of Gain Scores Between Groups in Module 2 (Phase Changes)

Group	n	M gain	SD	t	df	p	Mean difference (SE)	Cohen's d
Experimental	40	2.92	1.29	8.13	78	<.001	2.25 (0.277)	1.81
Control	40	0.68	1.19					

Note. H_a: $\mu_{experimental} \neq \mu_{control}$. Student's *t*-test was used because the group variances were comparable (SD = 1.29 vs. 1.19). Cohen's *d* was computed from the reported means and standard deviations (pooled SD = 1.24).

A regular Student's *t*-test was conducted on the gain scores because the standard deviations of the two groups were comparable (SD = 1.29 vs. 1.19). The experimental group's mean gain of 2.92 (SD = 1.29) was significantly higher than the control group's mean gain of 0.68 (SD = 1.19), $t(78) = 8.13$, $p < .001$, with a mean difference of 2.25 ($SE = 0.277$) and a large effect size ($d \approx 1.81$).

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Decision on the null hypothesis

Because the within-group pretest–posttest differences were significant for both groups, and the between-group differences in gain scores were significant in both modules (Module 1: $p < .001$; Module 2: $p < .001$) with large effect sizes, the null hypothesis of no significant difference between the pretest and posttest scores of the control and experimental groups is rejected. Baseline equivalence of the groups (Module 1: $p = .812$; Module 2: $p = 1.000$) indicates that the greater gains of the experimental group cannot be attributed to initial differences in prior knowledge.

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DISCUSSION

This study developed two localized comic-based modules for the least-learned Grade 7 chemistry competencies of the MATATAG Curriculum, validated them with experts and end users, and tested their effectiveness against conventional instruction. This section interprets the findings in light of the literature, draws implications for science education, and states the limitations of the study.

Development of the Modules

The development process responded directly to documented learning gaps. Selecting competencies through the Index of Mastery and item analysis ensured that the modules targeted topics where learners scored lowest, as recommended in the analysis phase of ADDIE (Branch, 2016). The modules' localized settings and storylines reflect the principle that connecting scientific concepts to learners' situations, experiences, and local context aids understanding (Department of Education, 2016), and Rivera and Turno (2024) likewise reported high teacher agreement with, and positive student perceptions of the visual attractiveness and content of, comic-based instructional materials.

The modules treat comics as instructional tools in their own right rather than as illustrations. Rasmet et al. (2025) noted that comics have been used at the primary, secondary, and tertiary levels and are associated with conceptual understanding, motivation, engagement, and critical thinking. This is consistent with the Cognitive Theory of Multimedia Learning, in which learners process verbal and visual information into meaningful learning, especially when prior knowledge is engaged (Mayer, 2024). Ismiyanto et al. (2025) suggest that coordinating comics, curriculum goals, and visual design is essential to effective comic-based teaching tools. Typography also affects reading and information processing: Čeleš et al. (2026) found that the reading efficiency of Grade 7 and Grade 8 pupils depends on typeface and that larger type sizes improve comprehension, and Amarin and Al-Saleh (2020) note that color can make concepts and relations concrete and affect learners' psychological and emotional state. Both considerations informed the modules' typefaces and color-coded sections.

Embedding safety precautions reflects attention to the environment in which learners perform activities as well as to the cognitive aspect of the task. The response spaces, tables, and QR codes support the selection, organization, and integration of information, which yields more meaningful learning than mere exposure to learning material (Mayer, 2024). QR codes in printed materials link physical modules with digital media and can improve outcomes and engagement (AbuElEla, 2026).

Expert Validation

Content

The experts' ratings of content (27.34 of 28 points) are consistent with DepEd's LRMDS guides, under which quality learning materials should be curriculum-aligned, developmentally appropriate, inclusive, culturally responsive, and interesting (DepEd, 2016). They also support Mayer's (2020) finding that when words and pictures are designed coherently, learners process information better, avoid cognitive overload, and learn more meaningfully. The validators' suggestion to align assessment items with what is presented in the comic is consistent with Biggs and Tang's (2022) idea of constructive alignment, in which learning objectives, activities, and assessments are aligned to maximize learning. Their suggestion to use culturally relevant images and to contextualize the different parts of the module is consistent with DepEd Order No. 35, s. 2016, which promotes localized learning materials that relate what learners learn in school to their surroundings; contextualized instruction has been found to increase engagement and motivation and to improve concept understanding by making materials meaningful. Taken together, the evaluation shows that the modules have high content quality and meet the standards for instructional materials, while the recommendations offer clear ways to improve instructional flow, contextualization, and the alignment of objectives, activities, materials, and assessment.

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Format

The experts' ratings of the illustrations and design agree with Mayer's (2020) principles that people learn better when words and pictures are presented so that they can be processed meaningfully, and with the guidance that illustrations should not distract learners from the main concept. Cueing learners' attention to specific components of a module reduces extraneous processing (Clark & Mayer, 2023), and the modules applied these principles by using illustrations related to the science concepts being taught. The ratings also adhere to LRMDS standards for print quality, under which materials should be readable, well designed and laid out, and visually clear and engaging (DepEd, n.d.). Cultural responsiveness was embedded in the modules, as shown by the experts' call for familiar, culturally relevant images. In sum, the experts agreed that the modules have a highly acceptable format, with high ratings for print quality, illustrations, and design; the illustrators' recommendations (consistent text layout and carrying the comic's themes into the rest of the module) would improve the modules further.

Presentation and organization

The ratings on presentation and organization (19.33 of 20 points) align with Mayer's (2020) principles that instructional materials should be clear, organized, and coherent, which reduces the mental effort needed to understand what is presented and lets learners focus on making sense of information. Clark and Mayer (2023) likewise advise organizing text and visuals logically, using familiar language, and presenting information that is easy to read. The experts' ratings imply that the modules met these criteria by presenting information sequentially and using terms familiar to students. The ratings also comply with the quality standards of DepEd's LRMDS, under which resources should be logically organized, developmentally appropriate, easy to read, and interesting. The recommended revisions, which were minor, aim to add variety to sentences and to give enough spacing between multiple-choice items without affecting content quality.

Accuracy and up-to-datedness

The highest possible rating on accuracy and up-to-datedness indicates that care was taken during development and review to eliminate errors. This matters because conceptually or factually inaccurate material would harm learners' science education; scientifically accurate, current materials promote correct scientific knowledge and reduce the chance of misconceptions that confuse later lessons. The result aligns with LRMDS requirements that learning materials be free of conceptual, factual, grammatical, computational, and typographical errors before they are recommended, and with the Department of Education's (2023) MATATAG Curriculum guidance that learning resources provide accurate information aligned with the current curriculum to promote scientific literacy. Mayer (2020) likewise notes that learners understand concepts better when materials are free of unnecessary information or errors that distract or confuse, and Clark and Mayer (2023) point out that error-free resources let learners devote mental effort to processing new information.

User Acceptability

The learners' Outstanding ratings (4.53–4.88) show that the modules were acceptable to their intended users. The highest rating, for cultural sensitivity (4.88), suggests that learners appreciated contexts, characters, and situations they could relate to, which upholds the MATATAG Curriculum's call for learner-centered, contextualized resources that relate lessons to learners' experiences and immediate locality (DepEd, 2023). The second-highest rating, for making learning science interesting and easy (4.78), indicates that the comic format captured learners' interest and helped them understand science, which is in line with the OECD's (2021) report that learning materials that are interesting and relevant encourage participation and understanding. The ratings for compatibility with prior knowledge (4.65) and cognitive level (4.58) suggest that the modules suit their target users, consistent with UNESCO's (2021)

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statement that quality instructional materials should consider learners' developmental level and prior experience in order to provide inclusive and meaningful learning.

The language indicator received the lowest mean (4.53). Although still Outstanding, it may indicate that some words and explanations could be simplified for learners with different reading levels, an adjustment that would raise comprehension while preserving the scientific integrity of the lessons. Overall, learners favored the modules because their comic format is engaging and their lessons are relevant to learners' culture and appropriate to their age, factors that contribute to high acceptability and suggest that the modules can be useful for teaching Grade 7 chemistry.

Effectiveness of the Modules

Baseline equivalence

The absence of significant pretest differences in both modules (Module 1: $p = .812$; Module 2: $p = 1.000$) is important for interpreting the posttest results. It is consistent with Philippine research suggesting that learners starting from the same position, without exposure to contextualized, localized resources, often show comparably low scores on difficult physical science topics in traditional lecture-based settings (Badeo et al., 2021; Molina, 2024). Showing that the groups are statistically equivalent at baseline also makes the evaluation fair, because it reduces the likelihood of selection bias and supports internal validity (Gopalan et al., 2020); had the pretest scores differed significantly, one could not confidently attribute posttest gains to the cognitive benefits of localized storytelling (Bello, 2026). For phase changes, similar pretest scores across classrooms are also typical when learners hold shared misconceptions about particle arrangement (Villafañe et al., 2016), and novice middle school students, whatever their classroom, are at a similar disadvantage when models such as the change from solid to liquid to gas are presented through conventional formats (Taber, 2019). Equivalence at the start is required to measure a module's effectiveness, because it removes student ability as a competing explanation for differences at the end of the module (Akaygun, 2016).

Module 1: Scientific Investigation

The control group's modest gain (0.75 points) suggests that regular classroom instruction gave learners some opportunity to develop their understanding of scientific investigation, but the concentration of scores in the 8–11 range indicates that further instructional support would be beneficial. Tang (2023) emphasized the importance of integrating visual and verbal representations in scientific explanations in materials for junior high school learners, which suggests that supplementing conventional instruction with carefully designed visual representations may offer learners additional opportunities to understand scientific procedures. The experimental group's notable gain (2.33 points) is consistent with the systematic review of Ismiyanto et al. (2025), which examined 15 studies on comics in elementary science education and identified benefits for conceptual understanding, motivation, and critical thinking, and with the thematic review of 33 studies by Huang et al. (2024), which highlighted the educational potential of comics for making learning materials more engaging and accessible. In this study, localized situations and sequential visual explanations may have helped learners understand the steps of scientific investigation by presenting procedures in a more concrete and relatable way.

Although both groups improved significantly, the experimental group's advantage ($d = 1.48$ versus 0.62 within groups; $d = 1.12$ between groups) indicates that the comic-based intervention supported understanding substantially more than conventional instruction. Scientific investigation requires rigid, multi-step processes that can overwhelm Grade 7 learners when presented in a traditional format; Abungu et al. (2020) found that traditional text-based instruction does not give young beginners enough structural guidance to follow the chronological steps of a research process. The comic modules may have alleviated this difficulty by giving a graphic interpretation of the procedure. Vidergor (2024) asserts that when inquiry steps are placed within guided storylines, students experience less cognitive load and can place variables in context with more confidence, and Koutníková (2017) found that comics help students understand

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abstract, multi-step academic procedures by turning them into literal actions within a story. According to Castro and Tan (2023), sequential media such as comics reduce cognitive load by segmenting information-dense sequences into easy-to-process, engaging visual chunks. In addition, the significant gains may be attributed to the localization of the modules: Santos and Reyes (2025) found that context-specific science modules for the lower years of secondary education closed learning deficiencies by replacing decontextualized and foreign textbook situations with situations in the learners' own locality. The 1.58-point difference in mean gains is consistent with the view that conventional teaching limits learning in abstract science and that visual aids can supplement it (Aquino et al., 2022).

Module 2: Phase Changes

Learners need to connect observable changes of state with the underlying behavior of particles. Hu et al. (2024) explained that the particulate nature of matter is challenging for learners because microscopic processes are abstract and difficult to visualize, and they showed that computer simulations enhanced middle school students' ability to translate between chemical representations, particularly between macroscopic and submicroscopic levels. The control group received conventional instruction, and its modest gain (about 0.68 points), with scores concentrated in the 8–11 interval, suggests that some concepts need further reinforcement and that additional visual explanations and representations may strengthen conceptual understanding of changes of state. The experimental group's substantial gain (about 2.92 points) is consistent with Ismiyanto et al. (2025), who identified positive contributions of science comics to learners' conceptual understanding and motivation, and with Langbeheim et al. (2022), who emphasized the importance of visual and verbal representations in understanding the structure of matter and their relationship to scientific reasoning. In this study, the integration of illustrations, scientific explanations, and localized narratives may have helped learners connect observable changes of state with particle arrangements and energy changes.

Although learners in the control group made gains, the much larger gains in the experimental group (d = 2.27 versus 0.57 within groups; $d \approx 1.81$ between groups) suggest that the comic-based modules were considerably more effective in helping students understand a difficult chemistry concept. Understanding phases of matter requires middle school students to connect macroscopic phenomena (boiling, freezing) to unseen submicroscopic actions. Taber (2019) explains that text-based curricula give students no tangible reference for unseen chemical entities, so novices are left to memorize superficial information, which limits understanding. The comic modules may have broken down this barrier by letting students see what happens at the submicroscopic level through the personification of atoms and molecules in story bubbles; Lin and Lin (2016) describe how sequential illustrations of relative molecular distance and motion can reduce cognitive load and help dispel students' misconceptions about states of matter. According to Castro and Tan (2023), sequential art eases cognitive load by segmenting information about complex changes in atoms into smaller, picture-rich chunks, so that learners need not memorize dense paragraphs on how particles gain and lose energy and can instead encode how matter changes from solid to liquid to gas.

The gains may also reflect the localized framing of the modules. Santos and Reyes (2025) found that when science materials are localized for the elementary and junior high school levels, learning deficiencies narrow because students learn science through their everyday lives rather than through nameless characters from faraway places, and studies by Dela Cruz (2024) and Villanueva (2023) similarly show that localized materials create cultural familiarity. Culturally relevant materials help students form meaningful connections instead of memorizing what they do not understand. The wide gap between the groups is consistent with the interpretation that regular teaching alone may restrict learners' grasp of the submicroscopic world, and that localized visual stories may help narrow that gap (Aquino et al., 2022).

Implications for Science Education

The large gains of the experimental group in both Module 1 (Welch's $t(73.30) = 5.01$, $p < .001$, $d = 1.12$) and Module 2 ($t(78) = 8.13$, $p < .001$, $d \approx 1.81$) have important implications for secondary science education. That the pattern held

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across two consecutive modules suggests that traditional, textbook-dependent methods may not be enough to support students' understanding of abstract Grade 7 chemistry. Chemical processes at the particle level are not directly observable, so intangible scientific vocabulary can easily overwhelm learners. The promising results suggest that sequential comic art can help fill this gap: by pairing an illustration directly with text, teachers can ease cognitive demand, increase engagement, and help students process abstract concepts (Castro & Tan, 2023). Educators can therefore support understanding of difficult concepts, such as scientific investigation and changes of state, with contextualized, image-rich materials, and science teachers can provide context by creating modules with local examples in a comic format that helps students visualize chemistry topics. Student-friendly media such as comics can help students understand scientific concepts and, in turn, perform better on assessments.

The results also indicate that teachers can strengthen science instruction by making lessons more personalized and tailored to students' local surroundings, because the experimental group outperformed the control group. Lesson designers should move away from a "one-size-fits-all" mentality when creating supplementary learning packages (Santos & Reyes, 2025; Villanueva, 2023). School leaders and DepEd should support teachers who choose to create their own localized teaching materials, and schools should not rely exclusively on nationally produced textbooks and modules but should allocate school funds and teacher time to professional development. Training teachers to create, validate, and print their own learning materials with graphic-based media can have a lasting positive effect on student learning outcomes (Dela Cruz, 2024). Finally, although the pretest established that the sections had comparable knowledge of the topics, it is the significant difference in posttest gains that highlights the modules' effectiveness. Future researchers comparing alternative teaching media should consider using gain scores and effect sizes, because statistics that highlight a program's efficacy help to limit the influence of extraneous factors on participants' scores (Aquino et al., 2022).

Limitations

Several limitations should be considered when interpreting the findings. First, the study was conducted in a single private school with two intact Grade 7 sections, selected by simple random sampling of sections but not of individual students; results may not generalize to other schools, public-school settings, or other grade levels. Second, only 40 of 42 students in the experimental section had parental consent and received the modules, and the experimental group also served as the end-user validators. Third, the effectiveness test was short-term: it covered the first month of the first term and did not assess long-term retention, attitudes toward science, or interest in science. Fourth, the pretests and posttests were researcher-made 15-item tests, and the reliability and item statistics of these instruments are not reported here; the two test forms for each module were different sets of items, and a 15-item scale yields a limited range of scores. Fifth, the control condition was conventional lecture-based instruction; the design does not separate the effect of the comic format from that of localization, additional printed material, or novelty. Finally, the expert panel consisted of five validators, so the validity ratings are based on a small group, and ratings at or near the maximum on several indicators leave little room to discriminate among aspects of the modules. These limitations suggest cautious interpretation and motivate the recommendations below.

CONCLUSIONS AND RECOMMENDATIONS

Summary of Findings

Development. The localized comic-based modules were developed from the least-learned competencies in Grade 7 chemistry of the MATATAG Curriculum. They contain localized context, comic-strip stories, learner-centered activities, and formative and summative assessments aligned with the target competencies on scientific investigation and changes of state.

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Expert validation. Experts rated the modules Very Satisfactory on every criterion. Content received a total of 27.34 of 28 points (Passed); the experts agreed that the modules were curriculum-aligned, developmentally appropriate, engaging, and supportive of higher-order thinking, and recommended strengthening the presentation of particle arrangement in the comic dialogue, aligning assessment items with the comic, adding an introduction before each comic, integrating the comic's elements into the rest of the module, and using more culturally recognizable images. Format received 70.13 of 72 points (Passed), with high ratings for print quality, illustrations, layout, paper, and usability; the illustrators praised the comic strips' visual appeal but recommended greater consistency in text layout and font size. Presentation and organization received 19.33 of 20 points (Passed), with a recommendation to increase spacing between multiple-choice items. Accuracy and up-to-datedness received the perfect score of 24.00, with no conceptual, factual, grammatical, computational, typographical, or obsolete-information errors found.

User acceptability. Grade 7 learners rated the modules Outstanding (means = 4.53–4.88), with cultural relevance rated highest (4.88), followed by interest and ease of learning (4.78), compatibility with prior knowledge (4.65), suitability to cognitive level (4.58), and appropriateness of language (4.53).

Effectiveness. Baseline pretest scores did not differ significantly between groups in Module 1 ($t(78) = 0.24$, $p = .812$) or Module 2 ($t(78) = 0.00$, $p = 1.000$). Both groups showed statistically significant pretest–posttest gains (all $p < .001$), but the experimental group's gains were substantially larger (Module 1: $d = 1.48$ vs. 0.62; Module 2: $d = 2.27$ vs. 0.57). Gain scores were significantly higher for the experimental group in Module 1 (Welch's $t(73.30) = 5.01$, $p < .001$, $d = 1.12$) and in Module 2 ($t(78) = 8.13$, $p < .001$, $d \approx 1.81$). The null hypothesis was therefore rejected.

Implications. The large gains in both modules suggest that lecture- and textbook-heavy approaches may be insufficient for abstract Grade 7 chemistry concepts, and that contextualized, image-rich materials such as localized comic modules can help students visualize and understand them.

Conclusions

1. The localized comic-based modules developed for Grade 7 chemistry are aligned with the least-learned competencies in the MATATAG Curriculum. Embedding localized context, comic-based narrative, learner-centered activities, and assessments produced instructionally suitable materials that address the learning competencies they were designed to teach.

2. The modules are instructionally appropriate as perceived by experts. They scored satisfactorily on content, format, presentation and organization, and accuracy and up-to-datedness of information, indicating their appropriateness as materials for teaching and learning chemistry in Grade 7.

3. The modules are highly acceptable to the target learners, who perceived them as culturally relevant, engaging, suited to their intellectual level and background knowledge, and comprehensible in language.

4. The modules are effective as determined by learners' performance in Grade 7 chemistry. Both groups improved after the treatment, but learners exposed to the modules improved significantly more than those who underwent conventional instruction.

5. The results underscore the instructional usefulness of localized, media-rich instructional materials in science education. Learner-centered and culturally relevant materials such as comic-based modules can capture the interest of junior high school learners and make science learning feel more relevant and understandable.

Recommendations

1. Science teachers and instructional material developers may create and use localized instructional materials consistent with the competencies and learning needs outlined in the MATATAG Curriculum.

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2. Modules may undergo continuous evaluation and revision based on expert recommendations and classroom testing so that they remain relevant and suited to learners' needs in content, format, organization, and presentation.

3. Teachers may use localized and comic-based instructional materials to facilitate learner engagement and meaningful learning, especially when teaching topics that are abstract or difficult for learners.

4. The localized comic-based modules may be used as supplemental learning materials in Grade 7 chemistry, specifically for lessons on scientific investigation and changes of state, since the results showed that they improved learners' academic performance.

5. The validators' recommendations (more particle-arrangement concepts in the comic dialogue, assessment items answerable from the comic, an introduction before each comic, consistent characters, setting, color, font, and labeling throughout each module, culturally relevant images, and more spacing between multiple-choice items) may be incorporated in the next revision of the modules.

6. Other researchers may investigate localized comic-based instructional materials for other science competencies, grade levels, and contexts, including public schools, to further validate their use in science education.

7. Future studies may include delayed posttests to examine long-term retention, measures of attitude and interest in science, and report the reliability and item statistics of the achievement tests, to strengthen the evidence on effectiveness.

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