



The Development of ChemicoMine, Maritime Chemistry Comic Webtoon as an Edutainment Media Accordance to the IMO Regulations

Khoirotnun Nafillah^{1*}, Dhési Wulan Sari² and , Purwanto³ 

^{1,2} Department of Engineering, Politeknik Maritim Negeri Indonesia, Semarang, Indonesia

³ Department of Nautical, Politeknik Maritim Negeri Indonesia, Semarang, Indonesia

ARTICLE INFO

Article history:

Received July 9, 2024

Revised September 29, 2024

Accepted October 11, 2024

Available online November 14, 2024

Kata Kunci:

ChemicoMine, Komik Kimia Maritim, Webtoon, IMO, Edutainment

Keywords:

ChemicoMine, Maritime Chemistry Comic, Webtoon, IMO, Edutainment



This is an open access article under the [CC BY-SA](https://creativecommons.org/licenses/by-sa/4.0/) license.

Copyright © 2024 by Author. Published by Universitas Pendidikan Ganesha.

ABSTRAK

Berdasarkan kurikulum IMO Model Course 7.04, kimia merupakan mata kuliah pengantar yang harus dikuasai oleh seorang calon pelaut. Namun sebagian besar konsep kimia abstrak memerlukan media pembelajaran berbasis teknologi dan edutainment. Penelitian ini bertujuan untuk membuat ChemicoMine, komik kimia maritim berbasis Webtoon yang konten materinya mengikuti ketentuan IMO. Aplikasi webtoon digunakan untuk mendistribusikan ChemicoMine yang telah dikembangkan. Metode penelitiannya adalah R&D dengan model ADDIE yang dibatasi pada tahap pengembangan. Instrumen yang digunakan dalam penelitian ini adalah instrumen analisis kebutuhan, alat validasi storyboard, instrumen yang divalidasi oleh ahli media dan materi, dan instrumen untuk siswa. Teknik analisis data menggunakan skala likert 5. Hasil validasi dari ahli materi dan media menyatakan bahwa produk memperoleh persentase penilaian sebesar 87,66% dan 95,28% dengan kategori (sangat baik). Hasil respon siswa memperoleh persentase penilaian sebesar 88,94% dengan kategori (sangat baik). Berdasarkan hasil tersebut, ChemicoMine mendapat respon positif dari mahasiswa dan dapat dijadikan alternatif media edutainment.

ABSTRACT

Based on the IMO Model Course 7.04 curriculum, chemistry is an introductory course that a candidate for sailor must master. However, most abstract chemistry concepts require technology-based learning media and edutainment. Webtoon is a digital comic that presents the concept of chemistry through real-life visualization strategies to attract student interest. This research aimed to create ChemicoMine, a maritime chemistry comic webtoon whose material content follows IMO regulations. The research method is R&D with the ADDIE model, which is limited to the Development stage. The instruments used in this research were analyst instruments of necessity, the validation tools of storyboard, the instrument validated by an expert in media and material, and the instrument for students. The data analysis techniques used the Likert scale 5. Validation results from an expert in material and media stated that the product received a percentage rating of 87.66% and 95.28% with the category (very good). Student response results obtained percentage of rating of 88.94% with the category (very good). Based on the results, ChemicoMine received a positive student response and can be used as an alternative edutainment media.

1. INTRODUCTION

The potential of Indonesia to become the world's maritime focal point requires the development and management of the infrastructure and human resources (HRM). The IMO stated that the education, training, and navigation systems should follow the Standards of Training, Certification, and Watchkeeping (STCW) to deal with international challenges, especially in maritime. Based on the IMO (International Maritime Organization) Model Course 7.04 curriculum, chemistry is an introductory course that must be mastered by a candidate for sailor (IMO, 2014). This course provides procedural knowledge about the basis of chemistry, base acid, corrosion, water testing and treatment, fuel, and lubricants implemented in ship engineering. Maritime Vocational College provides chemistry courses to fulfill the need for human resources

*Corresponding author

E-mail addresses: khoirotnunafillah@polimarin.ac.id (Khoirotnun Nafillah)

in this field. The course aims to create students with competencies related to IMO regulations. This course is also a prerequisite for other courses, such as materials science.

The process of learning chemistry has some barriers, such as low motivation for learning chemists because most of it consists of abstract and complex concepts. This is also because Maritime Vocational College has a high concentration of semi-military activities, so students are less interested in conventional classroom learning or Teacher Centered Learning (TCL). According to previous research, chemistry textbooks are dominated by texts and formulas that make them difficult for students to understand. Besides that, the source of learning "maritime chemistry" is still limited. Because of that, the lack of interest in studying chemistry among students of maritime vocational colleges has become an urgent case that should be solved (Arisandi et al., 2021; Sankar & Benjamin, 2024).

The observations of maritime vocational students, especially the 3-year and 4-year diploma students in Ship Engineering Studies, obtained that the desired learning activity is a varied, interactive, and gadget-based learning experience. Therefore, learning activities in semi-military colleges should adopt Student-Centered Learning (SCL). The principle of SCL is the freedom of learning and creative thinking to discover knowledge from diverse sources in a pleasant atmosphere (Kerimbayev et al., 2023). The strategy creates a democratized learning atmosphere for a student that makes them learn independently according to their characters (Otto et al., 2024). Teachers also need to adapt to the characters of Gen Z students who are more interested in literacy through technology (Hernandez-de-Menendez et al., 2020).

Learning media has a crucial role firmly integrated with the world of education, specifically the learning process of teaching (Muller & Schulte, 2022). Chemical learning activities require learning media that can represent symbolic and microscopic objects through visualization strategies. Comics are a book that plays that role (Makmun, 2021). Comics provide an opportunity to enrich learning experiences rather than using conventional media such as textbooks (Aksu & Yilmaz, 2021).

SCL is characterized by learning in the 21st century, so it requires technology-based self-learning resources, such as digital-based chemical comics, accessible for free (Parastuti & Prihandari, 2021). The advantages of digital comics are cheaper, interactive, dynamic, and durable (Ramadhan & Rasuardie, 2020). Comics can represent the abstract of chemistry concepts through a combination of text and illustration in a creative storyline. Comics have also proven to attract the attention of students when learning science (Aksu & Yilmaz, 2021; Muller & Schulte, 2022).

Much research on chemical comics has been done, such as the truth of chemistry (Suprianingsih et al., 2022), essential acids (Halawa et al., 2022), electrolytes and non-electrolytes (Novianti & Putra, 2020), intermolecular styles (Aliifah et al., 2023), and thermochemistry (Ilmi et al., 2023). Technology development presents comics in digital and Android-based forms (Diah et al., 2023; Sari* & Exaudie Lubis, 2021). Implementing comics with android-based has shown the enhancement of students' critical thinking skills (Damayanti & Kuswanto, 2020). Another research proves that android-based media can measure the skills of the science process in high school students (Pratiwi & Junaidi, 2021). The perspective related to the feasibility of comics with android-based is theoretical and practical (Dixon & Turner, 2022).

In 2021, a study entitled "Development of Chemistry Comics based on Android and Its Implementation to Improve Learning Outcomes" showed that Android-based chemistry comics (Chemondro) can improve learning outcomes, demonstrated by an average of 81.91 in the experimental class and 71.76 in the control class—application features and program code developed with Android studios and JAVA programming languages (Sari* & Exaudie Lubis, 2021). The potential effects of comics have been proven to improve student learning outcomes by an average score of 84.22% on diesel engineering courses at the UNSRI Mechanical Engineering school (Yolanda et al., 2020). Integrating science literacy-laden chemical comics can improve students' understanding of concepts, writing and oral communication skills (Naila et al., 2022). Comics can improve problem-solving capabilities by a score of 47.3%, measured with the N-gain test category medium (Annisa et al., 2020).

The power of a comic depends on its illustration. The CET-based (chemo edutainment) approach is implemented to enhance students' creativity and learning outcomes from cognitive, affective, and psychomotor aspects (Nugraha, 2020). Researchers usually use the webtoon line application as an online comic platform to spread the product of their research, such as comics physics using the line webtoon application with the Clip Studio Paint application (Aliifah et al., 2023; M. Arsyad et al., 2022). Line Webtoon is one of the free digital comic platforms under the Line Corporation and Naver Corporation. Line webtoon has become a popular digital comics application in the Indonesian community, with more than 6 million active users since its launch in 2014 (Lestari, 2020).

Much research about comics on chemicals has been done, but the research about chemical comics in the maritime field using the IMO Model Course 7.04 has not been developed yet, especially for Maritime Vocational Students. Students in this era are Z-gen that are familiar with technology. Therefore, they need educational and entertaining (edutainment) learning media with digital-based. The research aims to create

ChemicoMine, a maritime chemistry comic based on webtoon using IMO regulations. This research expects to give a solution and alternative fun learning media based on gadgets to enhance students' learning motivation.

2. METHOD

This research used the Research and Development (R&D) method to validate or develop a product (Sugiyono, 2017). The model used in this research is the ADDIE model, comprises five distinct stages, which are Analysis, Design, Development, Implementation, and Evaluation. In this research, the ADDIE stage is limited to the Analyze, Design, and Development stages because this research only to determine the level of feasibility and student response. The instruments used in this research were the questionnaire for students to know the necessity of products, the validation instrument of material and media experts, and the questionnaire for students about the developed product. The assessment instrument referred National Education Standards Agency in 2014. The data was processed using the Likert scale. The score of each instrument, in the form of quantitative data, is converted into data using qualitative criteria according to the conversion of the actual score into a scale value of 5 with the provisions as in Table 1.

Table 1. Guidelines for Data Interpretation Criteria

Interval Skor	Quality Category
81-100	Very Good
61-80	Good
41-60	Sufficient
21-40	Poor
0-20	Not Good

The overall value of the maritime chemistry comic is determined by calculating the entire score for all criteria assessing and determining the quality of the developed maritime chemistry digital comics. The data obtained is calculated to obtain the ideal percentage using the formula:

$$P = \frac{f}{N} \times 100\% \quad (1)$$

with,

P = percentage of ideal,

f = average value, and

N = maximum average score.

This research was carried out at the Politeknik Maritim Negeri Indonesia, Engineering programs, from April to June 2024. The object of this research is learning media in the form of webtoon-based maritime chemistry comics in accordance with IMO regulations. The subjects in this research consisted of 2 material experts, 2 media experts, and 39 students from Engineering study programs.

3. RESULT AND DISCUSSION

Analysis

The research begins with the analysis stage. The analysis was carried out by interviewing and distributing questionnaires to 24 students from engineering study programs at the Politeknik Maritim Negeri Indonesia. This activity aims to understand students' needs regarding learning media, learning strategies, learning instruments, and the level of student motivation in learning chemistry. Needs analysis is a literature and field study that collects information (Ikhwanus Shofa et al., 2020) related to the situation and potential in the learning process. In analyzing student needs, it is known that aspects of difficulty in studying chemistry get an assessment percentage of 78% in the category "Agree". This difficulty is because chemistry concepts are mostly abstract (Rahmi et al., 2021) and microscopic. Apart from that, students also have difficulty finding learning resources/references about maritime chemistry that are interesting and fun. The analysis results show that students need learning media that can visualize abstract and microscopic chemical concepts to make them easier to understand. The language used in comics is attractive, so it can improve memory abilities from the large number of vocabulary words contained in comics. The position of digital comics can function as a conveyor of learning messages through visual elements to increase student learning motivation (Payanti, 2022). One platform that provides digital comic services is Webtoon. The needs analysis results show that 79% of students have used Webtoon comic services, but 88% of students have not used Webtoon comics as educational media. Students agree and are interested in comics as

learning media for chemistry courses, which can be accessed anytime and anywhere. For the this stages, problem and need analysis were carried out to obtain the facts and problems in the field.

Design

The second stage is the design stage, which is the preparation process for developing a product. This process has three stages: material analysis, storyboard design, and storyboard validation. The material analysis aimed to analyze the content or material that will be presented in maritime chemistry comics, as required by the provisions of IMO Model Course 7.04. This analysis is carried out by linking essential competencies with learning objectives, creating learning indicators by adapting Bloom's taxonomy, and determining the main sub-materials included in the comic. Table 2 explains the material analysis in maritime chemistry comics according to IMO Model Course 7.04.

Table 2. Analysis of Maritime Chemical Materials According to IMO Model Course 7.04

No	Chemical Comic Material	
	Chapter	Subchapter
1	Fundamentals	<ul style="list-style-type: none"> - Atoms and atomic theory - Elements, compounds and mixtures - Chemical reaction - Periodic system of elements
2	Acidity/Alkalinity	<ul style="list-style-type: none"> - The concept of acid base (acid rain phenomenon) - Determination of pH values (universal pH indicator and pH meter)
3	Corrosion	<ul style="list-style-type: none"> - Corrosion concept - Cause of ship corrosion - Corrosion prevention - Composition of seawater
4	Water testing and treatment	<ul style="list-style-type: none"> - Principle of steam boiler engine - Feed water requirements - Effect of pH on boiler water
5	Introduction to fuels and lubricants	<ul style="list-style-type: none"> - Marine Diesel Fuel (MDF) - Marine Fuel Oil (MFO) - High Speed Diesel (HSD)

The next stage is designing a maritime chemistry comic storyboard, a design before the media is developed. A storyboard visualizes ideas that can provide an overview of the product's appearance. It contains images and information displayed shot by shot so that they can be used as outlines for making products (Kunto et al., 2021). This is related to determining the characters, storyline, and illustration concept. The final stage is storyboard validation, as presented in Table 3. An assessment is carried out regarding the suitability of the chemical concept and the material in the comic. The aim of this activity is also to test the accuracy of maritime chemistry material in comics by the provisions of IMO Model Course 7.04. The results of the storyboard validation show a validity value of 86% with categories "Very Good" and can be continued to the development stage.

Table 3. Storyboard Validation Results

No.	Indicators	Average Score	Percentage of Ideal (%)	Category
1	The learning objectives or messages to be conveyed through comics are clear and well-defined	4.5	90	Very Good
2	The storyline and narrative are planned according to the message to be conveyed, and there are no contradictions and confusion in the story	4	80	Very Good
3	The style and language used in the comic suit the characteristics and preferences of the target audience	4.5	90	Very Good
4	The storyboard is easy to understand and attractive to the intended audience	4.5	90	Very Good
5	Comic storyboards meet the desired quality and effectiveness standards	4	80	Very Good
Overall Score		21.5	86	Very Good

Development

The development stages aims to create a validated product prototype. The Development stages consists of several stages: product development, material expert validation, media expert validation, and limited student testing.

The first stage is product development in the form of webtoon comics. The storyboard validated in the previous stage will be processed to the panel drawing stage. The comic drawing technique used is a digital technique, namely a pure digital drawing technique with the help of a device, tablet, or PC. The tools used were a laptop, Wacom Intuos CTH480 Pen Tablet, and iPad Pro. The applications used are Procreate (sketching and lineart), Clip Studio Paint (coloring, adding word balloons and text, and finishing), Croppy (for cutting story panels), and Webtoon (uploading comics).



Figure 1. Process of a) sketching, b) line application usage dariart, c) coloring, and d) shading

The drawing process starts with making sketches and lineart, base color, and shading. After that, add word balloons and text, as well as finishing. At this stage, the comic image style is also determined because choosing an image style can influence readers through unique images to provide a more exciting sensation (Musnur & Faiz, 2019). Therefore, the researcher chose a cartoon drawing style. Cutting story panels uses the Croppy application, which can be accessed at <https://knicknic.github.io/croppy/>. After the panel drawing process is complete, the panels will be combined into one canvas with the help of the Clip Studio Paint application. The size of the canvas used is 1400 x 10000 pixels, which is then cut in web croppy to 800 x 1000 pixels per canvas with a resolution of 300 dpi. The dialogue revision process is also carried out at this stage. The number of canvases for each episode ranges from 50-70 canvases. The next stage is uploading the comic to the webtoon application which can be accessed at <https://www.webtoons.com/en/>.



Figure 2. Process of using a) clip studio paint, b) croppy

At the development stage, the next step is validation of the material. The second stage was material validation, carried out by two material experts (chemistry lecturers). This validation instrument refers to the modified BSNP validation instrument sheet. Several aspects are measured in the material validation process, namely the writing approach aspect, the truth of concept aspect, the depth of concept aspect, sentence clarity aspect and implementation aspect.

The writing approach aspect consists of one criterion: the concept's suitability with the main chemistry material in IMO provisions with an ideal percentage of 90% and a very good category. The second aspect is the correctness of the concept, which consists of three criteria, namely connecting science and technology in the field of maritime chemistry, compatibility of concepts in maritime chemistry comics with concepts put forward by chemical experts, and explanation of concepts according to the needs of prospective student sailors. The truth aspect of this concept has an ideal percentage value of 83.33% and a very good category.

The third aspect is the depth of concepts, which consists of two criteria. The depth of concepts in maritime chemistry comics is determined by IMO regulations. The depth of the material is determined by the maturity of students' thinking and the presence or absence of material development. The depth of concept aspect has an ideal percentage value of 85% and a very good category. The aspect of sentence clarity has five criteria, namely, sentences that are easy to understand, use communicative and correct

language, accuracy and accuracy of the chemical terms used, sentences that do not give rise to double meanings and use figurative words and the language used is interesting and appropriate for EYD. The clarity aspect of this sentence has an ideal percentage value of 90% and a very good category. The final aspect assessed by media experts is implementation aspect, which consists of: 1) The contents of the maritime chemistry comic are not dangerous for students, 2) The chemistry comic is easy to use for edutainment, 3) The maritime chemistry comic can be used flexibly according to the allocation of chemistry course learning hours and independent study, 4) The maritime chemistry comic can provide direct experience. The implementation aspect has an ideal percentage value of 90% and a very good category.

Some of the revisions from the material experts involve writing chemical formulas and adding content, such as in the ship fuel and boiler feed water chapters. Recommendations from material experts have done this. Based on the research results, which can be seen in Table 4 and Figure 3, the average percentage result for all aspects of material validation is 87.66% with the category "Very Good". This indicates that the maritime chemistry concept contained in the comic is in accordance with IMO provisions and is suitable for use as an alternative educational learning media.

Table 4. Material Expert Validation Results

Aspect	Number of Criteria	Average Value	Percentage of Ideal (%)	Category
A Writing Approach	1	4.5	90	Very Good
B Truth of Concept	3	4.167	83.33	Very Good
C Depth of Concept	2	4.25	85	Very Good
D Sentence Clarity	5	4.5	90	Very Good
E Implementation	4	4.5	90	Very Good
Overall Score	15	21.91	87.66	Very Good

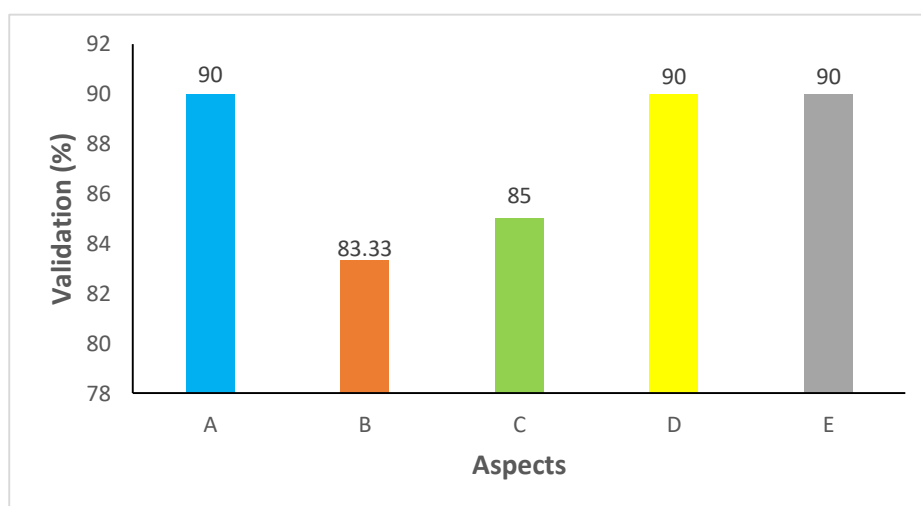


Figure 3. Percentage of material expert validation

The third stage is media validation, carried out by two media expert validator lecturers by assessing the quality of webtoon comic media. Four aspects are assessed in media validation: linguistic aspects, story presentation aspects, media effect aspects, and comprehensive view aspects. The linguistic aspect consists of seven criteria: sentences are easy to understand, use communicative and correct language, sentences do not give rise to double meanings and use figurative words, clarity and readability of text/dialogue is appropriate, the font choice used is good and attractive, text placement is good and has aesthetic value, and choosing the right diction. The overall score for the language aspect is 97.14% in the very good category. The story presentation aspect consists of five criteria: the regularity of the storyline in maritime chemistry comics is presented in an interesting way; introduction, conflict, and resolution are presented clearly; information delivery is effective and educative; continuation of the story attracts readers; and correctness of information and accuracy of maritime chemistry comic content. The overall value of the story presentation aspect is 94% in the very good category.

The next aspect is media effect, which consists of eight criteria: ease of access and distribution, digital quality (graphics and visuals), high resolution and proper compression, user and comic interactivity, application stability, and wide compatibility. Hence, readers enjoy content without technical obstacles, data

security and user privacy, clean and unambiguous interface design, and easy navigation. The overall score in this aspect is 95% in the very good category.

The final aspect is comprehensive view, which consists of transitions between panels that are easy to understand, the quality of the illustrations/images is good and interesting, visual consistency makes it easier for readers to understand the story, effective panel composition and layout, good visual balance and interest, visual appeal (aesthetics) attracts readers, the uniqueness and creativity of chemical comics impress readers, the choice of colors is appropriate and attractive, correct selection of characters and settings, and consistent use of color and good contrast. The overall score in this aspect is 95% in the very good category.

Based on the results of the validation assessment, it can be seen in Table 5 and Figure 4 that the webtoon maritime chemistry comic received an assessment percentage of 95.28%, which can be interpreted as getting the category "Very Good". This indicates that the performance of comics is appropriate and suitable for students to use as edutainment media. The assessment process from media experts has received several improvements, such as improvements to several images and illustrators. The following is one of the repair processes (Figure 5).

Table 5. Media Expert Validation Results

Aspect	Number of Criteria	Average Value	Percentage of Ideal (%)	Category
A Language	7	4.85	97.14	Very Good
B Presentation of the Story	5	4.7	94	Very Good
C Media Effects	8	4.75	95	Very Good
D Comprehensive View	10	4.75	95	Very Good
Overall Score	30	19.05	95.28	Very Good

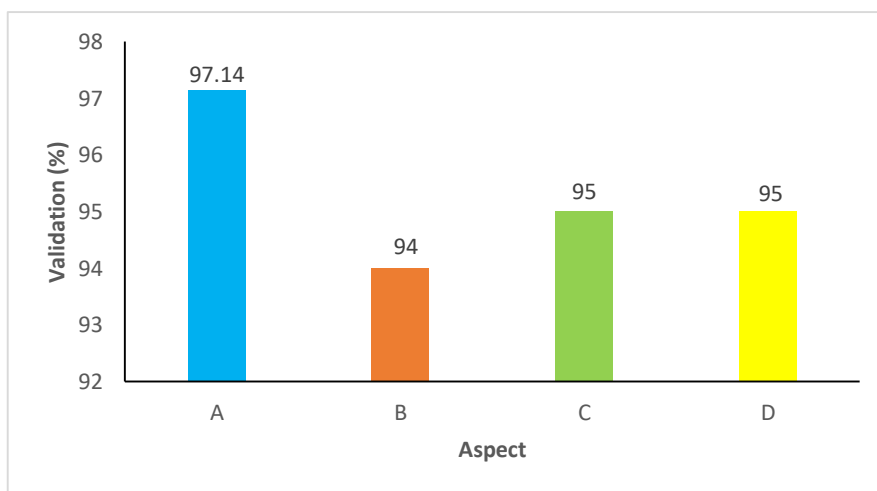


Figure 4. Percentage of media expert validation

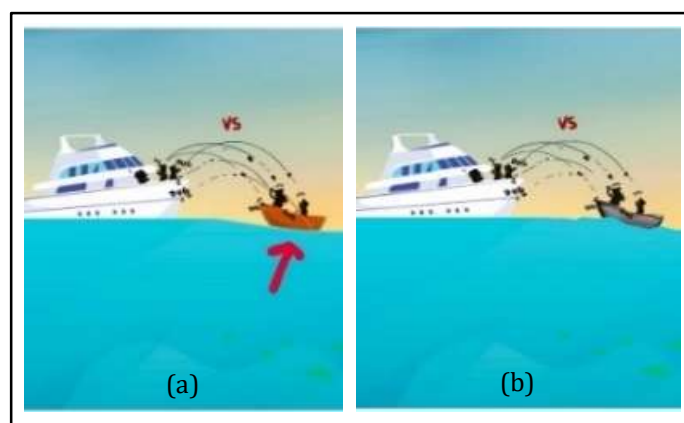


Figure 5. Process of a) pre-revision b) post-revision

The final stage is a student response test carried out with a limited test on 39 Engineering students, Politeknik Maritim Negeri Indonesia. This stage aims to see student responses to the maritime chemistry comic products that have been developed. The research results in the table show the percentage value for all aspects of 88.85% with categories "Very Good." This percentage can be broken down into three main aspects: the appearance aspect of 88.71%, the effectiveness aspect of 88.89%, and the satisfaction aspect of 89.23%.

Table 6. Student Response Test Results

	Aspect	Number of Criteria	Average Value	Percentage of Ideal (%)	Category
A	Appearance	6	4.43	88.71	Very Good
B	Effectiveness	3	4.44	88.89	Very Good
C	Satisfaction	2	4.46	89.23	Very Good
	Overall Score	11	13.34	88.94	Very Good

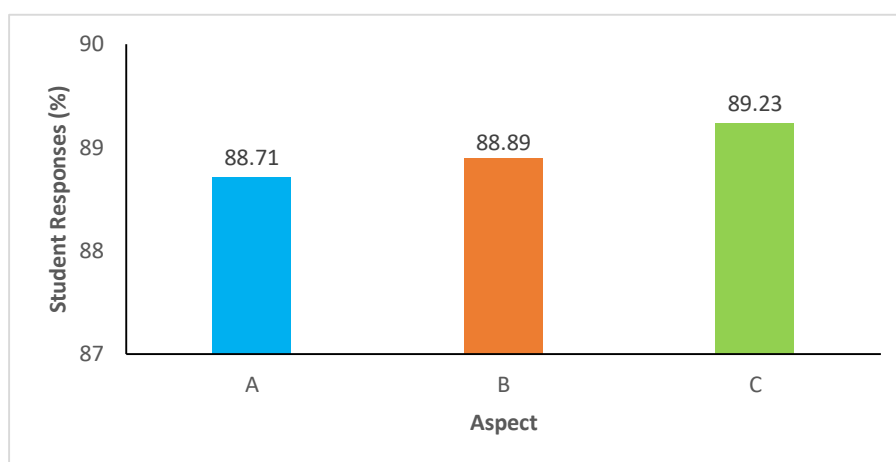


Figure 6. Percentage of student response test

The first aspect is appearance, resulting in 88.71% by category "Very Good." The assessment of the appearance aspect consists of 6 criteria. The first criterion is that comics have an attractive and aesthetic design, using colors, illustrations, and layouts that attract the reader's attention. The second criterion, the panel arrangement in the comic, is orderly and reasonable, making it easier for readers to follow the storyline smoothly. The third criterion is that the text and images in comics are clear and easy to read or understand, increasing readability and readers' understanding of the story. The fourth criterion, the comic display, can attract students' attention to learning with a combination of visuals and narratives that are interesting and relevant to the learning context. The fifth criterion is that the sentences accompanying the image/illustration are clear, and the message is clarified to the reader by the image being described. The sixth criterion is that comic illustrations are selected and placed strategically, helping to strengthen the story and better explain maritime chemistry concepts. Each of the six criteria shows the percentage of good results in sequence, namely 92.82; 87.17; 86.67; 88.20; 89.74; 87.69%.

This indicates that the illustrations contained in comic media, which function to provide story explanations, can make it easier to understand the forms described in the material (Krause, 2022; Wulan et al., 2020). In visual media, the main elements are essential, such as color, font, composition, and contrast. Determining font colors that have good contrast with the background is essential so that the colors look harmonious. The presence of well-organized pictures and illustrations makes students feel happy and not bored when reading webtoon comics. The overall criteria show that webtoon comics used in learning significantly generate learning motivation for students (Wulan et al., 2020).

The second aspect is effectiveness, resulting in a percentage of 88.89% with the category "Very Good." This aspect consists of three criteria. The first criterion is that the comic effectively conveys the concepts of chemistry and the maritime environment to readers, enriching their knowledge about these topics. The second criterion is that comics are effective in engaging readers through exciting stories and strong narratives, making students interested in continuing to read and learn further. The third criterion is that the text and images in comics are easy to read and understand, ensuring readers can understand the

messages. Science learning is linked to events in the surrounding environment, and it is felt more effective in fostering student activity and motivation (Rahman & Mulyono, 2022).

The third aspect is satisfaction, resulting in a percentage of 89.23% by the category "Very Good." This aspect consists of two criteria. The first criterion is that readers are satisfied with the experience of reading maritime chemistry comics, and feel entertained, educated, and inspired by the stories told. The second criterion is that comics are considered relevant to contemporary issues related to chemistry and the maritime environment, helping to increase readers' awareness and understanding of these issues. The results of this aspect indicate that the maritime chemistry comic received a positive response from students. The analysis of these three aspects resulted in an overall percentage of 88.94% edutainment.

Based on analyzing previous needs and problems, the comic can visualize abstract chemical phenomena more realistically through illustration strategies and storylines. The results of the overall data analysis from material experts, media experts and students obtained very good results, so it is hoped that in the future the product that has been developed (ChemicoMine) can increase students' learning motivation (Minawati et al., 2021), increasing students' desire to read, and improving students' scientific and digital literacy skills (Suryaningsih & Nisa, 2021). Additionally, digital comics can be educational and entertaining by maximizing internet and gadget technology. Through fun learning chemistry, students will find powerful tools to facilitate interesting and meaningful learning experiences.

In developing the ChemicoMine webtoon, our findings align with research emphasizing comic-based learning in increasing student engagement and understanding of complex concepts (Krause, 2022). However, no effectiveness test has been carried out on this product. This comic is adapted to contextually relevant IMO provisions but supports the idea that integrating entertainment with education will increase student motivation and learning outcomes (Zhou & Zhang, 2021).

Thus, ChemicoMine is an alternative edutainment tool in maritime studies. The digital maritime chemistry comic (ChemicoMine) has been developed that can be used via link https://www.webtoons.com/id/canvas/chemicomine/list?title_no=966301, so that it can be accessed online via the web or the Line webtoon application. Figure 5 shows the initial appearance of the webtoon comic distributed on the Line webtoon site.



Figure 7. The initial appearance of ChemicoMine

4. CONCLUSION

Maritime chemistry comics (ChemicoMine), according to IMO regulations as an edutainment medium, have been successfully developed using the R&D method through the ADDIE model, which is limited to development. The needs analysis results show that 78% of students have difficulty understanding chemical material, so they are interested in using webtoon comic media as a learning medium. The storyboard has been validated by experts with an assessment percentage of 86% in the category (Very Good). ChemicoMine received a material validation assessment percentage of 87.66% (Very Good), media validation of 95.28% (Very Good), and student responses of 88.94% (Very Good). In conclusion, according

to the material and media experts, the development of ChemicoMine comic can be applied as an alternative edutainment based learning source. It has also received a positive response from students perspective in order to assist them in learning chemistry especially for maritime vocational college students. This comic is categorized as "Very Good" and suitable to be implemented. The ChemicoMine has been distributed via the Line Webtoon website and can be accessed using the Line Webtoon application.

5. ACKNOWLEDGE

We thank the Directorate General of Vocational Education, Ministry of Education, Culture, Research and Technology of the Republic of Indonesia in 2024 for funding this research with contract number 83/SPK/D.D4/PPK.01.APTV/III/2024. Thank you for cooperating with Engineering study programs at the Politeknik Maritim Negeri Indonesia. Thanks are conveyed to material, media experts, and illustrators.

6. REFERENCES

- Aksu, M., & Yilmaz, R. (2021). The effectiveness of comic-based teaching materials in science education. *Journal of Science Education and Technology*, 30(2), 234–245. <https://doi.org/10.1007/s10956-021-09936-1>
- Aliifah, N. J., Ramli, M., & Yunita, L. (2023). Pengembangan Media Pembelajaran Komik Webtoon Terintegrasi STEM pada Mata Pelajaran Kimia Materi Gaya Antarmolekul. *SPIN-Jurnal Kimia & Pendidikan Kimia*, 5(1), 112–126. <https://doi.org/10.20414/spin.v5i1.7020>
- Annisa, S. A., Lesmono, A. D., & Yushardi, Y. (2020). Comic-Based Module Development Andro-Web to Improve Problem Solving Ability in Physics in High School Students. *Berkala Ilmiah Pendidikan Fisika*, 8(1), 40. <https://doi.org/10.20527/bipf.v8i1.7641>
- Arisandi, Y., Ibnu, S., Subandi, S., & Sumari, S. (2021). Vocational high school students' motivation towards learning chemistry. *AIP Conf. Proc.*, 2330. <https://doi.org/10.1063/5.0043417>
- Budiarti, W. N., & Haryanto, H. (2016). Pengembangan Media Komik Untuk Meningkatkan Motivasi Belajar Dan Keterampilan Membaca Pemahaman Siswa Kelas Iv. *Jurnal Prima Edukasia*, 4(2), 233. <https://doi.org/10.21831/jpe.v4i2.6295>
- Damayanti, A. E., & Kuswanto, H. (2020). The use of android-assisted comics to enhance students' critical thinking skill. *Journal of Physics: Conference Series*, 1440(1). <https://doi.org/10.1088/1742-6596/1440/1/012039>
- Diah, L., Pratiwi, A., & Mu'minin, A. A. (2023). Pengembangan Media Pembelajaran Komik Berbasis Android Pada Materi Hakikat Ilmu Kimia Untuk Siswa Kelas X Di MAN 1 Kota Kediri. 2(4), 221–233. <http://jurnal.anfa.co.id/index.php/seroja>
- Dixon, C., & Turner, R. (2022). Integrating mobile technology and comics in education: A practical approach. *International Journal of Mobile and Blended Learning*, 14(1), 45–62. <https://doi.org/10.4018/IJMBL.20220101.0a3>
- Halawa, A. A., Yulita, I., & Adriani, N. (2022). The development of Acid-Base Electronic Chemistry Comic Learning Media for High School Students. *Journal of Science Education Research*, 6(1), 24–30. <https://doi.org/10.21831/jser.v6i1.44997>
- Hernandez-de-Menendez, M., Escobar Diaz, C. ., & Morales-Menendez, R. (2020). Educational experiences with Generation Z. *Int J Interact Des Manuf*, 14, 847–859. <https://doi.org/10.1007/s12008-020-00674-9>
- Ikhwanus Shofa, M., Wayan Redhana, I., & Prima Juniartina, P. (2020). Analisis Kebutuhan Pengembangan Media Pembelajaran Ipa Berbasis Argument Mapping. 3(April), 31–40.
- Ilmi, S. N., Mawarnis, E. R., Herman, M., Studi, P., Kimia, T., Islam, U., Mahmud, N., & Batusangkar, Y. (2023). Pengembangan Media Pembelajaran E-Comic Kimia Berbasis Stem (Science, Technology, Engineering, Dan Mathematic) Pada Materi Termokimia Untuk Kelas XI MIPA SMA YDB Lubuk Alung. *Jurnal Pendidikan Tambusai*, 7(1), 2966–2975.
- IMO. (2014). *Model Course 7.04 Officer in Charge of An Engineering Watch*.
- Kerimbayev, N., Umirzakova, Z., Shadiev, R., & Jotsov, V. (2023). A student-centered approach using modern technologies in distance learning: a systematic review of the literature. *Smart Learn. Environ*, 10(61). <https://doi.org/10.1186/s40561-023-00280-8>
- Krause, S. (2022). Visual storytelling in comics: Enhancing comprehension in science learning. *International Journal of Science Education*, 44(5), 747–764. <https://doi.org/10.1080/09500693.2021.1974543>
- Kunto, I., Ariani, D., Widyaningrum, R., & Syahyani, R. (2021). Ragam Storyboard Untuk Produksi Media Pembelajaran. *Jurnal Pembelajaran Inovatif*, 4(1), 108–120. <https://doi.org/10.21009/jpi.041.14>
- Lestari, A. F. (2020). Line Webtoon Sebagai Industri Komik Digital. *Jurnal Ilmu Komunikasi*, 6, 134–148.
- M. Arsyad, M. K. K., Nurhayati, N., & Yani, A. (2022). Pengembangan Komik Fisika Berbantuan Aplikasi

- Lineweetoon. *Jurnal Sains Dan Pendidikan Fisika*, 18(2), 171. <https://doi.org/10.35580/jspf.v18i2.31525>
- Makmun. (2021). Balo Lipa: Jurnal Pendidikan Seni Rupa Komik : Media Komunikasi Pembelajaran. *Jurnal Pendidikan Seni Rupa*, 18–23.
- Minawati, D., Nanda, D. S., Sihotang, M. D., & Kusmindari, C. D. (2021). an Analysis of Using Webtoon in Improving Students' Reading Motivation At First Semester. *Beyond Linguistika*, 4(2). <https://doi.org/10.36448/bl.v4i2.2313>
- Muller, R., & Schulte, E. (2022). Visualizing chemistry: The role of comics in the teaching and learning of chemistry. *Chemistry Education Research and Practice*, 23(3), 689–700. <https://doi.org/10.1039/D1RP00234H>
- Musnur, I., & Faiz, M. (2019). Analisis Penyajian Karakter Dan Alur Cerita Pada Komik Vulcaman-Z. *Narada : Jurnal Desain Dan Seni*, 6(2), 339. <https://doi.org/10.22441/narada.2019.v6i2.010>
- Naila, N., Winarti, A., & Mahdian, M. (2022). Pengembangan Media Pembelajaran Komik Kimia Bermuatan Literasi Sains Untuk Meningkatkan Pemahaman Konsep Dan Kemampuan Komunikasi Peserta Didik. *Quantum: Jurnal Inovasi Pendidikan Sains*, 13(1), 1. <https://doi.org/10.20527/quantum.v13i1.11817>
- Novianti, R., & Putra, A. (2020). Development of Chemistry Comics as Alternative Learning Media on Electrolyte and Non Electrolyte Solution for Grade X SMA. *International Journal of Research and Review (Ijrrjournal.Com)*, 7(9), 25.
- Nugraha, D. A. (2020). Pengembangan Komik Kimia Sebagai Media Pembelajaran Berbasis Cet (Chemo-Edutainment). *Chemistry in Education*, 9(2), 1–7. <http://journal.unnes.ac.id/sju/index.php/chemined>
- Nurinayati, F., Sartono, N., & Evriyani, D. (2018). Development of Digital Comic as Learning Media on Immune System Topic in SMAN 13 Jakarta. *Biosfer*, 7(2), 47–52. <https://doi.org/10.21009/biosferjpb.7-2.8>
- Otto, S., Bertel, L. ., Lyngdorf, N. E. ., Markman, A. ., Andersen, T., & Ryberg, T. (2024). Emerging Digital Practices Supporting Student-Centered Learning Environments in Higher Education: A Review of Literature and Lessons Learned from the Covid-19 Pandemic. *Education and Information Technologies*, 29, 1673–1696. <https://doi.org/10.1007/s10639-023-11789-3>
- Parastuti, & Prihandari, I. (2021). *Pengantar Manga (Komik Jepang)*. CV Jejak.
- Payanti, D. A. K. D. (2022). Peran Komik Digital sebagai Media Pembelajaran Bahasa yang Inovatif. *Sandibasa I: Seminar Nasional Pendidikan Bahasa Dan Sastra Indonesia I*, 4(April), 464–475. <https://ojs.mahadewa.ac.id/index.php/sandibasa/article/download/2035/1484>
- Pratiwi, A., & Junaidi, I. (2021). Mobile learning applications to improve scientific inquiry skills among high school students. *International Journal of Educational Technology in Higher Education*, 18(1), 12. <https://doi.org/10.1186/s41239-021-00256-1>
- Rahman, F., & Mulyono, S. (2022). Utilizing local environmental issues to boost student engagement in science learning. *International Journal of Science Education*, 44(9), 1351–1370. <https://doi.org/10.1080/09500693.2022.2043992>
- Rahmi, C., Mujakir, & Febriani, P. (2021). Kemampuan Representasi Submikroskopik Siswa Pada Konsep Ikatan Kimia. *Lantanida Journal*, 9(1), 1–92.
- Ramadhan, B. S., & Rasuardie, R. (2020). Kajian Industri Komik Daring Indonesia: Studi Komik Tahilalats. *JSRW (Jurnal Seni rupa Warna)*, 8(1), 2–18. <https://doi.org/10.36806/jsrw.v8i1.80>
- Sankar, E., & Benjamin, A. E. . (2024). Studying the student's perceptions of engagement and problem-solving skills for academic achievement in chemistry at the higher secondary level. *Education and Information Technologies*, 29(7), 1–22. <https://doi.org/10.1007/s10639-023-12165-x>
- Sari*, S. A., & Exaudie Lubis, M. T. (2021). Development of Android Chemistry Comics as an Independent Learning Application to Improve Student Learning Outcomes. *Jurnal Pendidikan Sains Indonesia*, 9(3), 433–444. <https://doi.org/10.24815/jpsi.v9i3.20266>
- Sugiyono. (2017). *Metode Penelitian Kuantitatif, Kualitatif, dan R&D*. Alfabeta CV.
- Suprianingsih, N., Yenti, E., & Kurniawati, Y. (2022). Pengembangan Bahan Ajar Komik Terintegrasi Islam Pada Materi Hakikat Ilmu Kimia. *Journal of Chemistry Education and Integration*, 1(1), 16. <https://doi.org/10.24014/jcei.v1i1.15901>
- Suryaningsih, S., & Nisa, F. A. (2021). Kontribusi Steam Project Based Learning dalam Mengukur Keterampilan Proses Sains dan Berpikir Kreatif. *Jurnal Pendidikan Indonesia*, 2(6), 1097–1111.
- Wulan, I. S., Suprpto, P. K., & Kamil, P. M. (2020). Belajar Virus dengan Komik: Pengaruhnya terhadap Motivasi dan Hasil Belajar (Studi Eksperimen di Kelas X MAN Tasikmalaya Tahun Ajaran 2019/2020). *Bioedusiana: Jurnal Pendidikan Biologi*, 5(2), 70–83. <https://doi.org/10.37058/bioed.v5i2.2005>

- Yolanda, R., Harlin, H., & Yadi, F. (2020). Pengembangan Media Komik Pada Mata Kuliah Teknologi Motor Diesel Di Pendidikan Teknik Mesin Universitas Sriwijaya. *Jurnal Pendidikan Teknik Mesin*, 97–108.
- Zhou, Y., & Zhang, H. (2021). Connecting classroom learning to real-world issues: Enhancing student motivation in science education. *Journal of Educational Research*, 114(3), 281–290. <https://doi.org/10.1080/00220671.2020.1760079>