CHAPTER IV
RESEARCH RESULTS AND DISCUSSION

This development research aims to produce an electronic module integrated with virtual laboratory. The e-module is published in the form of flipbook. This e-module contains theory and practicum manual of acid-base titration material for undergraduate students:

4.1. Design of E-Module Integrated with Virtual Laboratory on Acid-Base Titration Material

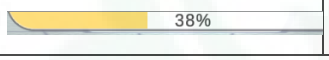
The design stage in this development research consists of choosing an integrated virtual laboratory and systematics of e-module. The following describes each design stage.

4.1.1. Integrated Virtual Laboratory

The virtual laboratory used is Praxilabs which can be accessed online via smartphones, laptops and computers. Praxilabs is a virtual laboratory site for chemistry that is presented with a 3D view. After Praxilabs is successfully opened, on the homepage several objectives for carrying out the experiment appear which is in accordance with the experimental title. At Table 4.1, there are some of the features on the homepage that can be used to support virtual practicum activities:

Table 4.1 General Features of Praxilabs

Feature	Explanation
1. Robot 	The Praxilab robot contains instructions that must be carried out by the practitioner step by step.
2. Stages 	There are several stages that allow the practitioner to be able to return to repeat the practicum easily.

Feature	Explanation
3. Menu 	The menu features include lab manuals, animated guides, video walkthroughs, exercises, settings, and enrichment.
4. Zoom in-out 	This feature is used to make it easier for practitioners to zoom in and out of the virtual laboratory view.
5. Percentage of experiment 	There is information on the extent to which the practitioner has carried out a virtual practicum in the form of a percentage.

Praxilabs presents virtual laboratory with many features and animations integrated into the e-module to make it easier for students to understand the material. This is in accordance with research by Suarni, Husain, & Salempa (2022) that the use of virtual laboratory media can help students visualize various abstract and complex concepts so that it makes it easier for students to understand the material being taught. This site is paid but is also presented in a free version for the basic type with 6 practicum simulations. The experiments carried out in this study were adjusted to the experiments contained in the Analytical Chemistry practicum manual in the Chemistry Education Study Program, namely titration of strong acid with strong base and titration of weak acid with strong base.

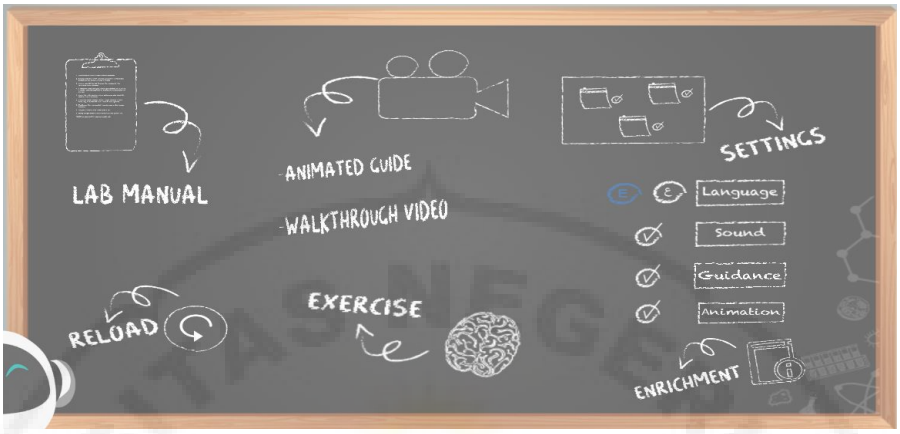


Figure 4.1 Menu Features of Praxilabs

Based on the Figure 4.1, Praxilabs was chosen to be integrated into the e-module because it has several features in the menu as follows:

1. Lab Manual: a general overview on the experiment
2. Animated Guide: an animated video explaining the steps of experiment
3. Walkthrough Video: a walkthrough video for the experiment
4. Exercise: to test knowledge about the experiment
5. Settings: contains of language, sound, guidance, animation
6. Enrichment: an additional information regarding the experiment
7. Reload: to reload the virtual laboratory

Apart from the homepage and menu features, the animation in the Praxilabs virtual laboratory is also found in the tools and materials used during the practicum. Practitioners can find out the names of tools and materials by simply placing the computer cursor on the tools and materials. When the titration process, such as pouring the solution, is carried out, the tools and materials will move like when the practitioner is doing practical work in a real laboratory. The features in the Praxilabs virtual laboratory are very suitable for students because there are so many instructions which is very helpful in doing practicum virtual especially at their first time. The animations also make students easily to do the steps because the tools will twinkle if students take a longer time to understand the instructions.

4.1.2. Systematics of E-module

Several Analytical Chemistry modules and practicum modules from several universities has been analyzed which found from the internet with the aim of making a systematics of e-module. The software used in developing the e-module includes Canva and Flippingbook. Canva is used to design modules more attractive with illustrations, images and features in them. Meanwhile, flipping books are used to make modules accessible online in the form of attractive electronic modules. Table 4.2 is the systematic design of the practicum e-module that was developed.

Table 4.2 Systematics of Practicum E-Module Design

Part of E-Modul	Details
Cover	1. Module title 2. Name of course 3. Learning topics 4. Author
Foreword	
Table of contents	
Instructions for Using the Module	1. Target audience 2. Prerequisites 3. Presentation scenario 4. Course Learning Outcomes (CPMK) 5. Competency Achievement Indicator (IPK) 6. Ability check
Pre-test	
Basic theory	1. Learning objectives 2. Acid-base titration material 3. Praxilabs virtual laboratory 4. Exercise 5. Summary
Experiment	1. Purpose of the experiment 2. Tools & materials 3. Observation

Post-test
Glossary
Answer keys
Self-assessment

Preparation of draft modules is the process of compiling and organizing learning materials from a competency or sub-competence into a systematic unit. Several Analytical Chemistry modules and practicum modules from several universities obtained from the internet were studied so that they could become e-modules that were suitable for use as teaching materials as well as a guide for virtual practicum activities.

1) Table of Content

The table of contents page functions as a 'homepage' where each sub-topic is clicked on that page, the table of contents page will change to the sub-topic page that was clicked. Each page also has a home icon which if clicked will return directly to the table of contents page.

2) Instructions for Using the Module

In order to make the module easier to understand, the objectives, prerequisites and presentation scenarios for using the module and conducting experiments are mentioned in the module. CPMK and IPK are described in this section to find out the final abilities planned at each learning stage. Ability checks are provided in this e-module using a hyperlink connected to the Google form so that students can fill it out.

3) Pre-test

In this section, students are required to answer the pre-test first that can be accessed by clicking the Pre-test icon. There are 10 multiple choice questions with reasons in the google form. Students must upload the image which needs calculation in the form of jpg image.

4) Basic Theory

The learning objectives are used to support the achievement of competence in students after participating in learning activities. Acid-base

titration material is divided into several subtopics, such as basic concepts and principles of acid-base titration, standard solutions, acid-base indicators, titration curves. Several subtopics are also given examples of questions. The virtual laboratory used is Praxilabs which can be accessed via a computer or smartphone online. Before using it, how to be able to sign up and log in to the Strong Acid and Strong Base Titration and Weak Acid and Strong Base Titration laboratories, is explained in the module. In addition, there are five multiple choice practice questions to hone students' skills after reading and understanding the basic theory.

5) Experiment

In accordance with the Learning Outcomes of the Course, the experiment was divided into two, namely Strong Acid and Strong Base Titrations and Weak Acid and Strong Base Titrations. The results of observations in experiments conducted in a virtual laboratory will also be automatically downloaded to the smartphone, laptop or computer used so that students only need to upload the file to the e-learning link provided in the module.

6) Post-test

In this section, students are required to answer the post-test after finishing the practicums that can be accessed by clicking the Post-test icon. There are 10 multiple choice questions with reasons in the google form. Students must upload the image which needs calculation in the form of jpg.

7) Glossary

The glossary includes clear and concise definitions for terms and concepts relevant to acid base titration. Each definition provides a brief explanation of the term, ensuring learners have a solid understanding of its meaning.

8) Answer keys

The answer keys for the exercises in the module can be accessed by scanning the QR code. It will be downloaded automatically in user device in the form of pdf document.

9) Self-Assessment

To find out the final ability of students, students can assess the results of working on their own practice questions by looking at the scoring guidelines in the Self-Assessment section.

Teaching materials are arranged systematically and completely to refresh the teachers in the subject matter, deepen the knowledge in their field of study, train learners to develop learning devices and introduce teaching technology in accordance with the latest advances in digital technology (Situmorang et al., 2022). The systematics of writing an e-module is adapted from the preparation of a draft module according to the Ministry of National Education (2008) which at least includes module titles, competencies, objectives, materials, procedures or training activities, practice questions or assignments, evaluations or assessments that function to measure students' abilities. in mastering the module, and the answer key.

The tests in the e-module included in the exercise section is validated by two Analytical Chemistry lecturers as test experts. This question is in accordance with Competency Achievement Indicators (IPK). These questions are multiple choice questions accompanied by reasons or also known as the two-tier test. It was found that the use of a two-level test evaluation instrument to measure students' critical thinking skills could be done with multiple choice questions. This is in line with research conducted by Van Hayus, Shidiq, & Masykuri (2014) that the Two-tier Multiple Choice instrument can be used to measure higher order thinking skills. The questions are also designed in such a way as to fit the six indicators of critical thinking skills according to George Brown College.

4.2. Standardization of E-Module Integrated with Virtual Laboratory on Acid-Base Titration Material

This development stage is carried out by experts until the validator states that the developed e-module is feasible for use at the implementation stage. The e-module development stages are divided into several stages, namely:

4.2.1. Expert Validation

The creation of this e-module was validated by four lecturers, namely two material experts and two media experts. Each expert filled out a validation questionnaire which contained several aspects related to the development of media and materials in the e-module. The assessment instrument in this development was prepared by referring to the BSNP assessment and using a Likert scale of 4 answers. The results of the validation of material experts and media experts are as follows:

1) Material/Content Expert Validation

Material/content expert validators in the development of e-module integrated with virtual laboratory on acid base titration material are two lecturers from FMIPA, Universitas Negeri Medan. The results of material/content validation are presented in Table 4.3.

Table 4.3 Assessments Results from Experts on the Feasibility of Material

Assessment Aspect	Validator	Category
Material	79.16%	Valid
Presentation	82.5%	Very valid
Language	83.33%	Very valid
Average	**81.66%**	**Very valid**

Based on the results of material validation, it is known that the material feasibility aspect obtains an average value of 79.16% in the “valid” category. The presentation feasibility aspect obtained an average value of 82.5% in the “very valid” category. The language feasibility aspect obtained an average value of 83.33% in the “very valid” category. Based on the description above, the results of the material expert validation as a whole obtained an average value of 81.66% in the “very valid” category so that the

developed e-module is feasible to use, but there are several things that need to be revised based on suggestions and comments given by the validator. Material validation results and data processing can be seen on Appendix 9 and Appendix 10.

2) Media Expert Validation

Media expert validators in the development of e-module integrated with virtual laboratory on acid base titration material are two lecturers from FMIPA, Universitas Negeri Medan. The result of the media expert validation in graphic design is obtained an average value of 87.03% in the "very valid" category so that the developed e-module is feasible to use, but there are several things that need to be revised based on suggestions and comments given by the validator. Media validation results and data processing can be seen on Appendix 11 and Appendix 12.

3) Test Expert Validation

Currently, quality education focuses more on the extent to which students' performance on tests can predict their potential performance on standardized tests. This test as a test for formative assessment and evaluation (Ristanto & Miarsyah, 2022). Test expert validators in the development of e-module integrated with virtual laboratory on acid base titration material are two lecturers from FMIPA, Universitas Negeri Medan. The results of the test expert validation as a whole obtained an average value of 94.79% in the "very valid" category so that the developed e-module is feasible to use, but there are several things that need to be revised based on suggestions and comments given by the validator. Test validation results and data processing can be seen on Appendix 7 and Appendix 8.

4.2.2. Revision

Based on comments and suggestions given by experts during validation, there are improvements to the product.

1) Material Expert

The following suggestions/inputs from material experts for improving the product being developed are:

- Connect the content of the material in daily life
- Add examples and questions in exercises
- Improve the format of tables and figures

Based on the suggestions/inputs provided by material/content experts during validation, the researchers made improvements according to these suggestions and input. Validation statement of material experts is attached on Appendix 17. Material improvements made can be seen in the Table 4.4.

Table 4.4 Improvement from Material Expert Suggestions/Inputs

<table>
<tr><th>No</th><th colspan="2">Improvements/Suggestions</th></tr>
<tr><td>1</td><td colspan="2">Connect the content of the material in daily life</td></tr>
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 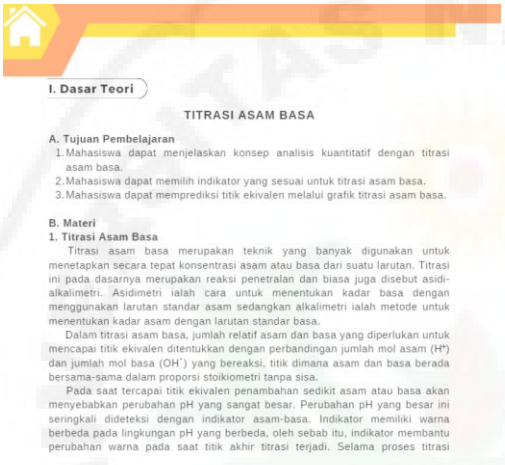
I. Dasar Teori
TITRASI ASAM BASA
A. Tujuan Pembelajaran
1. Mahasiswa dapat menjelaskan konsep analisis kuantitatif dengan titrasi asam basa.
2. Mahasiswa dapat memilih indikator yang sesuai untuk titrasi asam basa.
3. Mahasiswa dapat memprediksi titik ekivalen melalui grafik titrasi asam basa.
B. Materi
1. Titrasi Asam Basa
Titrasi asam basa merupakan teknik yang banyak digunakan untuk menetapkan secara tepat konsentrasi asam atau basa dari suatu larutan. Titrasi ini pada dasarnya merupakan reaksi penetralan dan biasa juga disebut asidi-alkalimetri. Asidimetri ialah cara untuk menentukan kadar basa dengan menggunakan larutan standar asam sedangkan alkalimetri ialah metode untuk menentukan kadar asam dengan larutan standar basa.
Dalam titrasi asam basa, jumlah relatif asam dan basa yang diperlukan untuk mencapai titik ekivalen ditentukkan dengan perbandingan jumlah mol asam (H^+) dan jumlah mol basa (OH^-) yang bereaksi, titik dimana asam dan basa berada bersama-sama dalam proporsi stoikiometri tanpa sisa.
Pada saat tercapai titik ekivalen penambahan sedikit asam atau basa akan menyebabkan perubahan pH yang sangat besar. Perubahan pH yang besar ini seringkali dideteksi dengan indikator asam-basa. Indikator memiliki warna berbeda pada lingkungan pH yang berbeda, oleh sebab itu, indikator membantu perubahan warna pada saat titik akhir titrasi terjadi. Selama proses titrasi</td><td>After Revision
B. Materi
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Titrasi asam basa merupakan teknik yang banyak digunakan untuk menetapkan secara tepat konsentrasi asam atau basa dari suatu larutan. Titrasi ini pada dasarnya merupakan reaksi penetralan dan biasa juga disebut asidi-alkalimetri. Asidimetri ialah cara untuk menentukan kadar basa dengan menggunakan larutan standar asam sedangkan alkalimetri ialah metode untuk menentukan kadar asam dengan larutan standar basa.
Terdapat beberapa penerapan titrasi asidimetri dan alkalimetri dalam kehidupan sehari-hari, diantaranya:
• Penetapan kadar asam lemak bebas pada sabun mandi dengan metode asidimetri
• Analisa kadar asam lemak bebas dalam minyak goreng dengan metode alkalimetri
• Analisis kandungan boraks sebagai bahan pengawet pada bakso
• Penetapan kadar natrium benzoat pada kecap manis dengan metode alkalimetri.
Dalam titrasi asam basa, jumlah relatif asam dan basa yang diperlukan untuk mencapai titik ekivalen ditentukkan dengan perbandingan jumlah mol asam (H^+) dan jumlah mol basa (OH^-) yang bereaksi, titik dimana asam dan basa berada bersama-sama dalam proporsi stoikiometri tanpa sisa.
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<tr><td>2</td><td colspan="2">Add examples and questions in exercises</td></tr>
<tr><td></td><td>Before Revision
• Example
Konsentrasi larutan standar dalam titrasi dapat dinyatakan molaritas (M) atau normalitas (N).
a. Molaritas atau kemolaran (M)
Satuan ini menyatakan konsentrasi sebagai banyaknya mol solut per liter larutan (mol/L atau mmol/mL). Konsentrasi molar biasanya dinotasikan dengan menggunakan tanda kurung siku, misalnya konsentrasi molar X ditulis [X].
$\text{Molaritas (M)} = \frac{\text{Mol zat terlarut (n)}}{\text{Volume larutan (V)}}$
Karena $\text{Mol} = \frac{\text{Gram zat terlarut (g)}}{\text{Massa Molekul Relatif (Mr)}}$
Jadi $M = \frac{g}{Mr \times V}$
$g = M \times Mr \times V$
b. Normalitas (N)
Normalitas suatu larutan menunjukkan banyaknya mol 'unit yang bereaksi' per liter. Satu mol unit yang berreaksi dinamakan ekivalen.
Normalitas = jumlah ekivalen zat terlarut per liter larutan.
$\text{Normalitas (N)} = \frac{\text{Ekivalen Zat Terlarut (ek)}}{\text{Volume larutan (V)}}$
$ek = g/BE$
sehingga $N = \frac{g}{BE \times V}$
$gr = N \times V \times BE$
Hubungan antara Normalitas dan Molaritas adalah:
$N = n \times M$;
n = jumlah mol ion Hidrogen, elektron atau kation univalen yang tersedia dalam reaksi kimia.
• Exercise</td><td>After Revision
• Example
Contoh:
Seorang mahasiswa melakukan titrasi untuk menentukan konsentrasi larutan barium hidroksida. Sebanyak 25 mL larutan tersebut dititrasi dengan larutan standar asam klorida 0,14 M. Titik akhir titrasi dicapai setelah penambahan titran sebanyak 23,3 mL. Berapakah konsentrasi larutan barium hidroksida tersebut?
Jawab:
Tulis reaksinya dan pastikan telah setara:
$2HCl(aq) + Ba(OH)_2(aq) \rightarrow 2H_2O(l) + BaCl_2(aq)$
Mol titran, mmol HCl = M x V = 0,14 mmol/mL x 23,3 mL = 3,262 mmol
Berdasarkan persamaan reaksi, maka mol $Ba(OH)_2$ adalah setengah mol HCl
mmol $Ba(OH)_2$ = 1/2 mmol HCl = 1/2 x 3,262 mmol = 1,631 mmol
Maka konsentrasi $Ba(OH)_2$ adalah $\frac{1,631 \text{ mmol}}{25 \text{ mL}}$ = 0,0652 M

b. Normalitas (N)
Normalitas suatu larutan menunjukkan banyaknya mol 'unit yang bereaksi' per liter. Satu mol unit yang berreaksi dinamakan ekivalen.
Normalitas = jumlah ekivalen zat terlarut per liter larutan.
$\text{Normalitas (N)} = \frac{\text{Ekivalen Zat Terlarut (ek)}}{\text{Volume larutan (V)}}$
$ek = g/BE$
Sehingga $N = \frac{g}{BE \times V}$
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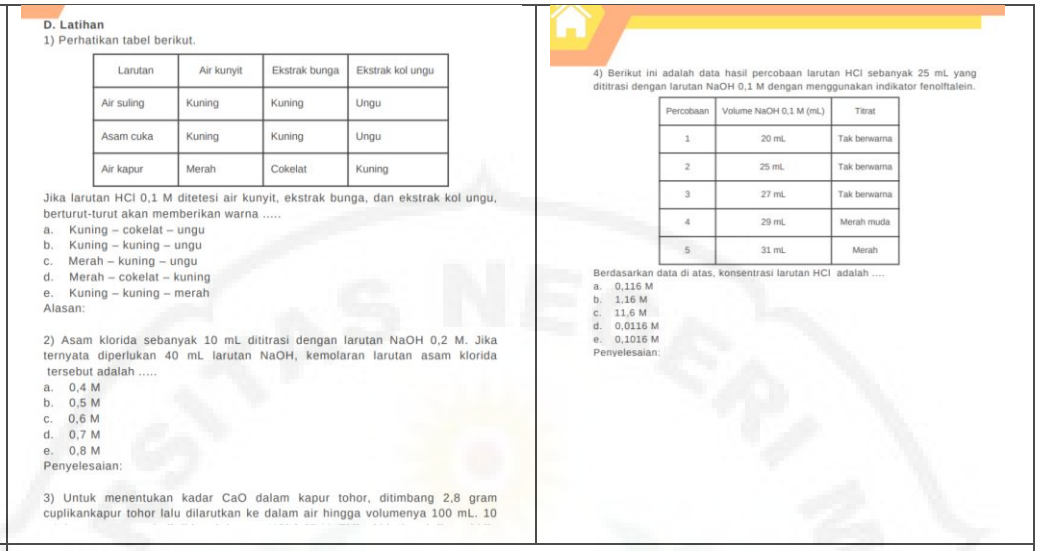
Hubungan antara Normalitas dan Molaritas adalah:
$N = n \times M$;
n = jumlah mol ion Hidrogen, elektron atau kation univalen yang tersedia dalam reaksi kimia.
Contoh:
Hitunglah berat ekuivalendan normalitas larutan 6,0 M H3PO4 jika diketahui reaksinya sebagai berikut:
• $H_3PO_4(aq) + 3OH^-(aq) \rightleftharpoons PO_4^{3-} + 3H_2O(l)$
• $H_3PO_4(aq) + 2NH_3(aq) \rightleftharpoons HPO_4^{2-} + 2NH_4^+$
• $H_3PO_4(aq) + F^-(aq) \rightleftharpoons H_2PO_4^- + HF(aq)$
• Exercise</td></tr>
</table>



D. Latihan

1) Perhatikan tabel berikut.

Larutan	Air kunyit	Ekstrak bunga	Ekstrak kol ungu
Air suling	Kuning	Kuning	Ungu
Asam cuka	Kuning	Kuning	Ungu
Air kapur	Merah	Cokelat	Kuning

Jika larutan HCl 0,1 M ditetesi air kunyit, ekstrak bunga, dan ekstrak kol ungu, berturut-turut akan memberikan warna .....

a. Kuning – cokelat – ungu
b. Kuning – kuning – ungu
c. Merah – kuning – ungu
d. Merah – cokelat – kuning
e. Kuning – kuning – merah

Alasan:

2) Asam klorida sebanyak 10 mL dititrasi dengan larutan NaOH 0,2 M. Jika ternyata diperlukan 40 mL larutan NaOH, kemolaran larutan asam klorida tersebut adalah .....

a. 0,4 M
b. 0,5 M
c. 0,6 M
d. 0,7 M
e. 0,8 M

Penyelesaian:

3) Untuk menentukan kadar CaO dalam kapur tohor, ditimbang 2,8 gram cuplikankapur tohor lalu dilarutkan ke dalam air hingga volumenya 100 mL. 10

4) Berikut ini adalah data hasil percobaan larutan HCl sebanyak 25 mL yang dititrasi dengan larutan NaOH 0,1 M dengan menggunakan indikator fenolftalein.

Percobaan	Volume NaOH 0,1 M (mL)	Titrat
1	20 mL	Tak berwarna
2	25 mL	Tak berwarna
3	27 mL	Tak berwarna
4	29 mL	Merah muda
5	31 mL	Merah

Berdasarkan data di atas, konsentrasi larutan HCl adalah ....

a. 0,116 M
b. 1,16 M
c. 11,6 M
d. 0,0116 M
e. 0,1016 M

Penyelesaian:

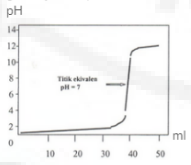
3	Improve the format of tables and figures

Before Revision

Tabel 2. pH Selama Titrasi 40 ml HCl 0,1 M dengan NaOH 0,1 M

Volume NaOH ditambahkan (mL)	pH akhir larutan	Kondisi akhir larutan
0	1,000	Belum ada penambahan basa
10,0	1,222	Belum mencapai titik ekivalen
20,0	1,477	
30,0	1,845	
35,0	2,176	
39,0	2,898	
39,7	3,378	
40,0	7,000	Mencapai titik ekivalen
40,3	10,62	Terdapat kelebihan basa
41,0	11,09	
42,0	11,39	

Berdasarkan hubungan antara volume NaOH yang ditambahkan dan nilai pH larutan dapat dibuat kurva titrasi yang ditunjukkan pada Gambar 1.



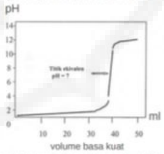
Gambar 1. Kurva Titrasi Asam Kuat-Basa Kuat

After Revision

Tabel 2. pH Selama Titrasi 40 ml HCl 0,1 M dengan NaOH 0,1 M

Volume NaOH ditambahkan (mL)	pH akhir larutan	Kondisi akhir larutan
0	1,00	Belum ada penambahan basa
10,0	1,22	Belum mencapai titik ekivalen
20,0	1,47	
30,0	1,84	
35,0	2,176	
39,0	2,89	
39,7	3,37	
40,0	7,00	Mencapai titik ekivalen
40,3	10,62	Terdapat kelebihan basa
41,0	11,09	
42,0	11,39	

Berdasarkan hubungan antara volume NaOH yang ditambahkan dan nilai pH larutan dapat dibuat kurva titrasi yang ditunjukkan pada Gambar 1.



Gambar 1. Kurva Titrasi Asam Kuat-Basa Kuat

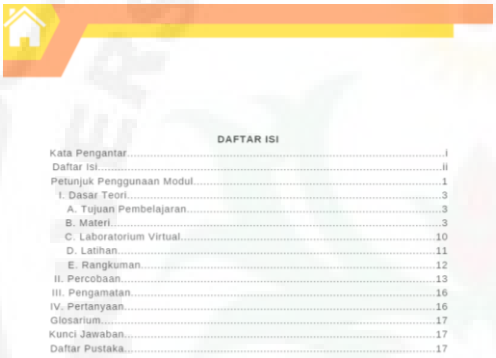
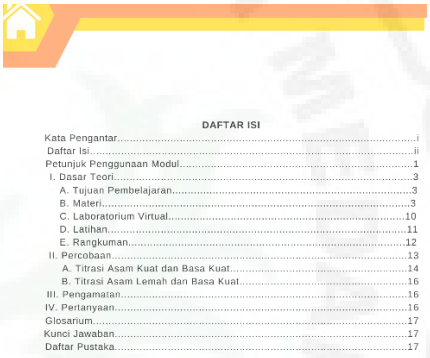
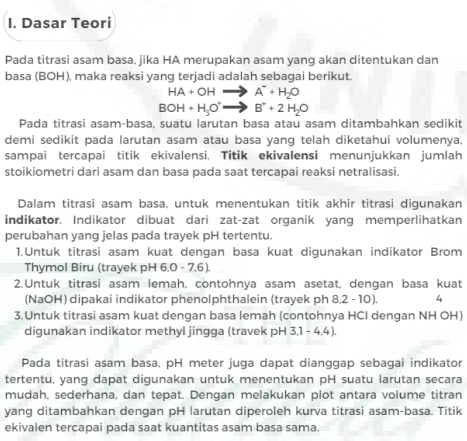
2) Media Expert

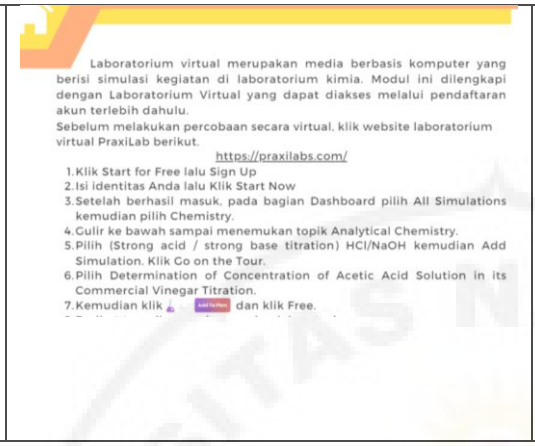
The following suggestions/inputs from media experts to improve the product being developed are:

- Change the Table of Contents in order to go to the practicum part directly
- Add theory about the principle of acid-base titration
- In the virtual laboratory section, provide a separator design

Based on the suggestions/inputs provided by media experts during validation, there are improvements according to these suggestions and input. Validation statement of media experts is attached on Appendix 18. Media improvement carried out can be seen in the Table 4.5.

Table 4.5 Improvement from Media Expert Suggestions/Inputs

<table>
<tr><td>No</td><td colspan="2">Improvements/Suggestions</td></tr>
<tr><td rowspan="2">1</td><td colspan="2">Change the Table of Contents in order to go to the practicum part directly</td></tr>
<tr><td>Before Revision
 
</td><td>After Revision
 
</td></tr>
<tr><td rowspan="2">2</td><td colspan="2">Add theory about the principle of acid-base titration</td></tr>
<tr><td>Before Revision
 
</td><td>After Revision
 
</td></tr>
<tr><td rowspan="2">3</td><td colspan="2">In the virtual laboratory section, provide a separator design</td></tr>
<tr><td>Before Revision</td><td>After Revision</td></tr>
</table>


Laboratorium virtual merupakan media berbasis komputer yang berisi simulasi kegiatan di laboratorium kimia. Modul ini dilengkapi dengan Laboratorium Virtual yang dapat diakses melalui pendaftaran akun terlebih dahulu.
Sebelum melakukan percobaan secara virtual, klik website laboratorium virtual PraxiLab berikut.

https://praxilabs.com/

1. Klik Start for Free lalu Sign Up
2. Isi identitas Anda lalu Klik Start Now
3. Setelah berhasil masuk, pada bagian Dashboard pilih All Simulations kemudian pilih Chemistry.
4. Gulir ke bawah sampai menemukan topik Analytical Chemistry.
5. Pilih (Strong acid / strong base titration) HCl/NaOH kemudian Add Simulation. Klik Go on the Tour.
6. Pilih Determination of Concentration of Acetic Acid Solution in its Commercial Vinegar Titration.
7. Kemudian klik dan klik Free.


C. Laboratorium Virtual

Laboratorium virtual adalah media berbasis komputer yang berisi simulasi kegiatan di laboratorium kimia. Sebelum melakukan percobaan secara virtual, klik website laboratorium virtual PraxiLab berikut.

https://praxilabs.com/ atau pindai kode QR

- Klik *Start for Free* lalu *Sign Up*
- Isi identitas Anda lalu klik *Start Now*
- Setelah berhasil masuk, pada bagian *Dashboard* pilih *All Simulation*
- Pilih *Chemistry*.
- Gulir ke bawah sampai menemukan topik *Analytical Chemistry*.
- Pilih (*Strong acid / strong base titration*) HCl/NaOH kemudian klik *Add Simulation* dan klik *Go on the Tour*.
- Pilih *Determination of Concentration of Acetic Acid Solution in its Commercial Vinegar Titration* kemudian klik *Add Simulation* dan klik *Go on the Tour*.
- Kemudian klik lalu klik *Free*.
- Pada *Dashboard*, klik *My Simulations* lalu pilih laboratorium yang ingin digunakan.

Berikut tampilan laboratorium virtual yang telah ditambahkan.

3) Test Expert

The following suggestions/inputs from test experts to improve the product being developed are:

- The composition of the questions in the pre-test and post-test must be balanced.
- The narrative of the item items is adjusted to the Competency Achievement Indicator with a time allocation of 50 minutes each for each test totaling 10 questions each.
- Improve some components to match the indicators of critical thinking.

Based on the suggestions/inputs provided by test experts during validation, there are improvements according to these suggestions and input.

- There are 10 questions in the pre-test and 10 questions in the post-test.
- There are two questions each on each Competency Achievement Indicator (5 indicators).
- Items are also adapted to the 6 indicators of Critical Thinking Skills by George Brown College.

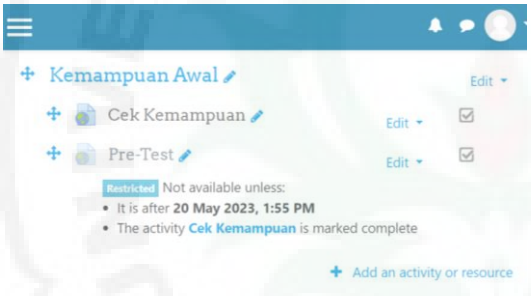
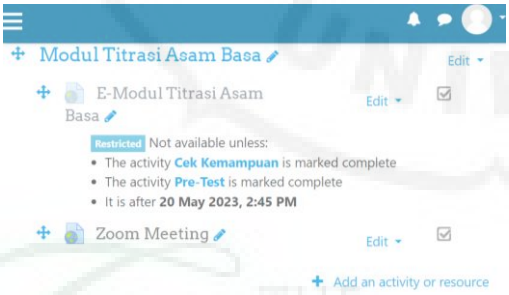
The questions that have been validated are then used in pre-test and post-test attached to the Appendix 3 and 4. Validation statement of test experts is attached on Appendix 16.

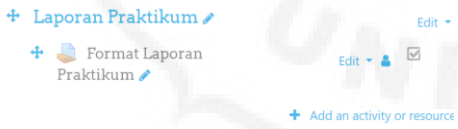
4.3. Students' Activities in Teaching Acid-Base Titration

In implementing the e-module that has been developed, Learning Management System (LMS) is used which is already available at Universitas

Negeri Medan, namely SIPDA. The trial was conducted at Universitas Negeri Medan in Chemistry Education class of 2021 with a total of 28 students. Acid-base titration practicum is done online because their schedule for doing an offline practicum has already been used by another practicum in the Analytical Chemistry course, so this situation is very suitable for research using an e-module that is integrated with a virtual laboratory. In LMS, several stages are carried out as described in Table 4.6.

Table 4.6 Student Activities Using Learning Management System

Section	Information
1. Initial Ability 	In this section students fill out the Ability Check form which is also attached to the e-module and then students can work on the pre-test in 50 minutes for 10 questions. The pre-test is done individual and students are observed while doing the test using the Zoom meetings.
2. Acid-Base Titration Module 	Students can access the e-module after working on pre-test questions. The e-module can be opened via the link linked in this section in the form of a flipbook. Learning is carried out online by using the Zoom application as a forum for students to understand the contents of the module together and so that students can ask directly about material that has not been understood to researchers as laboratory assistants and discuss with their group. Students are enthusiast to learn the acid-base titration material because the e-module is easily

	accessed. They are motivated to do the exercise in the e-module and compare their answers with the answer keys which only can be accessed by scanning the QR code.
3. Virtual Practicum 	Students are given instructions to use Praxilabs as a virtual laboratory so they can do practical work in group. Students can see the steps in carrying out acid-base titrations that have been described in the module. The results of observations during the practicum are collected to the observation results link that has been linked in the e-module. After that, students can answer the post-test in 50 minutes for 10 questions.
4. Practicum Report 	The practicum report was collected a week later on a SIPDA that was connected to a link.

Acid-base titration learning is carried out online so that students have to join the Zoom meeting first. The student activity in zoom meeting can be seen on the Appendix 21. The Zoom application is used because this application can be used as a medium of remote communication that combines video conferencing, chat, online meetings and mobile collaboration. This application is used to support acid base titration learning because this application is effective for use in distance learning (Rahman & Silaban, 2021). After that, students are asked to visit the Learning Management System provided by Universitas Negeri Medan, namely SIPDA. LMS is a technology application developed specifically for managing classrooms, distributing learning materials and enabling collaboration between students and

teachers online. Teachers can create, design and manage classes interactively using the features provided by the SIPDA (Muchtar et al., 2021). Students have to do several activities on SIPDA, such as initial ability, reading the acid base titration e-module, doing the virtual practicum, and then students can upload the practicum report. SIPDA is used during the learning of acid base titration so it is divided into some sections. Each section has its own prerequisites to be able to access it. Before being able to do the pre-test, students are required to fill out the Ability Check questionnaire in the initial ability section. After the initial ability has been marked as done, students can access the e-module integrated with virtual laboratory, which can be seen on Appendix 20, in the next section and hold discussions with group mates on the zoom meeting link provided.

The e-module has been integrated with a virtual laboratory, namely Praxilabs, so that students can study material in the module while doing practicum. Then in the virtual practicum section, there is a post-test that can be done after the pre-test and acid base titration e-module has been marked as done. The pre-test in the initial ability section and the post-test in the virtual practicum section in the LMS will be directly connected to google forms. Google form is used because this tool with certain techniques has the ability to start from the management of teaching materials, assessment, and evaluation to an analysis of results student absorption (E. E. Sari & Hakim, 2020). Students implement the activities well because all students attend the zoom meetings while doing the pre-test and post-test on google forms, discuss the e-module in group and collect the practicum reports on SIPDA.

The development of innovative teaching materials will help students prepare for new skills that are relevant in the 21st century. One of the innovations in the delivery of teaching and learning materials is utilizing an interactive digital e-book called a flipbook which is one of the solutions in science learning as an effort to improve students' critical thinking skills (Riyanto et al., 2020). The use of e-module integrated with virtual laboratory is carried out in group learning systems can make students work together in building their understanding and knowledge, so students are easier to remember and understand. This is known when students answer probing prompting questions and encourage students to work together and discuss in answering this question. Thus learning becomes more effective and will have a

positive effect on scientific attitudes, students' thinking skills and student learning outcomes (Julita et al., 2019).

4.4. Results of Teaching on Acid-Base Titration

After the implementation stage is completed, the results of the student's pre-test and post-test are obtained. The data was obtained using two-tier instrument test of 20 questions which is in accordance with Subject Learning Outcomes (CPMK). These questions are multiple choice questions accompanied by reasons or also known as the two-tier test.

4.4.1. Normality Test and Hypothesis Test

The tests are answered by 28 students in Chemistry Education class of 2021 at Universitas Negeri Medan using an e-module integrated with a virtual laboratory, so the data recapitulation is obtained as follows.

1) Normality Test

The results were analysed using the Shapiro Wilk normality test using SPSS 25 to determine if the data is normally distributed or not.

Table 4.7 Normality Test based on Pre-test and Post-test Score

	Shapiro-Wilk		
	Statistic	df	Sig.
Pre	.982	28	.896
Post	.958	28	.317

Based on the normality test of Shapiro Wilk in Table 4.7 for the score of critical thinking skills pre-test, the p-value is 0.896 so that 0.896 > α = 0.05. This shows that the pre-test critical thinking skills data comes from samples that are normally distributed. Likewise, the post-test critical thinking skills obtained a p-value of 0.317 > 0.05, which indicates that the data comes from a normally distributed sample. Result of Normality Test using SPSS 25 can be seen on Appendix 14.

2) Hypothesis Test

Testing the average critical thinking skills of students after learning by using the e-module integrated with virtual laboratory is carried out by testing the One Sample T-Test using SPSS 25 software.

Table 4.8 Hypothesis Test based on Pre-test and Post-test Score

T-Test	t	df	Sig. (2-tailed)	Mean Diff.
Pre-test	35,920	27	.000	51.000
Post-test	96.686	27	.000	80.143

The results of the SPSS analysis in Table 4.8, for the post-test scores of critical thinking skills on acid-base titration material show that p(Sig.(2-tailed) = 0.000. Because p-value = 0.000 < α = 0.05 then H_1 is accepted. This means that there is an effect of using e-module integrated with virtual laboratory on acid base titration material. Result of Hypothesis Test using SPSS 25 can be seen on Appendix 15.

4.4.2. Effects of E-Module Integrated with Virtual Laboratory on Students' Critical Thinking Skills

From the pre-test and post-test, the critical thinking skills is analyzed based on students' reasons in choosing the answers which has matched with the four assessment criteria. The criteria can be seen in the Appendix 2. The pre-test questions and post-test questions is in accordance with the critical thinking skills by George Brown College. Based on Table 4.9, it can be seen that students' critical thinking skills have increased from the average of 49.77 in pre-test result to 80.90 in post-test result. The comparation of pre-test and post-test in the critical thinking skills assessment can be seen on the Table 4.9. The critical thinking skills of student is in the category of "very good" which is the post-test has the total score of 80.90 after using the e-module integrated with virtual laboratory on acid-base titration material.

Table 4.9 Category of Critical Thinking Skills Assessment

No	**Indicator**	**Score**		**Summary**
		Pre-test	**Post-test**	
1.	Identification of problems	42.41	84.82	Very Good
2.	Supporting sources	63.39	87.79	Very Good

3.	Analysis	58.03	75.29	Good
4.	Contradictory facts	57.14	75.00	Good
5.	Personal Assumptions	40.17	82.14	Very Good
6.	Conclusion	37.5	80.35	Very Good
	Total	**49.77**	**80,90**	**Very Good**

From the Table 4.9, each indicator of critical thinking skills shows improvement. Students' critical thinking skills have been achieved after implementation of the e-module integrated with virtual laboratory on acid-base titration material. It can be described on the Table 4.10.

Table 4.10 Description of Critical Thinking Skills in Tests

No.	Skills	Description of Critical Thinking Skills
1	Identification of problems	This skill is in clarifying issues. In the e-module, the students have the skill to choose the method for titration after understanding the principle of acid-base titration. Based on the students' post-test answer sheets, it can be analyzed that most of them can solve this skill problem correctly because students are able to determine titrants, titrates, and indicators in acidimetric titrations. Students can determine the type of acid-base titration curve well.
2	Supporting sources	This skill is in identifying information or facts that are used to build reasons. In the e-module, student have the skill to choose the standard solution and acid-base indicators to do the titration experiments after understanding the standard solution and indicator topic. In this skill, students are able to solve questions correctly because students are able to determine the correct pH range and indicator for an acid-base titration based on the information provided.
3	Analysis	This skill is in analyzing statements or facts to build arguments or conclusions. In the e-module, student have the skill to choose the tools and materials they use in each

		experiment, analyze the right indicators, analyze the data they get from using the pH meter and making the titration curve. In this skill, students can estimate the shape of the titration curve from acid-base, calculate the volume of carbonic acid in a titration, and determine titrant and titrate solutions based on the titration curve presented.
4	Contradictory facts	This skill is in reviewing conflicting facts, information, or methods. In the e-module, student have the skill to do the experiment in virtual laboratory well and make sure the practicum data in experiment is similar to theories. In this skill, students can determine titrant and titrate solutions based on the titration curve presented.
5	Personal Assumptions	This skill is in acknowledging individual prejudices or assumptions. In the e-module, student have the skill to measure their ability in doing experiment so they have to checklist the ability check first. In this skill, students can analyze ions whose number is more dominant before the titration reaches the equivalence point.
6	Conclusion	This skill is in making conclusion. In the e-module, student have the skill to make the practicum report. In this skill, students calculate the concentration of a base in a titration based on the information about the volume, molarity and indicator of acid-base titration.

After students understand the acid base titration material in the e-module integrated with a virtual laboratory, students can provide logical and critical reasons so that they can meet the criteria for assessing critical thinking skills. This is in line that the critical thinking includes the ability to read with understanding and identify material that is needed. It also means being able to draw conclusions from the data provided and be able to determine inconsistencies and disagreements within a group of data (E. E. Sari & Hakim, 2020). It can be concluded that the e-module integrated with virtual laboratory can improve the critical thinking of students on acid-base

titration material because the average of each critical thinking indicator is in the category of "very good".

4.4.3. Effect of E-Module Integrated with Virtual Laboratory on Student Learning Outcomes

Students are given 20 multiple choice question with a score of 2 for each right answer and with a maximum score of 8 for each reason. The result of pre-test and post-test score by 28 students in Chemistry Education Study Program class of 2021 can be seen on Appendix 13. The descriptions of pre-test and post-test result can be seen on Table 4.11.

Table 4.11 Description of Pre-test and Post-test Result

Information	Score	
	Pre-Test	**Post-Test**
Maximum	66	88
Minimum	34	70
Average	51	80.14
Standard Deviation	7.513	4.386

It can be seen that the highest score of pre-test is 66 and the lowest score of pre-test is 34 while the highest score of post-test is 88 and the post-test lowest score is 70. The data can be presented as the students' learning outcomes that come from the post-test score. Students' mastery learning is measured by competency achievement seen from their learning outcomes. The students' achievement was obtained from pre-test and post-test marks, the range of marking scale is 0-100. Students who have achieved >75 learning outcomes are classified as competent (Sutiani et al., 2021).

The e-module integrated with virtual laboratory can improve students' learning outcomes on acid-base titration material. This is in line with several studies which have shown that the use of flipbooks has a positive impact on improving the quality of the process and student learning outcomes (Isnaeni & Agustina, 2018). The use of a virtual laboratory itself also effects the critical thinking skills so that the students' learning outcomes increased. This is in line with the research by H. K.

Sari et al. (2020) shows that there is an increase in the average learning outcomes and critical thinking skills in virtual laboratory assisted learning on acid-base titration topic.

The e-module integrated with virtual laboratory has advantages and disadvantages as a learning material. The advantages of this e-module include:

- The e-module integrated with virtual laboratory is an acid base titration learning material that can be accessed via smartphone and computer anytime and anywhere.
- The e-module integrated with virtual laboratory can be downloaded in the form of pdf document from the link of flippingbook to be saved offline.
- The e-module integrated with virtual laboratory on acid base titration learning material is very likely to be developed in accordance with the development of science and technology.
- The e-module integrated with virtual laboratory can improve students' critical thinking skills.

The disadvantages of this e-module include:

- The material presented in the e-module integrated with virtual laboratory is limited to acid base titration.
- The practicums only consist of strong acid-strong base titration and weak acid-strong base titration.
- The language of virtual laboratory used in this e-module is not available in Indonesian.