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Research Article

Development and Validation of Discovery-Based Modules in Teaching Chemistry

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ABSTRACT

This study is focused on developing and validating the discovery-based modules in chemistry. This exploration was initiated in response to the criminology student's least-learned concepts in the general (organic) chemistry course. A descriptive–developmental approach was utilized and guided by the Analysis-Design-Development-Implementation-Evaluation (ADDIE) model in the development and validation of the discovery-based modules. In the study, two discovery-based modules were developed. Each module had the following parts: a pre-test, an overview, safety precautions, preparation, a review, the activity itself, a discussion after the activity, a post-activity test, an application, and a reference. Five (5) chemistry teacher experts and five (5) criminology student-users evaluated the aspects of the discovery-based modules using the validation and evaluation forms of the study. The researcher interviewed the criminology student-users using the validated interview guide questions to determine their feedback using the modules. Findings revealed that both chemistry teacher experts and criminology student-users rated the two developed discovery-based modules as excellent and strongly agreed on all pertaining aspects of the modules, in terms of objectives, content, format and language, presentation, and usefulness. The feedback of the student-users revealed interactive, well-designed, discovery-based, and outcome-based themes perceived as the characteristics of the developed chemistry modules. Therefore, it was concluded that the developed discovery-based modules in chemistry are valid, acceptable, and could be used as supplementary material for criminology students and further recommended for possible replication to cover the other least-learned chemistry concepts.

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INTRODUCTION

A self-instructional learning module is an instructional learning material that has been utilized purposively in shifting to flexible learning amid the pandemic (Pawilen, 2021; Castroverde & Acala, 2021; Dangle & Sumaoang, 2020). Moreover, modules are designed for the user to master specific learning objectives with a minor teacher's role (Akinbobola et al., 2010). It means the teacher acts as a facilitator who guides and gives directions to the user (Udo, 2010). The usage of modules allows learners with a high ability to learn and master the material more quickly. Meanwhile, students with low learning speed can be learned by repeating the parts that are not being understood (Sukiman, 2011). Modules make students learn individually and adjust their learning speed according to their ability (Septiani et al., 2014).

The paramount importance of using modules allows the student to learn independently, for teachers to improve teaching and learning activities, and facilitate the effectiveness of the instruction (Fradd et al., 2001; Matarazzo et al., 2010; Madrazo & Dio, 2020). The Module is systematically arranged and designed to help the student learn the subject independently with minimal guidance from the teacher. The students in their learning can utilize the Module to search or find information on the topic being studied that is packed systematically, containing a set of planned learning activities and explored experiences designed to aid the learners in achieving a specific learning objective or competencies (Daryanto, 2013).

Using instructional material such as modules supports the theory of Piaget (1954). Cognitive development theory states that children construct and understand the world around them by experiencing disparateness of their prior knowledge versus what they discover in their environment. The cognitive developments meant how children think, explore, and figure out things by themselves. Therefore, cognitive development is a progressive reorganization of the mental process due to biological maturation and environmental experience. In the study, the development of the module was based on the discovery learning approach as a chosen model by the researchers to provide the learner an independent learning and active involvement with the concept and principles (Nasution et al., 2020). Moreover, it offers learning opportunities to enhance students' knowledge and overcome deficiencies in learning (Gordon & Nicholas, 2013; Madrazo & Dio, 2020; Dela Fuente & Biñas, 2020). Hence, the development of the module underwent a validation process by the pool of experts in the field as to the validity of the produced self-instructional materials as a product of the study that could be used in the classes for teaching chemistry courses.

The General chemistry (organic) course is an additional general education (AdGE) course administered to criminology students, usually during their second year in the Bachelor of Science in Criminology Program. This course allows the criminology students to study the general concepts of chemistry, such as common elements, the principles of chemical reactions, and the chemistry of carbon and carbon compounds with organic chemistry, with particular attention to criminal investigations (CHED CMO NO. 21, 2005; CHED CMO NO. 04, 2018). The course General chemistry (organic) is vital for criminology students in crime scene processing (Barar, 2016) and forensic science in investigating and detecting crime as they will apply the knowledge, skills, scientific attitudes, and values learned from undertaking the course (CHED CMO NO. 04, 2018, Daalen, 2016). Discovery learning is a model that helps learners achieve active learning, acquire knowledge, and build scientific concepts that learners discover themselves (Carin, 1997). The use of discovery learning as an approach to develop self-instructional materials such as modules adheres to Bruner (1961) that discovery learning follows active learning and knowledge that automatically generates the best results. He also suggested that learning is more meaningful for students if they focus on understanding information structure and must identify themselves.

Several research findings claimed that a discovery-based module would reduce the teacher's role, which means the teacher is not thoroughly explaining the center of learning. Still, the teacher acts as a facilitator who guides and directs the students (Dela Fuente, 2021; Ellizar et al., 2018). This

process allows the learner to learn at their own pace, and a learner can acquire the skills, knowledge, and attitude in the absence of the teacher through a discovery-based module (Padmapriya, 2015). The discovery learning process improves students' critical thinking skills (Desriyante et al., 2019). In addition, discovery learning can enhance the mastery of materials, retention, and transfer of knowledge and understanding (Sukiman, 2011). Thus, learners can develop positive attitudes learning in the discovery approach and improve learning outcomes (Yerimadesi et al., 2018). The discovery learning model has the characteristics of a scientific approach and could be used to enhance and strengthen critical thinking skills. This approach encourages students to think and analyze independently to find their knowledge and understanding (Dela Fuente, 2019;Yuliani & Saragih, 2015), the same way as Risdianto said that using the discovery learning model gives the student developed thinking ability (Risdianto, 2013). Furthermore, Sugiarti & Husian (2021) revealed that implementing Contextual-Based Discovery Learning in Chemistry on the topic Acid-Base affects students' academic honesty. The academic honesty test and observation showed that learners being taught with Contextual-Based Discovery Learning achieved significantly higher than those learning without Contextual-Based Discovery Learning, indicating an influence of the Contextual-Based Discovery Learning model on the academic honesty of high school students.

There are several published related articles on the validity and practicality of modules, particularly in teaching chemistry, that use a discovery learning approach, such as the "Validity and Practicality of Buffer Solution Module Based on Discovery Learning with a Scientific Approach to Increase the Critical Thinking Ability of 11th Grade High School Students" (Lestari et al., 2019). Based on the research and data analysis results, the level of validity is very high and very high practicality level from small group questionnaire results, high field test results questionnaire, and high practicality level from results of questionnaire response. Also, the same results are recorded on the topics of the Acid-Base Module Based on Guided Discovery Learning for Senior High School (Yerimadesi et al., 2018). However, there is no online research on the development and validation of discovery-based modules in teaching chemistry that can be used in higher educational institutions (HEIs) in modular distance learning settings in the new normal education. Most of the published related research online is on the development of discovery-based modules in chemistry in the K to 12 education programs. Moreover, the researchers' institution has not strictly utilized and implemented a module format that could be used by all the teaching staff of the institutions in teaching all the courses offered. It has resulted in various forms of module format created solely by the teachers in delivering their given courses, particularly for general education, such as teaching general chemistry. Therefore, it is imperative to develop a discovery-based module as there are no studies conducted on creating a module that focuses on teaching chemistry in HEIs.

Objectives

The study primarily aims to develop and validate the discovery-based modules in chemistry for criminology students. Specifically, this study sought to answer the questions below:

1. What is the validity of the Discovery-Based Modules in Chemistry as evaluated by the teacher experts based on objectives, content, format and language, presentation, and usefulness?
2. What is the validity of the Discovery-Based Modules in Chemistry as evaluated by the student-users based on format and content?
3. What is the student-users feedback on the Discovery-Based Modules in Chemistry?

METHOD

This study has utilized the descriptive–developmental research design as it focuses on developing instructional material in the form of a discovery-based module in chemistry. The researchers developed the discovery-based chemistry modules from the criminology students' least-learned general chemistry (organic) concepts. The Analysis-Design-Development-Implementation-Evaluation model was used to guide the study process to design and develop an effective discovery-based chemistry module, as shown in Figure 1.

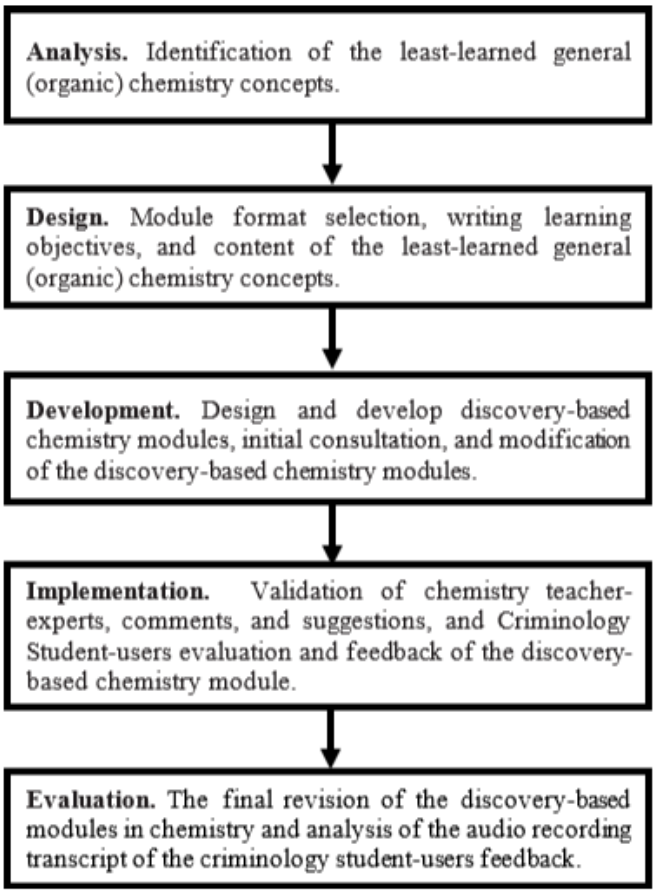

Figure 1. *Schematic diagram of the study*

Participants

The research participants of the study were five (5) student-users, purposively selected to evaluate the developed discovery-based module in chemistry. The selected student-users satisfied the following criteria: (1) The student-users are bonafide students from the institution in the academic year 2021-2022 during the second semestral period; (2) The student-users must be enrolled under the program Bachelor of Science in Criminology; (3) Lastly, the student-users must be taking the General Chemistry (Organic) course at the time of the conduct of the study.

Validators

The study's research validators were five (5) teacher-experts who were purposively selected and are composed of two (2) public and three (3) private teachers or instructors in Higher Education Institutions (HEIs), which their educational qualifications are master's and a doctorate degree holder, have been teaching various chemistry courses for at least three years and have attended several seminar and training workshops on Module making.

Instruments

The research instruments employed in the study are the validation form for teacher-experts, the evaluation form for student-users, with validated interview guide questions to seek student-users feedback.

Teacher-experts validation form

Based on determining the general acceptability of the developed discovery-based modules in chemistry, a five-point rating scale was cited from a study by Torrefranca (2017) as adapted from Marasigan (2003) and Marin (2003). The researcher made some modifications to the five (5) items for the objective, content, format and language, presentation, and usefulness aspects of the discovery-based modules to suit the nature and purpose of the present study. The experts validated the modifications made to the items of each aspect.

Student-users evaluation form

This evaluation form uses a five-point rating scale that was cited in a study by Torrefranca (2017) as adapted from Marasigan (2003) and Marin (2003). Unlike the teacher-experts validation form, the student-users evaluation form only evaluated the ten (10) items of format and content aspects of the discovery-based chemistry modules with Interview Guide Questions. The researchers, aided by interview guide questions, as the primary instruments used to extract feedback from the student-users. The validated semi-structured interview guide used open-ended and probing questions to explore and describe their experiences, views, and perceptions of utilizing the discovery-based chemistry modules.

Procedures

The study process was guided by the Analysis-Design-Development-Implementation-Evaluation (ADDIE) model in the development and validation of the discovery-based chemistry modules.

Analysis phase

In the analysis phase, the researchers wrote a formal letter of permission to the President and CEO of one of the higher educational institutions in Ipil, Zamboanga Sibugay, offering a BS in Criminology program. The chemistry instructors in the criminology program identified the least-learned general (organic) chemistry concepts through an interview via mobile phone. The researchers purposively selected the least-learned general chemistry (organic) concepts from the feedback of the chemistry instructors, particularly in the organic chemistry area, on the structure of organic molecules and organic functional groups that were the basis for developing discovery-based modules in chemistry. In this phase, the purposive selection of the five (5) teacher-experts and five (5) student-users as validators and evaluators of the discovery-based modules were also identified.

Design phase

The researchers designed an appropriate learning objective, assessments, and content lesson to address the criminology students' least-learned general chemistry (organic). The researchers have selected the format of the discovery-based chemistry modules adapted from the published self-learning module in chemistry by the University of the Philippines National Institute for Science and Mathematics Education Development (UP NISMED, 2021). The format includes Pre-test, Overview, Safety Precaution, Advance Preparation, Review, activity Proper, Post-Activity Discussion, Post-test, Application, and Reference, respectively.

Development phase

In this phase, the researcher developed the first draft of the discovery-based chemistry modules and integrated discovery-based learning activities into the modules. The first draft underwent presentation and consultation with the thesis adviser, chemists, chemistry teachers, criminologists, criminology teachers and students, colleagues, and module experts to let the developed discovery-based modules be revised initially before the final validation. The initial validation and feedback from those mentioned earlier were taken into account to modify the

module's first draft before presentation to the teacher-experts and finally to the student-users, respectively.

Implementation phase

After the researchers had revised the discovery-based chemistry modules based on the comments, suggestions, and recommendations, they were printed out and presented to the intended student-users. After the student-user performed and answered all the discovery learning activities and guide questions on the discovery modules, the researchers collected their output and checked it. The researchers then provided the student-users with the evaluation form to evaluate the aspect of each module. They interviewed through a mobile call with the student-users at their most convenient time. An audio recording was done per the student participants' consent. The interview lasted 15-25 minutes and added follow-up questions to the response of the student-users that were not captured in the interview guide questions.

Evaluation phase

In this phase, the discovery modules were enhanced after completing the validation and evaluation feedback forms of the teacher-expert and student user, respectively. The data obtained from the validation and evaluation of the discovery-based modules from the teacher-experts and student-users were treated statistically using numerical and descriptive statistics like frequency count and weighted mean to measure central tendencies using MS Excel and SPSS (Creswell, 2012, p. 183). On the other hand, thematic analysis was used to analyze the interview transcripts to present the student-user feedback on the discovery-based module developed. There were six steps used: (1) Acquainting yourself with the interview transcripts, (2) generating initial codes of the student-user, (3) searching for the themes that emerged, (4) reviewing the themes, and (5) defining and naming the themes. Lastly, (6) produce a report on emerging themes (Braun & Clarke, 2006). This helped examine different student-users perspectives, highlighting similarities and differences and generating unexpected insights. The researchers then offered a holistic definition, explanation, and review of the experiences of the student-users of the developed discovery-based chemistry modules after member-checking the transcriptions to ensure the reliability of emerging themes from the transcripts.

RESULTS AND DISCUSSION

Validation results of discovery-based modules by the teacher-experts

The teacher-expert validators of the study validated the two (2) discovery-based modules based on the five aspects, which include: (1) objectives, (2) content, (3) format and language, (4) presentation, and (5) usefulness aspects of the discovery-based modules in chemistry as to the degree value of 4.50 – 5.00 (Strongly Agree) = Excellent; 3.50 – 4.49 (Agree) = Very Good; 2.50 – 3.49 (Undecided) = Good; 1.50 – 2.49 (Disagree) = Fair; and 1:00-1.49 (Strongly Disagree) = Poor as cited from the study of Torrefranca (2017) as adapted from Marin (2003) and Marasigan (2003), to evaluate the discovery-based modules in chemistry.

As reflected, Table 1 exhibits the rating results of the teacher-experts validation of the discovery-based module 1 in chemistry entitled “Structure of Organic Molecules: Use of Marshmallow Model.” The discovery-based module 1 obtained an excellent remark by the teacher-experts *(M = 4.92; SD = 0.17)* of its acceptability. Similar remarks as excellent material has been developed were observed from the average validation ratings of the teacher-experts on the individual aspects of the first discovery-based module as to the objectives *(M = 5.00; SD = 0.00)*, content *(M = 4.96; SD = 0.09)*, format and language *(M = 4.88; SD = 0.27)*, presentation *(M = 4.84; SD = 0.29)*, and usefulness *(M = 4.92; SD = 0.18)*, of the developed materials.

Table 1. Teacher-experts validation ratings of discovery-based module 1

No.	Aspect of the Discovery-Based Module / Item	Discovery-Based Module 1			% Agreement	
		Mean	SD	Remarks	Rating of 5 Strongly Agree	Rating of 4 Agree
	Objectives					
1.	The objectives are stated clearly in behavioral form.	5.00	0.00	Excellent	100	0
2.	The objectives are well-planned, formulated, and organized.	5.00	0.00	Excellent	100	0
3.	The objectives stated are specific, measurable, and attainable.	5.00	0.00	Excellent	100	0
4.	The objectives are relevant to the topics of each lesson of the modules.	5.00	0.00	Excellent	100	0
5.	The objectives take into account the needs of the students.	5.00	0.00	Excellent	100	0
Overall		**5.00**	**0.00**	**Excellent**	**100**	**0**
	Content					
1.	The content of each lesson is directly relevant to the defined objectives.	5.00	0.00	Excellent	100	0
2.	The content of each lesson is simple and easy to understand.	4.80	0.45	Excellent	80	20
3.	The topics of each lesson are fully discussed.	5.00	0.00	Excellent	100	0
4.	The topics are supported by illustrative examples, and the practice tasks are suited to the level of the students.	5.00	0.00	Excellent	100	0
5.	Each topic is given equal emphasis in the lesson.	5.00	0.00	Excellent	100	0
Overall		**4.96**	**0.09**	**Excellent**	**96**	**4**
	Format and Language					
1.	The format/layout is well-organized, which makes the lessons more interesting.	5.00	0.00	Excellent	100	0
2.	The language used is easy to understand.	5.00	0.00	Excellent	100	0
3.	The language used is clear, concise, and motivating.	4.80	0.45	Excellent	80	20
4.	The Chemical symbols used are well-defined.	4.80	0.45	Excellent	80	20
5.	The instructions in the discovery-based modules are concise and easy to follow.	4.80	0.45	Excellent	80	20
Overall		**4.88**	**0.27**	**Excellent**	**88**	**12**
	Presentation					
1.	The topics are presented in a logical and sequential order.	4.80	0.45	Excellent	80	20
2.	The lessons of the discovery-based modules are presented in a unique and original form.	5.00	0.00	Excellent	100	0
3.	The learning activities are presented clearly.	5.00	0.00	Excellent	100	0
4.	The presentation of each lesson is attractive and interesting to the students.	4.80	0.45	Excellent	80	20
5.	Adequate examples are given to each topic.	4.60	0.55	Excellent	60	40
Overall		**4.84**	**0.29**	**Excellent**	**84**	**16**
	Usefulness					
1.	The discovery-based modules will motivate the students to study general chemistry (organic).	4.80	0.45	Excellent	80	20
2.	The discovery-based modules will help the students master the topics at their own pace.	5.00	0.00	Excellent	100	0
3.	The discovery-based modules will allow the students to use their time more efficiently.	5.00	0.00	Excellent	100	0
4.	The discovery-based modules will develop the critical thinking, analytical thinking and reasoning skills of students in solving or answering problems in general chemistry (organic).	4.80	0.45	Excellent	80	20
5.	The discovery-based modules in teaching general chemistry (organic) will serve as a supplementary material that can cater to the needs of the students.	5.00	0.00	Excellent	100	0
Overall		**4.92**	**0.18**	**Excellent**	**92**	**8**
	Overall Aspect of the Discovery-Based Module					
	Objectives	5.00	0.00	Excellent	100	0
	Content	4.96	0.09	Excellent	96	4
	Format and Language	4.88	0.27	Excellent	88	12
	Presentation	4.84	0.29	Excellent	84	16
	Usefulness	4.92	0.18	Excellent	92	8
Overall		**4.92**	**0.17**	**Excellent**	**92**	**8**

The inter-rater agreement by the teacher-expert was calculated to establish the extent to which the teacher-expert agreed on the level of performance ratings on the various aspects of the discovery-based module in chemistry and to have a more realistic measurement of consistency ratings of the teacher-experts because the validation scores range from 4 to 5. As depicted in Table 1, the mean inter-rater agreement in terms of percentage showed a range from 84% in the presentation aspect to 100% in the objective aspect of the discovery-based module 1 by the teacher-experts.

Table 2 presents the rating results of the teacher-experts validation of the discovery-based module 2 in chemistry entitled "Organic Functional Groups." The second discovery-based chemistry module, Organic Functional Groups, was observed to be excellent *(M = 4.91; SD = 0.18* as validated by the teacher-experts. The same remarks were obtained on the aspect of the second discovery-based module in chemistry as to the objectives *(M = 5.00; SD = 0.00)*, content *(M = 4.84; SD = 0.29)*, format and language *(M = 4.84; SD = 0.36)*, presentation *(M = 4.88; SD = 0.27)*, and usefulness *(M = 5.00; SD = 0.00),* of the developed materials.

Table 2. Teacher-experts validation ratings of discovery-based module 2

No.	Aspect of the Discovery-Based Module / Item	Discovery-Based Module 2			% Agreement	
		Mean	SD	Remarks	Rating of 5 Strongly Agree	Rating of 4 Agree
	Objectives					
1.	The objectives are stated clearly in behavioral form.	5.00	0.00	Excellent	100	0
2.	The objectives are well-planned, formulated, and organized.	5.00	0.00	Excellent	100	0
3.	The objectives stated are specific, measurable, and attainable.	5.00	0.00	Excellent	100	0
4.	The objectives are relevant to the topics of each lesson of the modules.	5.00	0.00	Excellent	100	0
5.	The objectives take into account the needs of the students.	5.00	0.00	Excellent	100	0
Overall		**5.00**	**0.00**	**Excellent**	**100**	**0**
	Content					
1.	The content of each lesson is directly relevant to the defined objectives.	5.00	0.00	Excellent	100	0
2.	The content of each lesson is simple and easy to understand.	4.80	0.45	Excellent	80	20
3.	The topics of each lesson are fully discussed.	5.00	0.00	Excellent	100	0
4.	The topics are supported by illustrative examples, and the practice tasks are suited to the level of the students.	4.60	0.55	Excellent	60	40
5.	Each topic is given equal emphasis in the lesson.	4.80	0.45	Excellent	80	20
Overall		**4.84**	**0.29**	**Excellent**	**84**	**16**
	Format and Language					
1.	The format/layout is well-organized, which makes the lessons more interesting.	4.80	0.45	Excellent	80	20
2.	The language used is easy to understand.	4.80	0.45	Excellent	80	20
3.	The language used is clear, concise, and motivating.	4.80	0.45	Excellent	80	20
4.	The Chemical symbols used are well-defined.	4.80	0.45	Excellent	80	20
5.	The instructions in the discovery-based modules are concise and easy to follow.	5.00	0.00	Excellent	100	0
Overall		**4.84**	**0.36**	**Excellent**	**86**	**14**
	Presentation					
1.	The topics are presented in a logical and sequential order.	4.80	0.45	Excellent	80	20
2.	The lessons of the discovery-based modules are presented in a unique and original form.	5.00	0.00	Excellent	100	0
3.	The learning activities are presented clearly.	4.80	0.45	Excellent	80	20
4.	The presentation of each lesson is attractive and interesting to the students.	4.80	0.45	Excellent	80	20
5.	Adequate examples are given to each topic.	5.00	0.00	Excellent	100	0
Overall		**4.88**	**0.27**	**Excellent**	**88**	**12**
	Usefulness					
1.	The discovery-based modules will motivate the students to study general chemistry (organic).	5.00	0.00	Excellent	100	0
2.	The discovery-based modules will help the students master the topics at their own pace.	5.00	0.00	Excellent	100	0
3.	The discovery-based modules will allow the students to use their time more efficiently.	5.00	0.00	Excellent	100	0
4.	The discovery-based modules will develop the critical thinking, analytical thinking and reasoning skills of students in solving or answering problems in general chemistry (organic).	5.00	0.00	Excellent	100	0
5.	The discovery-based modules in teaching general chemistry (organic) will serve as a supplementary material that can cater to the needs of the students.	5.00	0.00	Excellent	100	0
Overall		**5.00**	**0.00**	**Excellent**	**100**	**0**
	Overall Aspect of the Discovery-Based Module					
	Objectives	5.00	0.00	Excellent	100	0
	Content	4.84	0.29	Excellent	84	16
	Format and Language	4.84	0.36	Excellent	86	14
	Presentation	4.88	0.27	Excellent	88	12
	Usefulness	5.00	0.00	Excellent	100	0
Overall		**4.91**	**0.18**	**Excellent**	**91**	**9**

Meanwhile, the inter-rater agreement by the teacher-experts on the level of performance ratings on the various aspects of the discovery-based module 2 depicted in Table 2 showed the mean inter-rater agreement showed in a percentage range from 84% in the content, format, and language aspects to 100% in the objective and usefulness aspects of the discovery-based module 2 by the teacher-experts.

Evaluation results of discovery-based modules by the student-users

The results shown here are the evaluation rating of the five (5) criminology student-user of the discovery-based modules in chemistry. Table 3 exhibits the rating results of the student-users evaluation of the discovery-based module 1 in chemistry entitled "Structure of Organic Molecules: Use of Marshmallow Model." The discovery-based module 1 obtained an excellent remark by the student-user evaluator *(M = 4.92; SD = 0.14)*. The same finding remarks as excellent were observed from the evaluation ratings of the student-users on the aspects of the discovery-based module as to the format *(M = 4.96; SD = 0.09)* and content *(M = 4.88; SD = 0.19)* of the developed materials used by the students.

Table 3. Student-users evaluation ratings of discovery-based module 1

No.	Aspect of the Discovery-Based Module / Item	Discovery-Based Module 1			% Agreement	
		Mean	SD	Remarks	Rating of 5 Strongly Agree	Rating of 4 Agree
	Format					
1.	The layout of the discovery-based modules is arranged in a logical and sequential order.	5.00	0.00	Strongly Agree	100	0
2.	The instructions in the discovery-based modules are emphasized well.	5.00	0.00	Strongly Agree	100	0
3.	The font size and font style of the discovery-based modules are readable.	5.00	0.00	Strongly Agree	100	0
4.	The chemical symbols used in the discovery-based modules are well-defined.	5.00	0.00	Strongly Agree	100	0
5.	The tables/diagrams are well presented and easy to understand.	4.80	0.45	Strongly Agree	80	20
6.	Key points and key concepts are well highlighted to focus attention while reading.	5.00	0.00	Strongly Agree	100	0
7.	Titles and subtitles in the discovery-based are clearly defined.	4.80	0.45	Strongly Agree	80	20
8.	Illustrations, pictures, and captions are properly laid out for easy reference.	5.00	0.00	Strongly Agree	100	0
9.	The discussion in the activity and guide questions are arranged sequentially and easy to follow.	5.00	0.00	Strongly Agree	100	0
10.	The discovery-based modules are generally formatted in a convenient manner considering the paper size used.	5.00	0.00	Strongly Agree	100	0
Overall		**4.96**	**0.09**	**Strongly Agree**	**96**	**4**
	Content					
1.	I easily understood the objectives in each lesson.	5.00	0.00	Strongly Agree	100	0
2.	I easily understood the instructions in each lesson.	5.00	0.00	Strongly Agree	100	0
3.	I could work on the lessons at my own pace.	4.40	0.55	Agree	40	60
4.	I understood clearly the ideas/concepts presented in each lesson.	4.80	0.45	Strongly Agree	80	20
5.	The illustrations/captions/icons guided me easily in following the instructions in the discovery-based modules.	5.00	0.00	Strongly Agree	100	0
6.	The learning activities in the form of laboratory activity helped me to understand fully the topic	5.00	0.00	Strongly Agree	100	0
7.	I appreciated the styles of illustrations and written expressions.	5.00	0.00	Strongly Agree	100	0
8.	I enjoyed performing and answering the activities as presented in the form of laboratory activities.	5.00	0.00	Strongly Agree	100	0
9.	I found it easier to study the general chemistry (organic) course using these discovery-based modules.	4.80	0.45	Strongly Agree	80	20
10.	I enjoyed working through the lessons until I finished the whole discovery-based modules.	4.80	0.45	Strongly Agree	80	20
Overall		**4.88**	**0.19**	**Strongly Agree**	**88**	**12**
	Overall Aspect of the Discovery-Based Module					
	Format	4.96	0.09	Strongly Agree	96	4
	Content	4.88	0.19	Strongly Agree	88	12
Overall		**4.92**	**0.14**	**Strongly Agree**	**92**	**8**

Meanwhile, the inter-rater agreement in terms of percentage was calculated to describe the level of performance ratings on the various aspects of the discovery-based module 1 and to have a more realistic measurement of the consistency of the ratings from the evaluation response of the student-user because the evaluation scores range from 4 to 5. As depicted in Table 3, the mean inter-

rater agreement by percentage showed a range from 88% in the content to 96% in the format aspects of the discovery-based module 1 by the student-users. Table 4 presents the rating results of the student-users of the discovery-based module 2 in chemistry entitled "Organic Functional Groups."

Table 4. Student-users evaluation ratings of discovery-based module 2

No.	Aspect of the Discovery-Based Module / Item	Discovery-Based Module 2			% Agreement	
		Mean	SD	Remarks	Rating of 5 Strongly Agree	Rating of 4 Agree
	Format					
1.	The layout of the discovery-based modules is arranged in a logical and sequential order.	5.00	0.00	Strongly Agree	100	0
2.	The instructions in the discovery-based modules are emphasized well.	5.00	0.00	Strongly Agree	100	0
3.	The font size and font style of the discovery-based modules are readable.	5.00	0.00	Strongly Agree	100	0
4.	The chemical symbols used in the discovery-based modules are well-defined.	5.00	0.00	Strongly Agree	100	0
5.	The tables/diagrams are well presented and easy to understand.	4.80	0.45	Strongly Agree	80	20
6.	Key points and key concepts are well highlighted to focus attention while reading.	5.00	0.00	Strongly Agree	100	0
7.	Titles and subtitles in the discovery-based are clearly defined.	5.00	0.00	Strongly Agree	100	0
8.	Illustrations, pictures, and captions are properly laid out for easy reference.	5.00	0.00	Strongly Agree	100	0
9.	The discussion in the activity and guide questions are arranged sequentially and easy to follow.	5.00	0.00	Strongly Agree	100	0
10.	The discovery-based modules are generally formatted in a convenient manner considering the paper size used.	5.00	0.00	Strongly Agree	100	0
Overall		**4.98**	**0.04**	**Strongly Agree**	**98**	**2**
	Content					
1.	I easily understood the objectives in each lesson.	5.00	0.00	Strongly Agree	100	0
2.	I easily understood the instructions in each lesson.	5.00	0.00	Strongly Agree	100	0
3.	I could work on the lessons at my own pace.	4.40	0.55	Agree	40	60
4.	I understood clearly the ideas/concepts presented in each lesson.	4.80	0.45	Strongly Agree	80	20
5.	The illustrations/captions/icons guided me easily in following the instructions in the discovery-based modules.	5.00	0.00	Strongly Agree	100	0
6.	The learning activities in the form of laboratory activity helped me to understand fully the topic	5.00	0.00	Strongly Agree	100	0
7.	I appreciated the styles of illustrations and written expressions.	5.00	0.00	Strongly Agree	100	0
8.	I enjoyed performing and answering the activities as presented in the form of laboratory activities.	5.00	0.00	Strongly Agree	100	0
9.	I found it easier to study the general chemistry (organic) course using these discovery-based modules.	4.80	0.45	Strongly Agree	80	20
10.	I enjoyed working through the lessons until I finished the whole discovery-based modules.	4.80	0.45	Strongly Agree	80	20
Overall		**4.88**	**0.19**	**Strongly Agree**	**88**	**12**
	Overall Aspect of the Discovery-Based Module					
	Format	4.98	0.04	Strongly Agree	98	2
	Content	4.88	0.19	Strongly Agree	88	12
Overall		**4.93**	**0.12**	**Strongly Agree**	**93**	**7**

As presented in Table 4, the discovery-based module 2, Organic Functional Group, obtained an excellent remark from the student-user evaluator *(M = 4.93; SD = 0.14)*. The same finding remarks as excellent were observed from the evaluation ratings of the student-users on the aspects of the discovery-based module as to the format *(M = 4.96; SD = 0.09)* and content *(M = 4.88; SD = 0.19)* of the developed materials used by the students. Meanwhile, inter-rater agreement in terms of percentage of the discovery-based module 2 from the evaluation response of the student-user

depicted in Table 4 revealed the mean inter-rater agreement by a percentage ranging from 88% in the content to 98% in the format aspects of the discovery-based module 2 by the student-users.

Feedback from student-users

In addition to the validity results of the discovery-based modules in chemistry validated by the teacher-experts and evaluated by the student-users, an interview was conducted (mobile call) to extract their perceptions and experiences of the student-users feedback after they had used the developed materials. Four (4) themes emerged from the student-users feedback based on their experiences in utilizing the discovery-based modules in chemistry. They were: *Interactive, Well-Designed, Outcome-Based,* and *Discovery-Based.*

Interactive

This theme refers to the developed modules being interactive, engaging, and exciting to explore. It is inextricably tied to the development of engaged learning and enhancing cognitive skills through interactive learning modules. This holds true for learners who actively contribute to knowledge creation, synthesis, and generalization. Learners are motivated, interested, and focused when learning modules incite and stimulate thorough instructions and activities.

In the context of interactive discovery-based learning modules, student-users were bewailed about their experiences when they asked what are their learning experiences in using the discovery-based module in chemistry? Student-Users claimed how operative the discovery-based modules were in directing them throughout the sequence, assessments, and evaluations. They affirmed,

> *"I enjoyed in utilizing the discovery-based modules kay naa kay time mag-scanned kung aha ko pwede magbalik-balik. Then, ang module nga nahatag sako kay naa na tanan samot na ang ang mga examples nga kinahanglan. Naa sa iya tanan, naan na sa module, sir. I am really thankful ingato ang arranged. Actually, sir nindot gyud kayo siya kay na-arranged gyud hantud sa application. Medyo challenging siya pero na-enjoyed kayo nako ang challenging part.* [I enjoyed utilizing the discovery-based modules because I had time to scan and go back when needed. I required a variety of examples, which were provided to me. The module had everything that I needed. I was really thankful that it was arranged constructively until its application. They were difficult, but I thoroughly appreciated them.]-SU4, SU3, SU1

According to Bomia (1997), student engagement is the willingness to participate in the learning process. The student's willingness to utilize can be attributed to the chosen approach, which is discovery learning, which allows the student to independently learn the concept and would not depend on the physical teacher while using the developed material (Prinstin & Handayati, 2020). When students are motivated to do well in their courses, involved or invested in their desire to learn, and willing to exert the effort expected by their instructors, they are more likely to be engaged in their education (Dela Fuente, 2021; Mandernach et al., 2011). This claim was observed and manifested based on the responses of the student-users.

Well-designed.

This theme refers to the quality of the design, illustrations, layout, format, and appropriate chemical symbols, which can help a student understand the lesson in the material. This theme infers that every lesson and assessment is in line with the desired outcomes and that the well-designed module is constructively aligned so that learners may actively create their own understanding. A well-designed module can only be successful and effective when the learning objectives or outcomes align with the assessment and the teaching strategy. Student-users showed positive feedback and exploration when asked what particular aspect of the discovery-based module gets their attention or interest.

Student-User 1 deliberately appreciated and shared his thoughts on how seamless and distinct the discovery-based module design is from others. He noted,

> *"Lahi rakayo siya sir sa ubang modules kay clear ang words ug lay-out kay ang ubang teachers or instructors kay ihatag ra wala man lang ka-effort, or style or good format. Gusto kayo nako ang discovery-based modules sa Chemistry, sir kay 100% ang effort.* [It was distinct from other modules since the language and layouts were comprehensible, unlike other teachers or instructors, who simply lay down or distribute the modules without agreeing or exerting any effort, style, or acceptable format. I genuinely appreciated the discovery-based modules in Chemistry, sir, for you had put 100% effort into it.]-SU1, SU3

A well-designed module is a self-sufficient, formally organized, and systematized learning experience with a coherent and clear set of learning outcomes and assessments. A structured, comprehensive approach to the process with an emphasis on the student's learning is required while designing modules. Cheng and Abu Bakar (2017) stressed that the educational process of designing a module does not just concentrate on the content and how the materials are intended; the designs, readable texts, clarity, images, graphics, layouts, physical look, and illustrations offered an excellent presentation. Moreover, Cossid (2021) and Dela Fuente (2021) claimed that colored images and pictures or visual illustrations could trigger student engagement and interest in learning and completing the developed material because it is well-designed. This was observed and manifested based on the responses of the student-users.

Discovery-based.

This theme is the standpoint of the development and evaluation of the discovery-based module in Chemistry that emerged from the transcript. This exemplifies the discovery learning approach, which allows students to take control of their learning through hands-on exploration, and inquiry rather than memorizing (Drexel University, 2000), but students must discover for themselves (Fatihah et al., 2020). Further, student-users believe that this approach allows them to learn new concepts in the discovery-based modules in chemistry by performing the learning activities found in the modules. When they were questioned about the veracity and applicability of the discovery-based module, specifically, what learnings have they gained in using the discovery-based modules in chemistry? Their responses were,

> *"Nakatuon ko, sir, particular atong mangitag bagay sa kusina ng mga ingredients na makatabang sa pagdiscover gikan sa mga material sa balay. Wala kasi kayo koy idea sir ato sir maoto pag start ngyud sa activity naa nakoy much idea like identification of the products nga nakatabang sa pagdiscover ug pagcategorize sa chemical products according to its functional groups, sir.* [I now knew and learned that the material ingredients in the kitchen could be used to identify them by scanning the list of ingredients. I initially lacked prior knowledge, but when the activity began, I was able to recognize the items, which helped me find and classify chemical products located in the kitchen according to their functional groups.]-SU1, SU2, SU3, SU4

The utilization of guide questions allowed student-users to discover the concepts for themselves (Fatihah et al., 2020). The goal of the discovery learning approach is to teach students how to discover concepts on their own. Students are encouraged to study independently through active engagement with the chemistry lesson through exploration of the discovery-based chemistry modules. Thus, the integration of guide questions in the discovery learning activity of the modules provided the student-users to learn in-depth the chemistry concepts on their own judgment, which

adhered to the ultimate goal of the discovery learning approach (Mostafaee, 2015; Kukar et al., 2012). Evidently, the material encouraged students-users to experience discovery-based learning activities that enabled them to discover the chemistry concepts in the chemistry modules (Nasution et al., 2020). This was observed and manifested based on the responses of the student-users.

Outcome-based.

This theme validates a result that differs from considering what they will teach and learn in that it is centered on students' outcomes to build upon throughout the process. It generates a mark in relation to the results and with the inclusive criterion. This means students would thereby acquire deeper knowledge since they would need to provide proof that they had mastered each learning objective in the module instead of just accumulating points.

When probed about the scope of the outcome-based learning module and how the discovery learning activity enables them to discover and understand the lesson? In effect, student-users acclaimed and emphasized that,

> *"Interesting kayo sir, sa application kay kanang na-realized nako na ang Chemistry kay importante siya sako kurso sa Criminology kay syempre daghan kaayog investigation. Kailangan ug Chemistry sir para maka-imbestiga ug tarong*. [It was interesting, sir, because I have finally realized that chemistry is necessary for my criminology course because it covers various investigations that are relevant to my course.]-SU2, SU3

Literature implies that developed modules with outcome-based characteristics could improve student learning course outcomes and the quality of teaching. Even there are various ways that students learn must be taken into account when making instructional materials, and teachers must use these materials to help them teach better and improve the quality of education (Callanta et al., 2019).

This unequivocally proves that the key component of outcomes-based learning is the constant enhancement of students. A deeper grasp of the degree to which the students are learning what is expected of them to learn should be at the heart of outcome-based assessment. The direct measures of their abilities of interest improve every student's or learner's ability to think critically and perform genuinely. Students would thus be better prepared to take ownership of their learning since it is clear enough what they endeavoured to learn. They would therefore gain a deeper understanding of what they need to improve on and pinpoint it more accurately. This was observed and manifested based on the responses of the student-users on the developed discovery-based chemistry modules (Barkley & Major, 2016).

CONCLUSION AND RECOMMENDATION

On the basis of the result findings, the developed discovery-based modules in chemistry on the structure of organic molecules and organic functional groups are highly valid, usable, and acceptable as validated by five (5) teacher-experts in terms of objectives, contents, format and language, presentation, and usefulness aspects and evaluated by the five (5) student-users in terms of format and content. The teacher-experts and student-users agreed to all the items pertaining to the aspects for validation and evaluation, which implies that the discovery-based modules in chemistry satisfy the pertaining aspects, key parts, and features of supplementary learning material. The feedback based on the interview of the student-users revealed the salient characteristics of the developed discovery-based chemistry modules to be interactive, well-designed, discovery-based, and outcome-based as emerging themes perceived by the student-users feedback. Future studies are suggested to chemistry teachers to design and develop discovery-based modules to undertake other least-learned general (organic) chemistry to engage students in the learning process as they continue their learning pursuits in the present learning modality.

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