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Evaluation of Introductory Environmental Chemistry Course for Prospective Chemistry Teachers Using Context, Input and Process Models

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ABSTRACT

This study aims to evaluate the learning programme of the Introduction to Environmental Chemistry course of the Chemistry Education study programmer in one of the public universities in Bandung City. This research needs to be evaluated and improved because there are still aspects that are not in accordance with 21st century learning such as conventional learning methods, as evidenced by document analysis and learning observations. The method used is a qualitative approach and the CIP (Context, Input, Process) evaluation model as a tool for evaluating and improving lecture programs that focus on the Context aspect in the form of an analysis of the suitability of the Semester Learning Plan (SLP) with the administrative assessment sheet, the Input aspect in the form of lecturer interviews with interview guide instruments and the Process aspect in the form of learning observations with lecture practice observation sheet with a sample size of 40 students and 1 lecturer. The results obtained from the analysis show there are several findings that need to be evaluated due to the incompatibility of aspects in the SLP document update such as administrative completeness, the General Skills Aspect (GSA) 1 listed is not in accordance with the Context of Learning Outcomes (CLOs), based on interviews with teaching lecturers it is stated that problem-based learning (PBL) with the context of validated environmental issues in relevant theoretical content and in the aspect of the learning observation process it was found that there were aspects of learning practices that were not in accordance with the SLP document reference. The evaluation also highlighted the importance of updating and adjusting learning media to be more interactive and relevant to the context of environmental issues. The assessment of the last three years shows the potential to further develop programmers can to improve students' higher order thinking skills.

Keywords: Context, Input and Process Evaluation; CIP Model; Environmental Chemistry Course Programmed and Learning Method.

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1. INTRODUCTION

Chemistry is a branch of science that explains the composition and properties of matter, material changes, and chemical reactions. These chemical phenomena are related to everyday life and situations. Understanding chemistry is very important, and is the basis for studying other sciences, some experts argue that chemistry also explains complex and invisible concepts to describe the reasons or processes behind chemistry-related phenomena (Srisawasdi et al., 2019). Currently, the values of sustainable development must be instilled in the younger generation through the field of education. Chemical education is one of the fields of education that can contribute positively or negatively to sustainable development (Zuin et al., 2021). Negative contributions if chemical education in the learning process does not apply the principles of environmentally friendly principles, every chemical process carried out will cause harm. The positive role of chemical education in sustainable development in the cultivation of concepts and applications in the form of practice (Al Idrus et al., 2020).

The study of chemistry which includes the environment is one of the focus areas in learning chemistry, in the Introduction to Environmental Chemistry course there is learning related to environmental issues, characteristics and transformation of chemical compounds in the atmosphere, hydrosphere, and lithosphere / soil, environmental pollution factors and their countermeasures, and the concept of green chemistry. In general, the learning of Introduction to Environmental Chemistry in a university includes the method of lecture discussion and structured assignments, theoretical learning strategies are not appropriate if used in this learning, because the lecture method is a simple learning tool, only focuses on the teacher and does not support 21st century learning (Kay et al., 2019). According to research by Ardianti et al. (2020), it shows that the use of conventional learning methods can limit students' critical thinking skills and creativity in understanding real problems. Science learning should encourage students to think scientifically, which can lose its essence if it only relies on traditional methods such as lectures. Some previous studies have found that the decline in students' interest and motivation to learn science is caused by monotonous learning with the lecture method (Ningsih & Suryani, 2021 and Reinsini et al., 2021). Most learners feel that chemistry is a complicated and uninteresting subject. Learners believe that concepts such as structure, electron position, reaction process, and chemical characteristics tend to be abstract, making it difficult to understand and the methods used in lecture-oriented learning they are more interested in chemistry practicum because they can directly see the results of what they are doing (Naeem & Ahmed, 2022).

In addition to learning theory, learning Introduction to Environmental Chemistry requires students to be sensitive to environmental problems and be responsible for maintaining the balance of nature and understanding the factors that affect populations and the environment from the simplest to the most complex. Learning Introduction to Environmental Chemistry requires teaching methods that provide more opportunities to conduct investigations, measure simple things in the environment, and work together in groups to develop skills (Asadollah et al., 2021). To support the realisation of this, new and systematic learning approaches, methods and models are needed they can improve students' higher order thinking. Based on the research of Purwanto et al. (2022) that socio-critical and problem-oriented approaches can be used as an alternative approach to learning

chemistry or other subjects that are applicable and contextualised to increase students' activeness and critical thinking skills in the learning process.

Efforts to improve the effectiveness of the learning process are carried out by improving teaching practices which are influenced by the role of educators (Wahono et al., 2020). Thus, it is necessary to evaluate educational programs that focus on updating the curriculum and teaching methods which are considered important to ensure that the program is relevant to the needs of 21st century skills. Teaching is a complex system, so improvements must include important components such as objectives, materials and evaluation. The quality of learning is highly dependent on the interaction between learners and educators in the implementation of learning programmes. Evaluation is a means to determine the achievement of student learning outcomes in accordance with predetermined goals (Riadi, 2017).

Evaluation is an important stage that educators must go through to determine the effectiveness of learning. The evaluation process makes it possible to see the growth of students in the teaching and learning process (Müller & Mildenberger, 2021). Evaluation is also a planned activity that aims to understand the condition of an object by using certain instruments, and the results are compared with standards to draw conclusions. Evaluation results can be used as feedback for educators to improve learning programmes and activities (Dunn & Mulvenon, 2019). Moreover, evaluation is also a process of obtaining information to evaluate how effective and efficient a programme is in meeting learners' needs. Evaluation is conducted to gather information from the implemented programme, then analyse, assess, measure, and draw conclusions or decisions from the results (Ardoin et al., 2020). Thus, evaluation helps us to identify the strengths, weaknesses, and obstacles in the programme that has been implemented.

Evaluation of educational programmes should be carried out systematically and well planned. Evaluation results can be reported to the institution, parents, and educators (lecturers) to assist in decision-making and improve the quality of educational programmes (Zhu et al., 2020). One widely used evaluation model is the CIPP evaluation model, developed by Stufflebeam in 1966. This model emphasises the decision-making process and is oriented towards programme management. The components in the CIPP model, namely context, input, process, and product, which can help in identifying the needs of teachers, planning, learning processes, and outcomes are measured and assessed (Dizon, 2023). The context component plays an important role in helping teachers recognise the learning process and the needs of the community. Input, as part of the evaluation, is able to establish the best plan to understand the needs. Process, as an evaluation element, monitors the planning process and identifies obstacles, as well as plans for management needs. And Product, as an evaluation element that can be measured and assessed the output, and can estimate the benefits, value, significance, and opportunities (Bodur et al., 2022). Compared to previous studies, this study uses the CIPP model with a special focus on only three components: context, input, and process (without product components). This is because the main purpose of this study is to evaluate and improve the implementation of the Introduction to Environmental Chemistry course, especially to identify aspects that are not in accordance with 21st century skills and the relevance of environmental issues in learning materials. The focus on these three components is intended to evaluate the planning, readiness of

resources, and implementation of the teaching and learning process without evaluating the final results of the program, because the emphasis of the study is on improving the quality of the learning process and the product component is the limitation of the study that will be developed further and in depth.

2. METHOD

Programme evaluation is a necessity to assess a programme. This learning programme evaluation research uses the CIPP (Context, Input, Process and Product) model, an evaluation model is an essential framework in assessing performance used to evaluate various aspects of a system or programme, including effectiveness, efficiency, reliability, and safety (Ritonga et al., 2019). Furthermore, based on Sakti et al. (2023) added that evaluation models can also be used to assess the quality of a system or programme. The flexibility of the evaluation model is also highlighted by them, which can be applied to various types of systems or programmes, such as information systems, management systems, and government programmes. The CIPP model was developed by Stufflebeam in 1966 (Dizon, 2023) which stands for evaluation as a process of describing, obtaining, and providing useful information to assess alternative decisions. This research is only limited to evaluating related to context aspects in the form of Semester Learning Plan (SLP), Input aspects in the form of lecturer interview results and process aspects with the results of observations of Introduction to Environmental Chemistry learning. Based on Ngala et al. (2019) the definition of the CIPP model evaluation is designed to serve managers and administrators, (1) Context evaluation is used to serve planning decisions and (2) Process evaluation, used to serve implementation decisions: Once the programme has begun, important decisions concern how to modify its implementation.

The method used to collect data is qualitative method. Qualitative research on the process of data description in the form of narrative is produced. Data collection techniques are an important part of a study, because this technique is a step or method used by researchers in collecting data needed in their research (Creswell, 2017). Qualitative data was obtained from the analysis of SLP documents, analysis of the results of interviews with lecturers and analysis of the results of learning observations in the Introduction to Environmental Chemistry course at one of the public universities in Bandung City. The results of the qualitative data analysis are used as a basis/reference for later making decisions and recommendations for improving and improving the quality of future programmes that will produce a product. The method used is a qualitative approach and the CIP (Context, Input, Process) evaluation model as a tool for evaluating and improving lecture programs that focus on the Context aspect in the form of an analysis of the suitability of the Semester Learning Plan (SLP) with the administrative assessment sheet, the Input aspect in the form of lecturer interviews with interview guide instruments and the Process aspect in the form of learning observations with lecture practice observation sheet with a sample size of 40 students and 1 lecturer.

3. RESULTS AND DISCUSSION

3.1 CONTEXT EVALUATION

Results Context evaluation in the learning programme of Introduction to Environmental Chemistry starts from the profile of the place where learning is carried out. The students who are the subjects in this writing are those who take the Introduction to Environmental Chemistry course (40 people) and 1 lecturer. Semester Learning Plan (SLP) is a document prepared by lecturers or teaching team before starting the teaching process. This document includes components such as document identity and endorsement, Learning Outcomes (LOs), Learning Objectives, LOs achievement indicators, Learning Materials and Learning Resources, Learning Methods and Media, Learning Evaluation, and Assessment which can be seen in full in **Table 1** of the SLP document analysis section. Curriculum and SLP analysis an important step that must be taken by a researcher to ensure that the content of the planned learning materials and methods are in accordance with the expected learning outcomes (Schultz et al., 2022). This analysis can also aim to evaluate the suitability between learning objectives, lecture activities, and assessment, as well as to ensure that all learning components support the achievement of predetermined competencies (Yulis et al., 2024).

Table 1. Analysis of SLP Documents

No	Aspects	Minimum Standard	Findings
1	University identity	Contains the college logo and name, faculty name, study programme name and SLP document code	Available
2	Course identity	Course identity includes the name, code, family and weight of the course as well as the semester or academic year.	Available
3	Document validation orientation	Contains the date of preparation, ratification, signature of the lecturer, name of the lecturer in charge of the course, signature of the coordinator and head of the study programme	There is no date of SLP document preparation and the document approval date has not been updated
4	Learning Outcomes (LOs)	Contains the LOs of the study programme imposed on the course, course learning outcomes (CLOs), expected final abilities (sub- CLOs) and a correlation matrix between CLOs and sub-CLOs	Available
5	Course description and study materials	Contains course descriptions, study materials and lecture materials	Available
6	Prerequisite courses and learning references	Contains aspects of course name and weight in Semester Credit Units (SCU) prerequisite courses, main and supporting references.	Available
7	Methods, media and learning forms	Contains learning methods and media, forms of learning and estimated learning time	The methods listed have not been updated, still using lectures and discussions, the form of learning listed is only face-to-face.
8	Assessment	Contains assessment indicators for each meeting and score weights.	Available

Based on the analysis results listed in **Table 1**, the introductory environmental chemistry course is held in semester seven (7) with a weight of 2 SCU consisting of 1 SCU for 50 minutes using lecture and discussion methods. Before taking this course, students must have taken prerequisite courses, namely Physical Chemistry, Analytical Chemistry, Inorganic Chemistry, Organic Chemistry, and Biochemistry. The introductory environmental chemistry course aims to provide students with a comprehensive understanding of the concepts of environmental chemistry that can be applied in explaining various transformations of chemical compounds in the environment, and solving problems related to chemical phenomena in the environment. The course materials include (1) characteristics and transformation of chemical compounds in the atmosphere, hydrosphere, and lithosphere/soil, (2) contamination of water, soil, and air, (3) environmental toxicology and hazardous waste, (4) waste management, and (5) green chemistry. Assessment is conducted through written exams (unit tests), and structured assignments. The final course grade is an accumulation of assignment grades (25%) and Unit Test grades (1,2,3) with a total weight of 75%, the test aims to evaluate learning at the final stage or other similar examinations.

The presentation of the SLP quantitatively and qualitatively is still not good, this can be seen in the assessment of the administrative aspects of the availability of each item in each design and the assessment of the academic and pedagogical aspects that are not appropriate in each aspect included, which is prepared based on the SLP format according to the Ministry of Education and Culture's Higher Education Curriculum Guidelines, because there are several findings from the analysis of the SLP document, that the validation of the document has not been updated. This can be seen from the SLP document whose year is still 2020. Further findings of CLOs can be seen in **Table 2** which contains the selected Attitude Aspects (AA) that are in accordance with the CLOs, namely AA6 (Work together and have social sensitivity and concern for society and the environment), AA9 (Demonstrate an attitude of responsibility for work in their field of expertise independently) and AA11 (Behave and behave scientifically, educatively, and religiously and Silih Asih, Silih Asah, Silih Asuh in the work environment and community life that has global competitive and comparative advantages).

The selected Knowledge Aspects (KA) are KA3-5 (Mastering broad and balanced essential concepts of chemistry which include structure, properties, changes, kinetics, and energetics of molecules and chemical systems, identification, separation, characterisation, transformation, synthesis of micromolecular chemicals and their applications; Mastering broad and balanced essential concepts of chemistry in the fields of inorganic chemistry, organic chemistry, physical chemistry, analytical chemistry, and biochemistry; and mastering general concepts and principles in the fields of environmental chemistry, food chemistry, materials chemistry, and biological chemistry to be able to choose strategic decisions and provide alternative solutions based on simple chemical research using an interdisciplinary approach) that are in accordance with the CLOs, and the selected General Skills Aspect (GSA), namely 1 (Ability to apply logical, critical, systematic, and innovative thinking in the context of developing or implementing science and technology that pays attention to and applies humanities values in accordance with their field of expertise) and 2 (Ability to show independent, quality and measurable performance), the results of the analysis findings are in accordance with the CLOs and learning materials, but in the aspects of CLOs, one of which is designing learning models/ teaching materials for environmental chemistry in schools, it is not appropriate, these achievements should be outside this course, then the CLOs aspects

are also inappropriate with the learning methods listed in the Sub-CLOs, namely using lecture and discussion methods which still do not support 21st century skills. Aspects of Special Skills (SSA) are not included and are not specifically measured and the expected final abilities (sub-CLOs) are still not relevant to CLOs, this can be seen in **Table 2** in the form of CLOs Aspects of Introduction to Environmental Chemistry and **Figure 1** in the form of examples of sub-CLOs aspects at the first meeting.

Table 2. Aspects of CLOs Introduction to Environmental Chemistry

Code	CLOs Aspect	Outcome Measured
L1	Analyses various transformations of chemical compounds in the atmospheric/ air environment	AA6, AA9, AA11; KA3, KA4, KA5; GSA1, GSA2
L2	Analyse the types, sources and impacts of air pollution and their countermeasures.	
L3	Analyses various transformations of chemical compounds in the hydrosphere/water environment	
L4	Analyses the types, sources and impacts of water pollution and its mitigation efforts.	
L5	Annalise various transformations of chemical compounds in the lithosphere/ soil environment	
L6	Analyse the types, sources and impacts of soil pollution and their countermeasures.	
L7	Analyse exposure models for toxic compounds (B3), dose-response relationships for various toxic compounds, and mechanisms of toxicity in living organisms and the environment.	
L8	Analyse waste management and treatment models	
L9	Analyse the concept of green chemistry in various chemical processes in the environment	
L10	Designing learning models/teaching materials for environmental chemistry in schools	

Week/ Part to	Sub-CLOs/Learning Indicators	Study Materials/ Teaching Materials	Learning Approach/ Method	Time	Student Learning Experience	Assessment	References
1	Know the Semester Learning Plan (SLP) of the course and the scope of Introduction to environmental chemistry Explain the general rules and system of evaluation and assessment of introductory environmental chemistry lectures Describe learning resources that can be accessed	▪ Semester Learning Plan (SLP) ▪ Scope of lectures Introduction to Environmental Chemistry ▪ General rules and evaluation system for Introduction to Environmental Chemistry lectures	✓ Meaningful talk ✓ Discussion	2 x 50'	a. Students are given information about lectures, plans for one semester b. Students are given information about the scope of the lecture Introduction to Environmental Chemistry **c.** Students are given information about the general rules and evaluation system of lectures **d.** Students are given information on learning resources that can be accessed	-	**[1-10]**

Figure 1. Example of sub-CLOs aspects

In the next finding, the SCU weight of the prerequisite courses is not mentioned or the requirements for the number of SCU that have been taken are also not mentioned, then the next finding in the SLP does not explicitly mention the learning media used, and another finding is that the form of lectures only lists face-to-face lectures, there is no online scheme. The findings of this SLP are not yet based on OBE (Outcome-Based Education), which is an education system focused on learning achievements that are not only cantered on the material to be completed but also the outcomes. Simply put, this curriculum emphasis the continuity of the learning process in an innovative, effective, and interactive manner. Therefore, students can develop new skills that prepare them at a higher global level in supporting 21st century learning and sustainable environmental chemistry learning. Then the learning methods listed should be more suitable for the Problem Based Learning (PBL) method which emphasizes problem-solving learning, independent learning, learning in teams whose processes use a systematic approach (Moallem, 2019) in solving environmental problems in everyday life. The evaluation based on this context aspect will help in collecting and analyzing data to determine the goals, priorities and objectives to be achieved in the next lesson.

3.2 INPUT EVALUATION

Input evaluation can help to select the specific strategies to be implemented and to obtain the data sources and steps needed to achieve programme identification and materials for information collection, which are contained in the dimensions. (Sopha & Nanni, 2019). In this input evaluation, data obtained from interviews with lecturers teaching the Introduction to Environmental Chemistry course shown in **Figure 2**, stated that before starting the semester, the lecturer teaching the course must prepare an SLP that has been validated and adjusted to the study programme and lecture material. The SLP is uploaded to the Integrated Online Learning System (IOLS) students can access it and find out the learning plan.

In teaching, lecturers bring in the context of environmental issues to test students' preparation and use interactive media according to the material provided. Teaching materials used are problem-based and linked to environmental issues, with references listed from relevant sources. Although there is no mini project, students are directed to research if they are interested. Teaching challenges include having to keep updated on environmental issues (Ramadhan et al., 2019). Learning assessment consists of Unit Tests and Assignments. Lecturers consider problem-based learning more important than project-based. The assessment for the last three years shows that the reasoning of students' understanding in the test is still quite good, so it is necessary to indicate the possibility of developing a new programme to improve students' higher order thinking.

Figure 2. Interview with the lecturer of the Introduction Environmental Chemistry course

3.3 PROCESS EVALUATION

Stufflebeam (2001) explains that process evaluation aims to compare the implementation of activities with predetermined goals. Process evaluation helps in obtaining information about the course of programme implementation activities (Nukhbatillah et al., 2024). The discussion of the evaluation components of the process stage will be analyses and adjusted to the evaluation instrument for the implementation of national education standards specifically on process standards and standards for educators and education personnel. In the aspect of evaluating the process of this research, it relates to the process of implementing Introduction to Environmental Chemistry Learning before it starts, learning activities during learning, the closing part of learning and lecturer administration.

The results of observations in the learning practice of introductory environmental chemistry courses in the chemistry education study programme at a state university in Bandung City took place on Tuesday, in November 2023 at 10.00-12.00 WIB conducted online via Zoom, that after observing the course consisting of 40 students and one lecturer, it was confirmed by the appearance in **Figure 3**. However, the SLP document includes only face-to-face lecture forms and does not mention online schemes. Before the lecture, the lecturer checked the students' readiness by asking and reviewing the previous material, then made apperception and motivated the students).

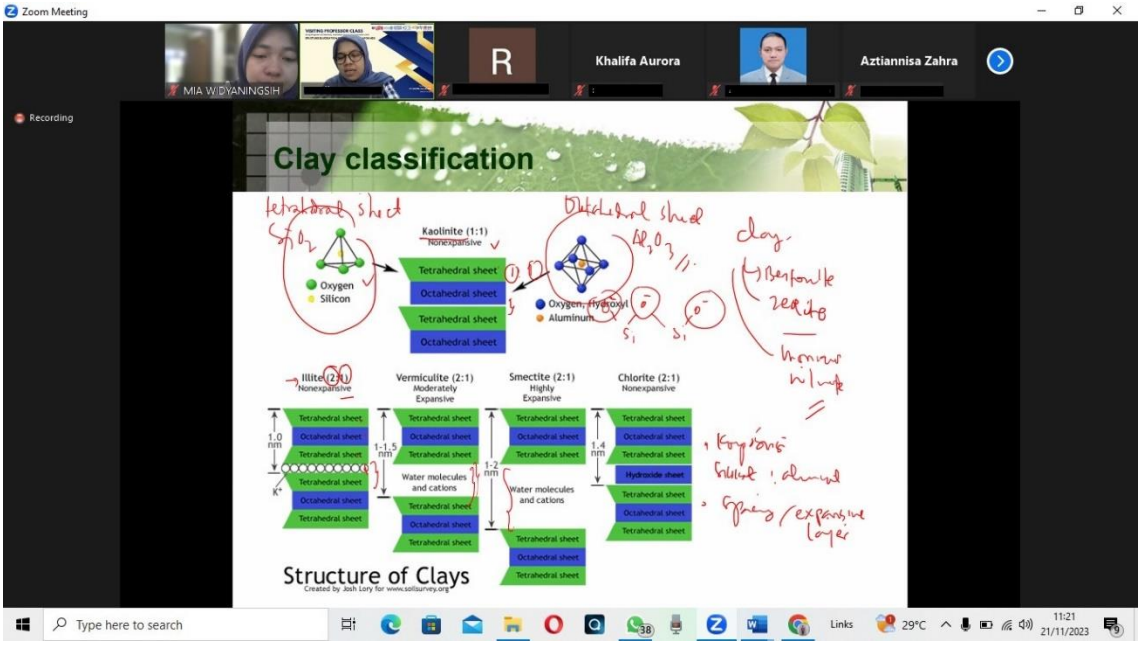

Figure 3. Learning Practices Observation of Introduction Environmental Chemistry

Based on **Figure 3**, in the core learning activities, the following were found (1) Lecturers showed mastery of the material when teaching the topic of Lithosphere. Lecturers relate the material to real life and other relevant knowledge such as elements in soil, soil layers, mineral structures, and soil pollution. Findings (2) the lecture approach is in accordance with the objectives to be achieved. Lecturers conduct lectures regularly and on time, paying attention to learning outcomes and student abilities. During learning, lecturers provide opportunities for students to ask questions and discuss. Lecturers use Power Point media and stationery to explain the material clearly and provide examples of application, the delivery of material becomes interesting and helps facilitate student understanding. Furthermore, finding (3) Lecturers monitor students' learning progress during learning, although they do not always conduct a final assessment. Completion of one topic usually takes place in 2 or 3 meetings. Lecturers use spoken and written language well, making the material easy to understand. However, there is one aspect that is lacking, namely students are not involved in the use of learning media. And (4) at the end of the meeting, the lecturer conducted a reflection by involving students and providing conclusions. The lecturer also gave directions for the next meeting so students could prepare themselves.

4. CONCLUSION

The evaluation of the Introduction to Environmental Chemistry learning programme using the CIPP model with a focus on Context, Input and process aspects shows that the SLP has been prepared and includes important components such as course identity, learning outcomes, and teaching methods, but there are some shortcomings in the update and accuracy of administrative documents such as the teaching methods listed are still conventional with lectures and discussions that do not fully support 21st century skills. The evaluation also highlighted the importance of updating and adjusting learning media to be more interactive and relevant to the context of environmental issues. In the learning process,

the methods used are problem-based as lecturers relate the material to real environmental issues and provide structured assessments. The assessment of the last three years shows the potential to further develop programmes that can improve students' higher order thinking skills. This evaluation emphasis's the need for adaptation of the OBE-based curriculum and improvement of the PBL method to ensure the achievement of effective and relevant learning.

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