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Research Artikel

ETHNO-STEM: DESIGN OF A CROSS-MAJOR COURSE WITH JAVANESE GAMELAN-THEMED

ETHNO-STEM: DESAIN MATA KULIAH LINTAS PROGRAM STUDI BERCORAK GAMELAN JAWA

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Abstract

Indonesia has a considerable diversity of local wisdom in the form of customs, arts, and culture that deserves to be preserved. Integrating local Javanese Gamelan wisdom and the STEM field in learning at the university level to support the Independent Study Campus Curricula is essential. This research aims to develop an Ethno-STEM course design that studies gamelan to preserve Javanese culture. This study chose Morrison & Kemp's learning design development model, which includes nine main components. Based on the results of KKNI curriculum analysis, literature studies, and following the nine components of Morrison & Kemp's model, the Ethno-STEM course design course is suitable for use in learning to support independent study.

Keywords*: Course design; ethno-STEM; gamelan; MBKM; merdeka belajar.*

Abstrak

Indonesia merupakan negara yang kaya akan keberagaman kearifan lokal berupa adat istiadat, seni maupun budaya yang patut untuk dilestarikan. Integrasi antara kearifan lokal Gamelan Jawa dengan bidang STEM dalam pembelajaran di tingkat perguruan tinggi dalam rangka mendukung Kurikulum Merdeka Belajar-Kampus Merdeka penting untuk dilakukan. Tujuan penelitian ini yaitu mengembangkan desain mata kuliah Ethno-STEM yang mengkaji mengenai gamelan dalam rangka melestarikan budaya Jawa. Model pengembangan desain pembelajaran Morrison & Kemp dipilih dalam penelitian ini yang mencakup 9 komponen utama. Desain mata kuliah Ethno-STEM yang telah dikembangkan terdiri dari dokumen diantaranya yaitu model rancangan matakuliah, Rencana Pembelajaran Semester (RPS), bentuk penyetaraan SKS, rekonstruksi pembelajaran, bahan ajar, video serta aplikasi android berbasis *augmented reality*. Berdasarkan hsil analisis Kurikilum KKNI, kajian literatur, dan mengikuti kesembilan komponen Model Morrison & Kemp, desain mata kuliah Ethno-STEM layak untuk digunakan dalam pembelajaran untuk mendukung merdeka belajar.

Kata Kunci: *Desain mata kuliah; ethno-STEM; gamelan; MBKM; merdeka belajar*.

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INTRODUCTION

Indonesia is a multicultural country consisting of various races and ethnicities. The Javanese, one of the tribes that inhabit the island of Java, also have a uniqueness in terms of customs, clothing, dance, music, and building architecture (Hidayati & Nafiiyah, 2017). Art in the form of gamelan represents a form of aesthetic symbol and its values from Javanese culture that must be preserved (Hananto, 2020). Gamelan is usually played at traditional events or wayang performances by reciting certain Javanese songs. Gamelan refers to musical instruments played simultaneously, usually featuring metallophones, gambling, drums, and gongs (Gatot Iswantoro, 2017). *Slendro* and *pelog titilaras* (tone systems) in Javanese gamelan (Risnandar, 2018) not only teach the noble values of regional culture but also being able to present STEM (*Science, technology, engineering, and mathematics*).

However, nowadays, the younger generation is less interested in gamelan art because of a lack of literacy related to culture and the onslaught of modern music (Kristanto, 2020; Pramanta et al., 2017). Therefore, an Ethno-STEM approach is needed that is packaged in an attractive and contemporary form following the industrial revolution 4.0 era. Augmented reality as a product of advances in digital technology will provide an attractive color in Ethno-STEM packaging. Augmented reality technology can bridge abstract material concepts, science, and mathematics, with the natural world (Sudirman et al., 2020). Regarding ethno or regional culture, Javanese gamelan is an ancestral heritage with a history and works of musical art that have a particular function in every traditional Javanese ritual. In the field of Science, Javanese gamelan is closely related to the discussion of sound waves and acoustics (Hendrawan et al., 2020; Risnandar, 2018; Suyatno et al., 2015). Technology is manifested in using analog and digital technology related to gamelan, for example, measuring gamelan sound intensity and acoustic parameters (Suyatno et al., 2017) and software to develop augmented reality (Mariyantoni et al., 2014). Engineering will be reflected in the process used in developing android applications based on Javanese gamelan augmented reality, while mathematics is directed at integral material.

The integration of STEM disciplines in learning is essential due to the massive need for a skilled, critical, and creative workforce to solve a problem (Sumarni & Kadarwati, 2020) and careers in STEM in the 21st century (Li et al., 2019). Ethno-STEM is an approach resulting from the fusion of ethnoscience in STEM disciplines (Sudarmin et al., 2019). In contrast to STEM, which has developed in several countries, this approach has not been widely applied in learning (Sudarmin et al., 2019). Several studies have discussed Ethno-STEM, for example, exploring Javanese gamelan (Nuryadi & Kholifa, 2020), improving understanding of the concept (Marufi et al., 2021), and higher-order thinking skills (Sumarni & Kadarwati, 2020); and development of integrated science teaching materials for junior high school students (Muttaqiin et al., 2021). Ethno-STEM has been applied in project-based learning to make batik motifs that are suitable for sale so that they can develop the entrepreneurial spirit of students (Sudarmin et al., 2019). Ethno-STEM can also bridge hybrid learning that can be combined with a Learning Management System (LMS) (Reffiane et al., 2021). However, the integration of Ethno-STEM aligned with augmented reality technology to study gamelan in learning at the tertiary level has never been done. As a form of packaging of learning that can be taken by cross-study programs, Ethno-STEM courses that study gamelan can represent the freedom of learning at the tertiary level. Furthermore, in a STEM-oriented approach students will be actively involved (Siregar et al., 2019) so that it can provide contextual nuances to improve students' higher-order thinking skills (Sumarni & Kadarwati, 2020). Therefore it is deemed necessary to design a new course that can accommodate the need for the preservation of local wisdom, namely gamelan which is integrated with the STEM field of science. Specifically, this research aims to develop the design of an Ethno-STEM course that examines gamelan to preserve Javanese culture.

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METHOD

This research is a research and development (R&D) study adapting the model of Morrison, Ross, Kalman & Kemp (2013), which is limited to analysis and design. This model was chosen because it is more efficient in terms of time and cost, has easy steps to implement and revise, and is easy to achieve larger learning objectives (Caliskan & Bicen, 2016; Morrison et al., 2013). The flow of analysis and design of the Ethno-STEM course is broken down into nine components. The analysis section includes instructional problems (learning problems); learner characteristics; task analysis; and instructional objectives (learning objectives). At the same time, the design section includes content sequencing (order of teaching materials); instructional strategies (learning strategies); designing the message; development of instruction; and evaluation of instruments.

This research ultimately resulted in a learning design for the Ethno-STEM course, which examines Javanese Gamelan from several fields of study, namely history, culture, and STEM. These learning-related products include course design models, Semester Learning Plans (RPS), forms of credit equalization, learning reconstruction, teaching materials, videos, and android applications based on augmented reality. In detail, the flowchart in this study is presented in Figure 1. This Ethno-STEM course is later expected to be implemented at the University as a form of *Merdeka Belajar*.

This research was conducted from January to June 2022 by involving stakeholders from the Science Education and Mathematics Education Programs and media and gamelan experts. This study focuses on the analysis and design steps which are translated into nine main components as follows:

Instructional Problems

This section analyzes learning problems in related subjects in the previously applicable IQF curriculum to be refined in MBKM. Issues that arose in previously taught courses, namely STEM in the Science Education study program and Ethnomathematics in the Mathematics Education study program would then be resolved through this research-based Ethno-STEM learning. This stage is carried out through document analysis, literature review, and Focus Group Discussion (FGD) with gamelan experts, augmented reality experts, and lecturers.

Learner Characteristics

The target student characteristics, namely students who meet the requirements to take Ethno-STEM courses with Javanese Gamelan patterns, are defined at this stage, for example, the number of credits taken, prerequisite courses, and academic ability.

Task Analysis

Task analysis is the elaboration of the course in the form of an outline to master the expected study material or competencies. Task analysis includes content structure analysis, procedural analysis, concept analysis, and information processing. Content structure analysis is carried out by looking at the contents of the curriculum that has been and will be carried out, in this case, namely the KKNI and MBKM. A procedural analysis is carried out by identifying the stages in completing assignments given to students in one semester. Identification of the main concepts relevant to the study material and courses to be developed is carried out through concept analysis to produce a concept map. Meanwhile, information processing analysis is a continuation of procedural analysis, namely the formulation of assignments to be given for one semester according to the available time allocation and the credit load of the course to be developed. Information processing analysis will produce study material, relevant concepts, and assignments given to students, which will later be outlined as a semester lesson plan.

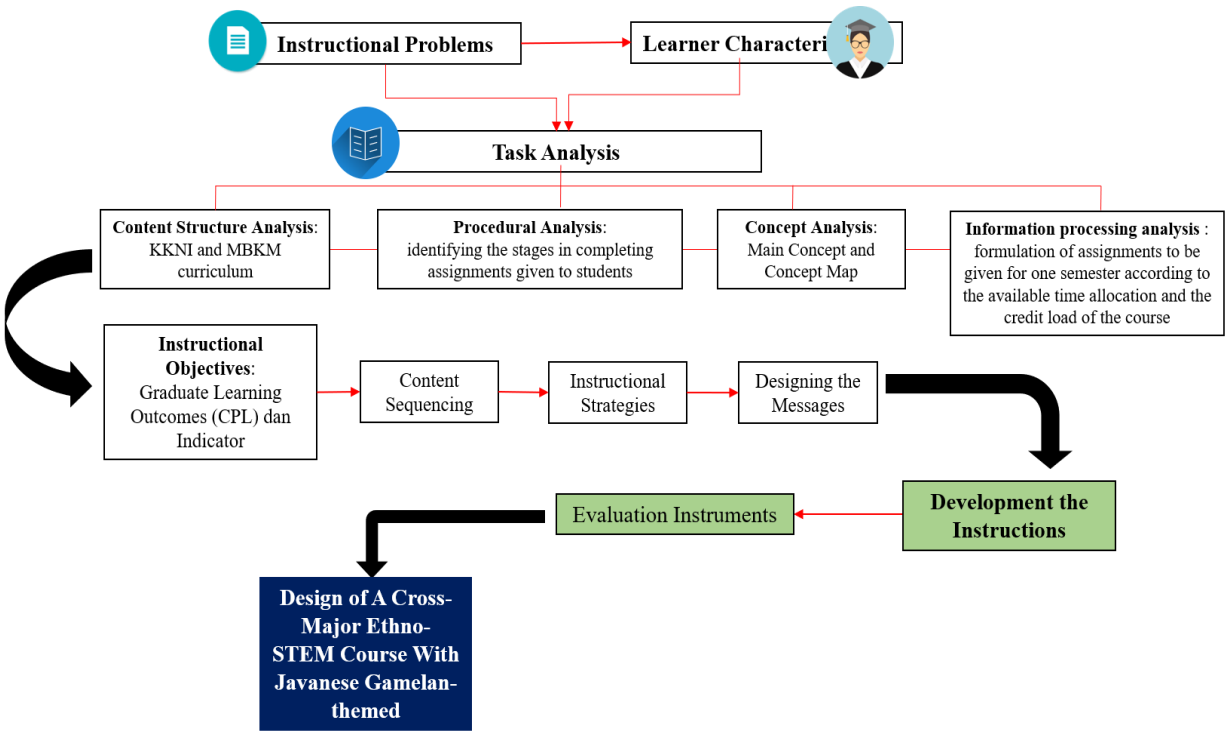

Figure 1. Flowchart of Research Development of Ethno-STEM Course Design

Instructional objectives

Instructional objectives are competencies that students must master. Instructional objectives are guidelines to design learning and what infrastructure will be needed later. Objectives have two main functions, namely (1) to design appropriate learning and (2) to provide a framework for designing evaluation activities (Morrison et al., 2013).

According to Morrison et al. (2013), instructional objectives were formulated after task analysis. Instructional objectives are grouped into three main domains, namely affective (attitude), cognitive (knowledge), and psychomotor (skills). Instructional objectives start from the general definition to the specific one.

Meanwhile, the instructional objectives in the tertiary curriculum are adjusted to the Indonesian National Qualifications Framework (KKNI) for Graduate Learning Outcomes (CPL) and Law Number 12 of 2012. The KKNI is a statement of the quality of human resources in Indonesia whose qualification levels are based on the level of ability stated in learning achievement. The preparation of a higher education curriculum must also refer to the National Higher Education Standards (SN-Dikti) (Junaidi, 2020).

Therefore, the components of instructional goals in general, as suggested by Morrison et al. (2013) then formulated into graduate learning outcomes (CPL) which are adjusted to the KKNI at level 6 or Bachelor and SN-Dikti. CPL is developed by referring to the KKNI descriptors for the domain of knowledge (P) and specific skills (KK), while for attitudes (S) and general skills (KU), according to SN-Dikti.

The CPL compiled in this study must be able to facilitate students between study programs to take Ethno-STEM courses which the Science Education study program will later offer. It is adjusted to internal policies in student exchange programs between study programs at the same University. The CPL matrices and supporting competencies from other study programs are produced in this stage which is adjusted to the

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Main Competency Indicators (IKU) and Additional Competency Indicators (IKT). Besides that, CPMK and learning indicators are also formulated in this stage.

Content Sequencing

Subjects taught for one semester in Ethno-STEM learning are sorted first by paying attention to five aspects: prerequisite knowledge, familiarity, difficulty, interest, and learner development.

Instructional Strategies

The learning strategy describes the sequence and learning methods to achieve CPL and predetermined learning indicators. The research learning model referred to in the courses to be developed project-based learning (PjBL), which can accommodate research needs. The PjBL model emphasizes meaningful and contextual learning through quite complex activities so that they can freely make plans; collaborate in the implementation of the project so that, in the end, it can produce a product (Jauhariyyah et al., 2017).

Designing the Messages

This section has designed patterns of information, sentences, words, and images that can be used to communicate with students in Ethno-STEM courses.

Development of Instruction

After a series of pictures, words, and other design results have been completed; learning tools can be arranged in this section. Learning tools that will be developed include semester learning plans (RPS), textbooks, and learning media that will be realized in augmented reality-based applications.

Evaluation Instruments

The evaluation instrument used in this Ethno-STEM course is designed at this stage and can measure the achievement of learning objectives.

RESULTS AND DISCUSSION

The MBKM program is one of the policies implemented in higher institutions since 2020. MBKM is regulated in Permendikbud No. 3 of 2020 concerning National Higher Education Standards, which further governs students' rights to study outside their study program for three semesters (Baharuddin, 2021). The goal of MBKM is to increase the competence of graduates, both soft skills and hard skills, so that they are more relevant and ready for the needs of the industrial revolution 4.0 (RI 4.0), as well as preparing future leaders with character and excellence (Fuadi, 2021). Higher Education Institutions are required to facilitate students' rights to take activities outside the study program for a maximum of 1 semester or the equivalent of 20 credits and outside of PT for a maximum of two semesters or 40 credits. Based on Permendikbud No. 3 of 2020 Article 15 paragraph 1, the form of MBKM learning activities that can be carried out inside or outside the study program includes eight activities, namely: (a) student exchanges; (b) teaching assistance in education units; (c) apprenticeship/work practice; (d) research/research; (e) humanitarian projects; (f) entrepreneurial activities; (g) independent studies/projects; and (h) building thematic real work villages/colleges.

An Ethno-STEM course design was developed to facilitate the MBKM program through student exchanges between study programs at the same University. Ethno-STEM integrates ethnoscience and STEM education (Sudarmin et al., 2020). STEM-based learning can improve students' attitudes, knowledge, and skills to identify and solve real-life problems (Nuryadi & Kholifa, 2020; Sumarni & Kadarwati, 2020).

This study aims to develop an Ethno-STEM course design with a Javanese gamelan theme from history, culture, and STEM studies. This course is one of the manifestations of Merdeka Belajar in the MBKM curriculum, which will be implemented in the Science Education Program and can be taken by students across the programs.

The design of this Ethno-STEM course adapts the model of Morrison et al. (2013) in the analysis and design section as part of the planning. The nine components are analyzed and designed to produce an effective learning design to implement. The learning design models of Morrison et al. (2013) are made in an oval shape without any arrows stating there is no specific sequence of which components must be completed first in carrying out the design process. Analysis and design can be done while carrying out revisions. However, in this study, the research started with the instructional problem component as the first step, followed by learner characteristics; task analysis; instructional objectives; content sequencing; instructional strategies; design of the messages; development of instruction, and ends with evaluation instruments, according to Figure 1. This step considers the explanation of the model of Morrison et al. (2013). The results of the analysis and design of the nine components are described in detail as follows:

Instructional Problem

This section analyzes learning problems in related subjects in the previously applicable KKNI curriculum to be refined in the MBKM. Issues that arose in previously taught courses, namely STEM in the Science Education study program and Ethno-mathematics in the Mathematics Education study program would then be resolved through this research-based Ethno-STEM learning. This stage is carried out through document analysis, literature review, and Focus Group Discussion (FGD) with gamelan experts, augmented reality experts, and lecturers.

The elements analyzed in the instructional problems related to the KKNI curriculum include (1) regulations for converting course credits, (2) provisions for taking courses across study programs, (3) program provisions that support independent learning, and (4) contents of local wisdom and STEM in the curriculum. A unique analysis was carried out on the KKNI curriculum of the Science Education Study Program and Mathematics Education to identify existing needs. The analysis results can be an input for developing the existing curriculum, especially related to integrating local wisdom content (ethno), namely Javanese gamelan, with the STEM field of study.

The KKNI curriculum document for the Science Education study program was analyzed based on the four aspects described earlier, including (1) the regulation of course conversion credits, (2) provisions for taking courses across study programs, (3) program provisions that support independent learning, and (4) content of local wisdom and STEM in the curriculum. The KKNI curriculum analyzed in this study is the 2019 document, refined through the MBKM curriculum in the 2020/2021 academic year.

Based on the results of the analysis, it is known that the curriculum for the Science Education study program (1) does not yet have written regulations regarding course conversion credits; (2) has not yet accommodated student independence to be able to take compulsory courses across study programs; (3) do not yet have regulations that support the independent learning program; and (4) the curriculum structure offers courses with an insight into local wisdom, namely Ethno-Science and insight into the four disciplines of science, technology, engineering, and mathematics, namely STEM courses.

The STEM courses conducted by the Science Education Study Program in the KKNI curriculum take place in semester four and are compulsory courses without prerequisites. Table 1 analyzes the relationship between Course Learning Outcomes (CPMK), descriptions, and subject matter of STEM courses. The STEM course discusses the context of science learning and examines various science content based on the STEM approach. However, the learning process is not optimal because it does not focus on using multiple learning models, for example, project-based. In fact, through STEM learning that is integrated with projects, students can practice responsibility and independence because they are given autonomy to design, investigate, and collect data. (Widiyawati et al., 2020)

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On the other hand, there are elective courses offered, namely Ethno-Science, in semester six, but students have never taken them because, in 2020, they have to change the curriculum to MBKM. Students have never received content regarding local wisdom, especially Javanese gamelan, which is integrated into science learning. Thus, the urgency of inserting material content regarding art and culture related to local wisdom is significant.

The KKNI curriculum document for the Mathematics Education study program was also analyzed based on the same four aspects as the Science Education curriculum. Based on the results of the analysis, it is known that the KKNI Mathematics Education curriculum (1) does not yet have written regulations regarding course conversion credits; (2) has not yet accommodated student independence to be able to take compulsory courses across study programs; (3) does not yet have regulations that support the independent learning program; and (4) the curriculum structure offers courses based on local wisdom, namely Ethnomathematics.

The Ethnomathematics elective course is offered in semester 6. It is an elective course that students have taken in an even semester. Learning in this course relies on analyzing journal articles that discuss local wisdom through discussion but have not yet discussed aspects of art and culture, especially gamelan. Students took this course during the online learning period during the Covid period, so it could not be implemented optimally. Thus, material regarding technology and gamelan must be integrated into the Mathematics Education Study Program learning.

Learner Characteristics

The characteristics of the target students, namely students who meet the requirements to take Ethno-STEM courses with a Javanese Gamelan style, are defined in this section. The target characteristics of students for the MBKM course, which is named Ethno-STEM, are determined based on several criteria because it will be included in the curriculum structure of the Science Education study program as a compulsory subject. The characteristics of the target students for the Ethno-STEM course take into account the independent study guides at the University level and from the Ministry of Education and Culture. Based on the analysis results, the characteristics of the target students for this course are set, namely even semester undergraduate students at the same tertiary institution without any prerequisite courses. This characteristic is general to facilitate more students from various study programs to choose Ethno-STEM courses.

This course has 20 credits and can be taken by students across study programs without prerequisite courses. Table 1 presents the analysis of courses in the Ivet University study program, which can be converted into the MBKM Curriculum to take Ethno-STEM courses. Ethno-STEM courses are also offered to all Ivet University students even though they have not been identified in the analysis results. It is because Ethno-STEM facilitates Freedom of Learning through learning activities, namely Student Exchange Between Study Programs in One Higher Education. The maximum quota for one Ethno-STEM class is 30 students taking into account the lecturer-student ratio for courses in the natural sciences and applied sciences. A thesis is included in the conversion analysis by considering the University's internal policy, namely granting thesis conversion recognition to students who can publish scientific articles in accredited journals at least SINTA 3.

Table 1. Analysis of Conversion Courses in the MBKM Curriculum

Program	Courses	Credit
Early Childhood Education	Basic Concepts of Early Childhood	2
	Music and Movement Early Childhood	3
	Research Methods	
	Elective courses	5
	Community Service Program	4
	Thesis	6
History Education	Classical Indonesian History	4
	Cultural History	2
	Research methods	2

Program	Courses	Credit
Science Education	Elective courses	2
	Community Service Program	4
	Thesis	6
	STEM	2
	Ethno-Sains	2
	Technoscience Learning	3
Mathematics Education	Elective courses	2
	Research methods	2
	Community Service Program	4
	Thesis	6
	Advanced Calculus	3
	Ethno-Mathematics	2
	Multimedia Matematics	3
	Elective courses	3
	Community Service Program	4
	Thesis	6
Informatika Education	Instructional Media	2
	Videografi	2
	Innovation and Technology Management	2
	Elective courses	4
	Community Service Program	4
	Thesis	6

Task Analysis

Task analysis or task analysis elaborates courses as an outline to master the expected study material or competencies. Task analysis includes content structure analysis, procedural analysis, concept analysis, and information processing.

Content structure analysis

The Ethno-STEM course is a form of MBKM activity that will be offered by the Science Education Study Program and is structured in such a general way as to accommodate the needs of all students across study programs. Observing the contents of the KKNI and MBKM curriculum for the Science Education Study Program, the Ethno-STEM study material (BK) is science Learning with the BK family, namely the core of science and supporting science and technology.

Procedural analysis

Ethno-STEM offers integration between local wisdom, in this case, namely Gamelan, which is viewed from four STEM scientific fields: science, technology, engineering, and mathematics. The Science Education Program will offer this course.

The following are the results of identifying the primary materials that will be taught in the Ethno-STEM course: (1) an introduction to Cultural Arts: Gamelan; (2) aspects of Gamelan Physics: Vibrations and Sound Waves; (3) Mathematical Aspects of Gamelan: Measuring the Volume of Rotating Objects; (4) aspects of Gamelan Technology: Media based on Augmented Reality.

Concept analysis and information processing

The time allocation for Ethno-STEM courses is 20 credits or the equivalent of 1,000 minutes. This course is allocated 3x face-to-face meetings per week, with each meeting of 3 credits (150 minutes), so the total face-to-face meeting is 48x face-to-face. Furthermore, structured assignments outside face-to-face are given to fulfill 20 credits in the form of:

1. Six face-to-face meetings (2x150 minutes or three credits) to discuss Gamelan Cultural Arts;
2. Six face-to-face meetings (2x150 or 3 minutes credits) discussing Gamelan Physics: Vibrations and Sound Waves;
3. Six face-to-face meetings (2x150 minutes or three credits) discussing Gamelan Mathematics: Measuring the Volume of Rotating Objects;
4. Nine face-to-face meetings (2x150 minutes or three credits) discussing Gamelan Technology: Augmented reality-based media
5. 11 face-to-face meetings (8x1500 minutes) for guidance on Project preparation: Mini research on Javanese gamelan in terms of Ethno-STEM

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aspects (local wisdom, science, technology, and mathematics)
6. Twelve face-to-face meetings for guidance on preparing scientific articles published in SINTA 3 accredited national journals.

Tasks

The structured assignments that will be given in the Ethno-STEM course include the following:

1. Week 2: Report on observation activities regarding Javanese gamelan art in the community to groups/studios/schools directly. Details of time allocation: 23x550 minutes.
2. Week 8: Augmented reality-based media. Details of time allocation: 4x550 minutes.
3. Week 10: Mini research project on Javanese gamelan in terms of Ethno-STEM (local wisdom, science, technology, and mathematics) aspects. The project must be able to cover the field of knowledge of all group members. Details of time allocation: 5x 550 minutes.
4. Week 13: Scientific articles published in accredited national journals as the result or report of a mini research project. Articles are written individually as part of a project. Details of time allocation: 5x550 minutes.

These assignments are expected to be able to bridge students acquire the skills to research so that they are following the course designs that are converted according to their original study program.

Instructional objectives

The instructional objectives component has the meaning of formulating learning objectives, starting from CPL and CPMK to teaching indicators. Graduate learning outcomes (CPL) are developed at this stage by adjusting to the study material. The CPL that is prepared must be able to facilitate students between study programs to take Ethno-STEM courses which the Science Education study program will later offer. It is adjusted to internal policies in student exchange programs between study programs at the same University. The CPL matrices and supporting competencies from other study programs are produced in this stage which is adjusted to the Main Competency Indicators (IKU) and Additional Competency Indicators (IKT). Besides that, CPMK and learning indicators are also formulated in this stage.

Graduate Learning Outcome (CPL) of Ethno-STEM Course

The CPL for the Ethno-STEM course was formulated referring to the Minister of Education and Culture Regulation concerning the National Higher Education Standards Number 3 of 2020 and the Graduate Skills Standards in the Internal Quality Assurance System (SPMI). It includes attitude, knowledge, general skills, and specific skills. Table 2 presents the results of the CPL analysis for the Ethno-STEM course.

Course Learning Outcome of Ethno-STEM

Independent learning in this lecture is realized through research activities following the separate learning-free campus guidebook. Research activities involve a study center, Sanggar Great, in Semarang City, and collaboration with partners PT. Kawanua Virtual Technology is engaged in augmented reality technology. However, students can also choose other research locations according to the theme of the mini-research project they will arrange. Table 3 presents the CPMK mapping and learning indicators for Ethno-STEM courses.

Table 2. Graduate Learning Outcome (CPL) Analysis for Ethno-STEM Courses

Factor		CPL
Attitude	S10	Internalize the spirit of independence, struggle, and entrepreneurship;
	S12	Internalizing an appreciative and caring attitude in preserving the environment, art, and socio-cultural values that develop in society
Knowledge	P1	Mastering facts, concepts, principles, laws, theories, and procedures in the core

Factor		CPL
		fields of science;
	P4	Mastering the theoretical concepts of problem-solving in science education procedurally through a scientific approach;
	P6	Mastering the structure and materials of the Science curriculum
General Skill	KU1	Able to apply logical, critical, systematic, and innovative thinking in the context of the development or implementation of science and technology that pays attention to and uses humanities values according to their expertise
	KU5	Able to make appropriate decisions in the context of solving problems in their area of expertise based on the results of information and data analysis
Specific Skill	KK4	Able to carry out practicum both in the form of verification, discovery, analysis, or synthesis conventionally or scientifically instrumented;
	KK5	Able to effectively communicate information, ideas, analysis, and arguments in various forms of media to the public based on the results of studies/research in science education;
	KK6	Conduct research by utilizing science and technology that can be used in providing alternative solutions to problems in the field of science education;
	KK7	Able to make decisions and provide appropriate solutions to science education problems based on accurate data and information either independently or in groups; and
	KK8	Plan and manage resources in organizing classes, schools, and educational institutions, which is their responsibility, and evaluate their performance comprehensively.

Table 3. Course Learning Outcome (CPMK) and Learning Indicator of Ethno-STEM

CPMK	Indicator
1. Students understand gamelan art and culture	1. Students can explain Javanese Gamelan Cultural Arts
2. Students observe gamelan art and culture in the surrounding community	2. Students can identify various types of Javanese gamelan instruments
3. Students understand the scientific concept of gamelan	3. Students can make observations in musical arts in society
4. Students understand the idea of the area of a rotating object	4. Students can explain the concept of gamelan physics related to vibration
5. Students understand the concept of the volume of rotating objects from gamelan	5. Students can explain the concept of gamelan physics related to sound waves
6. Students understand the concept of augmented reality-based media technology related to Javanese gamelan	6. Students explain the broad concept of rotating objects related to Javanese gamelan
7. Students compile media based on Augmented reality	7. Students can explain the concept of the volume of rotating objects
8. Students compile research related to gamelan arts and culture	8. Students can calculate the volume of rotating objects
	9. Students can explain technology related to gamelan
	10. Students can compile learning media based on augmented reality
	11. Students can develop projects: Mini research on Javanese gamelan in terms of Ethno-STEM aspects (local wisdom, science, technology, and mathematics)
	12. Students can compile articles published in SINTA 3 accredited national journals

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Content Sequencing

Content sequencing is the sequence of teaching materials in the Ethno-STEM course design for one semester. Subjects taught for one semester in Ethno-STEM learning are sorted first by paying attention to five aspects: prerequisite knowledge, familiarity, difficulty, interest, and learner development (Desi & Wekke, 2020).

Students from across study programs are accommodated to learn about several fields, namely arts and culture and STEM. The sequence of Ethno-STEM material begins with (1) the concept of Javanese gamelan art; (2) various types of Javanese gamelan instruments; (3) the concept of vibration is related to gamelan; (4) the concept of sound waves is related to gamelan; (5) the broad concept of rotary objects related to Javanese gamelan; (6) the concept of the volume of a rotary object is related to Javanese gamelan; (7) augmented reality-based media technology related to Javanese gamelan; (8) Javanese gamelan research mini project; and (9) preparation of scientific articles published in accredited national journals.

Instructional Strategies

The learning strategy describes the sequence and learning methods to achieve CPL and predetermined learning indicators. The research learning model referred to in the courses to be developed is project-based learning (PjBL) which can accommodate research needs. The learning model designed in the Ethno-STEM course is project-based learning (PjBL) which can accommodate research needs. The PjBL model emphasizes meaningful and contextual learning through activities that are pretty complex so that they are free to make plans; collaborate in the implementation of the project so that, in the end, it can produce a product (Jauhariyyah et al., 2017). PjBL can increase students' involvement and role in various activities (Umar & Ko, 2022). They will find a wide variety of information and learn to adapt facts and tools to achieve learning goals through solving real-world problems.

The Ethno-STEM model has the advantage of giving freedom to students to design projects in groups with the aim of (a) analyzing problems related to gamelan arts and culture developing in society, (b) reconstructing local knowledge about gamelan instruments into scientific knowledge related to the field physical sciences and mathematics; (c) integrating augmented reality technology to introduce local gamelan culture to be implemented in society in general and in schools; (d) developing students' high-order thinking skills in responding to gamelan projects, and (e) training students' abilities to publish their ideas and works through accredited scientific journals.

Designing the Message

This section has designed patterns of information, sentences, words, and images that can be used to communicate with students in Ethno-STEM courses. The message conveyed in the Ethno-STEM course is the 3D asset of gamelan instruments (gong, kendhang, and saron); the Unity and Vuforia apps; and video gamelan. The 3D view of the Javanese gamelan model and application developed in this study is presented in Figure 2.

The use of augmented reality-based learning media applications is expected to provide students with an overview of the virtual form of an object, in this case, gamelan instruments in 3D format. Thus, students seem to interact with these objects in the real world (Syahputra et al., 2019).

Augmented reality is a technology that combines the virtual world and the real world, which includes the use of images, text, music, video, 3D modeling, real-time tracking, intelligent interaction, and so on to be simulated in the real world (Chen et al., 2019).

(a)

(b) (c)

Figure 23. Interface (a) asset 3D model; (b) application interface gamelan STEM-Edu; and (c) barcode augmented reality for saron.

Development of the Instruction

After a series of pictures, words, and other design results have been completed; learning tools can be arranged in this section. Learning tools that will be developed include semester learning plans (RPS), textbooks, and learning media that will be realized in augmented reality-based applications. Learning tools developed to support Ethno-STEM courses include lesson plans, textbooks, and augmented reality-based learning media applications. RPS was designed following the guidelines of the University. Textbooks were created as part of the research output of each student who joined this research team to fulfill their final assignment. The augmented reality-based learning media application developed is named Gamelan STEM-Edu. The application was generated using the Unity and Vuforia applications by integrating 3D-model assets that had been made previously.

Evaluation Instruments

The evaluation instrument used in this Ethno-STEM course is designed at this stage and can measure the achievement of learning objectives. Evaluation instruments in this course include UTS, UAS, observation report assessment sheets, augmented reality-based media assignment assessment sheets, and project assessment sheets. The UTS questions are a formative evaluation instrument to test students' ability to master material after taking lectures. UAS questions are a summative evaluation instrument to determine the program's success (Nastiti et al., 2019), namely

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learning in Ethno-STEM courses. UTS and UAS questions use a written test technique in the form of description questions with a grid tailored to the learning objectives. The instrument was developed based on Marzano's HOTs version (Heong et al., 2011) to train students' higher-order thinking skills. HOTs measurement is a latent variable in cognitive symptoms that requires a standard scale measurement instrument (Bambang Sumintono & Widhiarso, 2015). Through the HOTs test instrument, students can look for patterns of relationships between concepts or knowledge they have learned and reuse them in real-world situations (Rashika & Salleh, 2019). Therefore, educators must be able to present HOTs questions in an integrated approach to the four STEM disciplines to achieve learning success and motivate students in a different atmosphere (Balakrishnan et al., 2016; Drake & Reid, 2018).

Meanwhile, the observation score sheets in this study were used to assess student performance in carrying out observations regarding gamelan in society, both in art galleries, schools, and other places. The six aspects assessed through this observation sheet include (1) selection of observation locations, (2) observation objectives, (3) theoretical basis, (4) data collection methods, (5) data presentation, and (6) discussion and references.

Media assignments and project assessment sheets measure students' ability to complete the assignments from the products collected and the processes carried out. In Ethno-STEM courses, assessment is not only based on tests. The test is less able to reflect students' ability as a whole, so a performance-based assessment is needed. The performance assessment conducts an assessment based on the work of students as an effort to monitor the development and achievement of the course (Bashooir & Supahar, 2018; Kusumastuti et al., 2020).

One way to accommodate holistic, inclusive, and contextual deep learning in STEM education is a project or problem-based learning (Wilson, 2020). Through STEM-PjBL learning, students have the autonomy and responsibility to develop project plans, collaborate with teams, and collect data from an interdisciplinary STEM perspective (Widiyawati et al., 2020). The design of the Ethno-STEM course developed in this study is integrated with PjBL studying Javanese gamelan as a pearl of local wisdom from the field of STEM science, including (a) science: a matter of vibrations, waves, and sound; (b) mathematics: area and volume of rotating objects; (c) technology: learning media based on augmented reality, (d) technique: has been integrated into an augmented reality that will be developed, namely in making flowcharts, storyboards, and compiling 3D models.

Studying gamelan in the field of STEM science is an effort to preserve one of Indonesian culture. Javanese Gamelan is a musical instrument that developed hundreds of years and is a medium of communication between the King and his people (Suyatno et al., 2015). The barrel, *gending*, and wasp technique in each gamelan show aesthetic symbols that reflect the culture of the Javanese people, namely extrinsic, intrinsic and instrumental symbols (Hananto, 2020).

Traditional gamelan instruments reflect the concept of vibration and sound waves in everyday life (Azmi Zakiyah, 2022; Hendrawan et al., 2020). Gamelan has been one of the focuses of science-physics and mathematics studies for a long time to turn indigenous knowledge into scientific knowledge. Suyatno et al. (2015) examine the acoustic parameters for Javanese gamelan performances at the Mangkunegaran Surakarta Hall from a mathematical and physical perspective. These parameters include frequency, sound envelope, and strength or loudness (Suyatno et al., 2013). Gamelan music has a frequency between 40-4000 Hz, and the sound envelope reaches 10 s or more. Mitrayana & Cytasari (2014) has even used digital technology, namely visual analyzer software, to measure the sound frequency of one of the Javanese gamelan instruments, namely *saron demung laras pelog*. From a mathematical standpoint, some materials are like geometry (Nuryadi & Kholifa, 2020), pattern of arithmetic sequences on the beat of

fluent music (Falah & Aritmatika, 2022), and *gending ketawang* (Dewi et al., 2020).

Educators will face challenges in presenting Ethno-STEM learning integrated with PjBL related to Javanese gamelan. Educators need to involve students in a project that requires the implementation of digital technology to solve real-world problems (Aydoğdu et al., 2013). Mobile Apps based on augmented reality can be used as a medium to introduce traditional gamelan musical instruments in the classroom (Mariyantoni et al., 2014; Mustika et al., 2020). Therefore, the design of the Ethno-STEM course that explores Javanese gamelan and integrates it with augmented reality technology is expected to be able to facilitate students in student exchange programs between study programs at Ivet University.

CONCLUSION

This research aims to develop an Ethno-STEM course design that examines gamelan to preserve Javanese culture. The Ethno-STEM course design that has been developed consists of documents including course design models, Semester Teaching Plans (RPS), SKS equalization forms, learning reconstruction, teaching materials, videos, and android applications based on augmented reality. Based on the results of curriculum analysis that has been running, namely KKNI, literature studies, and validation from experts, the Ethno-STEM course design is appropriate for use in learning. However, this research is not perfect, so for further study, it is hoped that it can implement the Ethno-STEM course design in the classroom with several stages of testing.

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