Development and Validation of an Instructional Module in Science, Technology, and Society (STS) in the Tertiary Education Curriculum

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ABSTRACT

Aims: As an institution of higher learning, the Central Bicol State University of Agriculture (CBSUA) shifted its instructional modality during the COVID-19 pandemicthrough Virtual Learning Portal. This study aims to determine the effectiveness of a developed instructional module in Science, Technology, and Society (STS) based on the competencies of revised tertiary education curricula implemented in 2018 and how valid it iswhen utilizedonline.
Study design: Descriptive-correlation design was used in the study.
Place and Duration of Study: The study was conducted at CBSUA, San Jose, Pili, Camarines Sur, in the second semester of 2020-2021.
Methodology: The developed instructional module for STS was uploaded to the University's Virtual Learning Portal (VLP) and utilized by 35 Bachelor of Secondary Education (BSEd) students comprised of 13 males and 22 females. The competencies of the IMs were based on the latest CHED Memorandum Orders (CMOs) of the teacher education curriculum. There were 15 modules and three assessments facilitated with pre-tests and post-tests for each module. The data were tabulated through means and t-tests.
Results: Results showedthat the evaluator's overall rating on the developed instructional module, with a mean of 4.42, signified a good evaluation of its validity. Further, there is a significant difference between the pre-test and post-test means, with the absolute value of the computed t-stat (-5.515) being greater than the t-stat tabular/critical for a one-tail distribution (1.771) and two-tail distribution (2.160). Further, the mean of the post-test (6.538) is significantly higher than that of the pre-test (5.987), reflecting the improvement of the cognitive aspect of students.
Conclusion: The instructional module developed in STS with competencies aligned with the revised tertiary education curricula was valid despite the utilization of it through online modality due to the pandemic.

Keywords: Developed instructional module, pre-test and post-test, virtual learning portal,Science, Technology, and Society

1. INTRODUCTION

Implementing the K to 12 Enhanced Basic Education (Republic Act 10533) in 2016 brought an unprecedented change in Philippine education. The reform is an effort not exclusive to the Department of Education (DepEd) but across the whole landscape of Philippine education, requiring all agencies to work together in transitioning to the new educational system. In alignment with the curriculum, the Commission on Higher Education (CHED) has undergone rigorous revision of the Higher Education curriculum to complement with K to 12 curricula. Hence, Policies, Standards, and Guidelines of the various undergraduate and graduate degree programs were revised and issued through CHED Memorandum Orders (CMOs) for the revised curricula to be implemented in 2018, wherein the first batch of Senior High School students shall enter tertiary education. Along with

revising the tertiary education curricula is the need to revise the different instructional materials, which are expected to be outcomes-based and purposely designed for 21st-century learners.

The COVID-19 pandemic has created the most significant disruption in higher education, leading to a tremendous instructional design shift in teaching-learning. Institutions are forced to migrate from face-to-face in support of the continuation of providing quality education in an online modality. Distance learning has been the sole choice of various institutions around the globe that developed new strategies and processes for delivering instruction. Debeş (2021) states that distance learning activities in higher education involve synchronous courses and asynchronous activities and tasks. She stressed that learners are engaged in interactive activities focusing on opportunities to help other learners build a basic understanding of technology-enhanced instruction in synchronous courses. In contrast, asynchronous activities and tasks include quizzes, group work assignments, group discussions, feedback, and projects (Debeş, 2021). Several Higher Education Institutions (HEIs) developed learning modules separating subjects into small learning units to continue the teaching-learning process during the pandemic.

Several HEIs in the Philippines have implemented proactive policies for the continuity of education and to respond to the needs of learners. In the case of the Central Bicol State University of Agriculture, the Learning Management System has been the primary means of delivering online learning during the COVID-19 pandemic. Brown, Murphy & Hammond (2021) stated that LMS had facilitated distance, face-to-face, and blended education, where online teaching and learning strategies are now included in most HEIs strategic plans. As LMS offers information technology resources that support online education, it also expands delivery options for content, knowledge assessment, practical exercises, and user collaboration (Brown et al., 2021). The adoption of LMS in academic institutions has forced educators to provide online learning opportunities, create interactive materials, and promote student engagement. Most HEIs reported various challenges in implementing online learning through LMS as it has been underused for a long time.

LMS is designed to foster student-centered learning that integrates activities grounded in learning objectives, making it the most advanced tool for facilitating learning (Rottman et al., 2020). The CBSUA has developed its LMS to facilitate the teaching and learning process continuity despite the COVID-19 pandemic. Virtual Learning Portal (VLP) offers a smart alternative for educators to deliver customized and relevant content, leverage various pedagogical models, and engage their students much better than possible. The VLP comprises a syllabus, course overview, learning modules, assessments, submission bin, announcements, and profile of instructors. In delivering instruction, learning modules encourage independent study and develop a sense of responsibility to accomplish the tasks provided.

Instructional materials are crucial in enhancingstudents' academic skills in various fields. Self-instructional materials, like modules, are an independent form of instruction consisting of planned learning activities that help students accomplish well-defined instructional objectives. These educational materials provide individualized instruction withsequential, skill- or concept-oriented learning presentations. In CBSUA, faculty are expected to prepare instructional modules that aid the learning needs of students, foster autonomy and self-confidence through learning, and conveyfavorable outcomes among students. A modular learning approach combining technological advancements can help students to prepare, practice, and develop appropriate skills in professional settings. Careful analysis of the syllabus and learning activities is needed to design effectiveinstructional modules.

The CHED Memorandum Order No. 20 s. 2013 defines Science, Technology, and Society (STS) as an interdisciplinary course that engages students in real-life situations involving socio-political, cultural, economic, and philosophical underpinnings (McNamara et al., 2018). Ariola (2018) describes that the learning content in STS introduces an

appreciation of the societal impact of science and technology development to produce learners with values of humanist orientation, analytical and problem-solving skills, and competencies in science and technology that rapidly changes globalized society. The subject intends to develop a theoretical and practical understanding of the role of science, technology, and innovation in society. The STS subject was implemented in CBSUA inthe year 2018.

The validity of a developed instructional module has been investigated. This study indicates that a valid instructional moduleis useful in learning, considering that the post-test results are higher than the pre-tests despite the shift in modality brought about by the pandemic.

2. METHODOLOGY

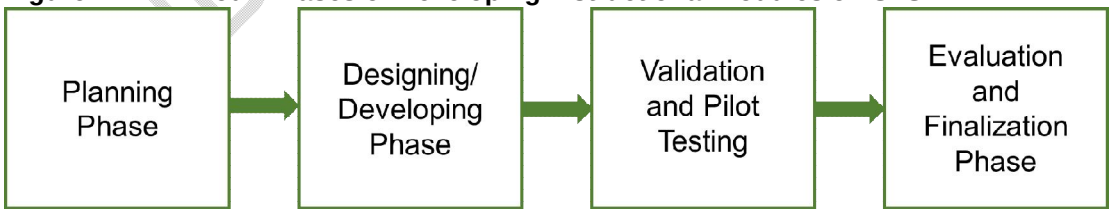
The study employed the descriptive-correlation method to evaluate the effectiveness of the developed instructional module in STS that adhere to the revised tertiary education curriculum in the Philippines. The descriptive method was used to depict the development of the instructional module and the validation process. The correlation method was used to evaluate the effectiveness of the instructional module through administered pre-tests and post-tests for each lesson. The developed instructional module in STS was utilized by 35 BSEd students consisting of 13 males and 22 females through the Virtual Learning Portal (VLP). VLP is a kind of LMS where students access the syllabus, course content, learning activities, pre-tests and post-tests, and assessments as required for a specific course.

As to the validation of the instructional module, four experts served as validators for content, presentation, and readability. A rating sheet for face validation was also provided that includes the validity of the content and format of the instructional modules. The average weighted means were used to determine the module's evaluation level in objectives, content, format and language, presentation, and usefulness and calculate the pre-test and post-test weighted means for each lesson. T-test was used to compare the pre-test and post-test results at a 0.05 significance level to evaluate the effectiveness of the developed instructional module.

2.1. Phases of Developing Instructional Module in Science, Technology, and Society (STS)

Figure 1 shows the four phases for developing an instructional module on STS,including planning, designing and developing, validation and pilot testing, and evaluation and finalization.

Figure 1. Four Phases of Developing Instructional Modules on STS



Planning Phase

The competencies, scope, and sequence for STS prescribed in the revised tertiary curriculum were checked. Textbooks and other reference materials related to the topics were determined to capture the content included in the instructional module. A matrix showing the essential competencies for STS was created. Choosing instructional settings, estimating the cost, and allocating the budget for the printout modules were considered in this phase.

Designing/Developing Phase

The instructor structured the instructional module according to the target learners and topics. Outlined procedures were included in the process of developing the instructional module. These are:

Stage 1. Determining the design of the module. The instructional module developed in this study follows the prescribed format of the University. The module has the following components:

1) Introduction. This part gives an overview of the module that includes a brief context of the topic. It also summarizes what the students will learn in the module, the lesson's primary objective, and the basic instructions on using the module.
2) Pre-Test. It is designed to determine the students' baseline knowledge about the topic.
3) Explore. These include discussing the concepts aligned with the module's learning objectives.
4) Post-Test. It measures the student's understanding of the concept and retention of information gained from the module.

Stage 2. Specifying the objectives and subtopics. The specific objectives for each lesson were identified and based on the competencies of the revised tertiary education curriculum. The instructional module covered 15 lessons for Science, Technology, and Society.

Stage 3. Determining the instructional activities. The instructor ensured that each instructional activity was written in clear and appropriate language suited to the level of the BSEd students. The instructional activities should engage students in active learning that reflects each lesson's learning outcomes.

S*tage 4. Preparing the pre-test and post-test for each lesson of the instructional module.* The pre-tests and post-tests were based on the specific objectives identified in each lesson of the instructional module.

Validation and Pilot Testing

Expert validators were sought in this study to validate the developed instructional module in terms of adequacy of objectives, content, format, language, presentation, and usefulness to the intended users. The first draft of the instructional module was printed and presented to the expert validators. Comments, suggestions, and recommendations from the expert validators were used to revise and improve the instructional module. The revised instructional modules were subjected to another set of validation. The panel of experts consisted of four validators with content, presentation, and readability expertise. The instructional modules were examined based on five indicators: objectives, content, format and language, presentation, and usefulness.

Evaluation and Finalization Phase

The developed instructional module on STS was evaluated by comparing the performance of students in the pre-test (administered before the lesson) and post-test (administered after the lesson). The instructional module was finalized based on the outputs in the evaluation stage.

2.2. List of Topics for Science, Technology, and Society (STS)

Science, Technology, and Society (STS) is a discipline that introduces significant intertwining relationships between the three components and their contribution to global development. This subject also explores and understands how modern science and technology shape modern culture and values. The content of the instructional module was

based on the syllabus, which contain the competencies indicated in the CMO for the revised tertiary education curriculum.

Table 1. List of Topics for Science, Technology, and Society (STS)

Lesson	Topics
1	Course Overview
2	Historical antecedents in which social considerations changed the course of science and technology a. In the World: Ancient, Middle and Modern Ages b. In the Philippines
3	Intellectual revolutions that defined society: a. Copernican b. Darwinian c. Freudian d. Information e. Meso-American f. Asian g. Middle East h. African
4	Science and Technology and Nation building: a. The Philippine Government S&T Agenda b. Major Development Programs and Personalities in S&T in the Philippines c. Science Education in the Philippines d. Selected Indigenous Science and Technologies
5	Philosophy: Its Origin and Nature and Importance in Studying STS. Philosophy in the Context of Philippine Society.
6	Assessment 1
7	Philosophy contrasted with other fields of knowledge a. Philosophy vs. Science b. Philosophy vs. Art c. Philosophy vs. Religion d. Philosophy vs. Education
8	Human person flourishing in terms of science and technology. Technology as a way of revealing. Human flourishing vis-à-vis the progress of science and technology
9	The "Good Life"
10	Impact of technology to society or when technology and humanity crossed to one another.
11	Why does the future not need us? Local government policies that protect humanity in the advent of new technologies.
12	Assessment 2
13	Impact of "The Information Age" (Gutenberg to social media)
14	Biodiversity and The Healthy Society
15	Genetically Modified Organisms: Science, Health, and Politics or Its Impact to Society
16	The Nano World The Gene Therapy (Stem Cells)
17	Mandated Topics on STS: a. Climate Change and the Energy Crisis b. Environmental Awareness Other topics on STS: Alternative Energy Resources (e.g., O-Tech Ocean Thermal Energy Conversion).
18	Assessment 3

3. RESULTS AND DISCUSSION

Many Higher Education Institutions have to adopt LMS, like VLP, as a modality inthe teaching-learning process due to the COVID-19 pandemic. With such a modality, the study shows the results of the effectiveness of the developed instructional module on STS.

3.1. Developed Instructional Module

An instructional module that includes 15 lessons on STS was developed and validated. It also includes a pre-test, learning resources on the topic, explorative activities in audio-visual materials, and a post-test. The lessons in the developed instructional module were based on the book designed by Serafica, Pawilen, Caslib, & Alata (2018)that includes essential competencies in STS.The instructor ensured that it has built-in statements of objectives in each lesson to inform students about what they should be able to learn after instruction. Each lesson in the developed instructional module follows an information sequence in logical steps, and pre-test and post-test are undertaken. A sample of the developed instructional module in STS is presented below for illustrative purposes.

LESSON 13 — **The Information Age**

LEARNING OUTCOMES

At the end of the lesson, the students must have:

1. defined information age,
2. discussed the history of the information age; and
3. identified the factors that must be considered in checking website sources.

INTRODUCTION

Highly modernized, automated, data-driven, and technologically advanced—these bests describe our society nowadays, as evidenced by how information can be transferred or shared quickly. The different areas of society have been influenced tremendously, such as communication, economics, industry, health, and the environment. Despite our gains due to the growing development of information technology, the rapid upgrade of information also has disadvantages. This lesson will discuss the history and impact of technological advancements on society.

Life is accompanied by endless transmission of information within and outside the human body. Webster's Encyclopedic Unabridged Dictionary defines information as "knowledge communicated or obtained concerning a specific fact or circumstance." Hence, information is a very important tool for survival.

The Information Age is a "period starting in the last quarter of the 20th century when information became effortlessly accessible through publications and the management of information by computers and computer networks" (Vocabularey.com, n.d.). The means of conveying symbolic information (e.g., writing, math, other codes) among humans has evolved rapidly. The Information Age is also called the Digital Age and the New Media Age because it was associated with the development of computers.

According to James R. Messenger, who proposed the Theory of the Information Age in 1982, "the Information Age is a true new aged based upon the interconnection of computers via telecommunications, with these information systems operating on both a real-time and as-needed basis. Furthermore, the primary factors driving this new age forward are convenience and user-friendliness, which, in turn, will create user dependence."

PRE-TEST

I. ESSAY: Answer briefly and comprehensively the following statements/questions.

1. Trace and discuss the existence of information technology.
2. Identify and explain the importance of information technology to society.
3. Identify and explain the seven facts about the information age.

EXPLORE

History

The table below traces the history and emergence of the Information Age (United States American History, n.d.).

Year	Event
3000 BC	Sumerian writing system used pictographs to represent words.
2900 BC	Beginnings of Egyptian hieroglyphic writing
1300 BC	Tortoise shell and oracle bone writing were used.
500 BC	Papyrus roll was used
220 BC	Chinese small seal writing was developed
100 AD	Book (parchment codex)
105 AD	Woodblock printing and paper was invented by the Chinese
1455	Johannes Gutenberg invented the printing press using movable metal type
1755	Samuel Johnson's dictionary standardized English spelling
1802	• The Library of Congress was established
	• Invention of the carbon arc lamp
1824	Research on persistence of vision published
1830s	• First viable design for a digital computer
	• Augusta Lady Byron writes the world's first computer program
1837	Invention Of the telegraph in Great Britain and the United States
1861	Motion pictures were projected onto a screen
1876	Dew Decimal system was introduced
1877	Eadweard Muybridge demonstrated high-speed photography
1899	First magnetic recordings were released
1902	Motion picture special effects were used
1906	Lee DeForest invented the electronic amplifying tube (triode)
1923	Television camera tube was invented Zvorkyn
1926	First practical sound movie
1939	Regularly scheduled television broadcasting began in the US
1940s	Beginnings of information science as a discipline
1945	Vannevar Bush foresaw the invention of hypertext
1946	ENIAC computer was developed
1948	Birth of field-of-information theory proposed by Claude E. Shannon
1957	Planar transistor was developed by Jean Hoerni
1958	First integrated circuit
1960s	Library of Congress developed LC MARC (machine-readable code)
1969	UNIX operating system was developed, which could handle multitasking
1971	Intel introduced the first microprocessor chip
1972	Optical laserdisc was developed by Philips and MCA
1974	MCA and Philips agreed on a standard videodisc encoding format
1975	Altair Microcomputer Kit was released: first personal computer for the public
1977	RadioShack introduced the first complete personal computer
1984	Apple Macintosh computer was introduced
Mid 1980s	Artificial intelligence was separated from information science
1987	Hypercard was developed by Bill Atkinson recipe box metaphor
1991	Four hundred fifty complete works of literature on one CDROM was released
January 1997	RSA (encryption and network security software) Internet security code cracked for a 48-bit number

POST-TEST

I. ESSAY: Answer briefly and comprehensively the following statements/questions.

1. Identify and explain the seven facts about the information age.
2. Identify and explain the importance of information technology to society.
3. Trace and discuss the existence of information technology.

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Learning modulesas a form ofindividualized instruction is one idea of online learningthat may vary in different forms, such as hard copy orprinted, e-copy e-copy sent via different onlineplatforms, or on a learning management system (Tugano et al., 2022). In addition, the study of Benito et al. (2022) shows that modules were helpful for students' knowledge adaptation appropriate to their level that demonstrates the mastery of essential goals and competencies of a certain subject in self-directed, self-paced, and self-monitored learning.The developed instructional module in STS helped the students tolearn how modern science and technology shape modern culture and values and contribute to global development.

3.2. Validation of Developed Instructional Module on STS

Expert validators evaluated the developed instructional module to determine its validity using pre-determined criteria: objectives, content, format and language, presentation, and usefulness using the pre-determined criteria using a scale of 1 to 5, with 1 as strongly disagree and 5 as strongly agree.

Table 2 presented the evaluator's overall rating on the developed instructional module, with a mean of 4.42, signifying a good evaluation of its validity. The objectives of the module it has a mean of 4.75 with an interpretation of very good. The computed mean for the content of modules is 4.30, signifying a good interpretation. In the format and language of modules, the computed mean is 4.38, having an interpretation of good in its validity. A

mean of 4.35 was computed for the presentation of the module with a good interpretation. For usefulness, it obtained a mean of 4.30, having a good interpretation of its validity.

Table 2. Evaluation of the Developed Instructional Module on STS based on Expert's Judgments

Aspects of the Instructional Module		Indicators	Means	Standard Deviations	Interpretations
Objectives of the Module	1.	The objectives are clearly stated in the behavioral form.	4.50	0.58	Very Good
	2.	The objectives are well-planned, formulated, and organized.	4.75	0.50	Very Good
	3.	The objectives stated are specific, measurable, and attainable.	4.75	0.50	Very Good
	4.	The objectives are relevant to the topics of each lesson of the modules.	4.75	0.50	Very Good
	5.	The objectives take into account the needs of the students.	5.00	0.00	Very Good
Content of the Module	1.	The content of each lesson is directly relevant to the defined objectives.	4.50	0.58	Very Good
	2.	The content of each lesson is simple and easy to understand.	4.50	0.58	Very Good
	3.	The topics of each lesson are thoroughly discussed.	4.50	0.58	Very Good
	4.	The topics are supported by illustrative examples, and the practice tasks are suited to the level of the students.	3.50	1.00	Good
	5.	Each topic is given equal emphasis in the lesson.	4.50	0.58	Very Good
Format and Language of the Module	1.	The format/layout is well-organized, which makes the lessons more interesting.	3.75	0.50	Good
	2.	The language used is easy to understand.	4.50	0.58	Very Good
	3.	The language used is clear, concise, and motivating.	4.50	0.58	Very Good
	4.	The instructions in the instructional modules are concise and easy to follow.	4.75	0.50	Very Good
Presentation of the Module	1.	The topics are presented in a logical and sequential order.	4.75	0.50	Very Good
	2.	The lessons of the modules are presented in a unique and original form.	4.25	0.50	Good
	3.	The learning activities are presented clearly.	4.75	0.50	Very Good
	4.	The presentation of each lesson is attractive and interesting to the students.	4.00	0.82	Good
	5.	Adequate examples are given for each topic.	4.00	0.00	Good
Usefulness of the Module	1.	The instructional modules will motivate the students to study STS.	4.00	0.00	Good
	2.	The instructional modules will help the students master the topics independently.	4.50	0.58	Very Good
	3.	The instructional modules will allow the students to use their time more efficiently.	4.25	0.50	Good
	4.	The instructional modules will develop students' analytical thinking and reasoning skills.	4.50	0.58	Very Good
	5.	The instructional modules will serve	4.25	0.50	Good

	as supplementary material that can cater to the needs of the students.			
Overall Evaluators' Responses on the STS Module	Objectives	4.75	0.42	Very Good
	Content	4.30	0.66	Good
	Format and Language	4.38	0.54	Good
	Presentation	4.35	0.46	Good
	Usefulness	4.30	0.43	Good
	Overall	**4.42**	**0.50**	**Good**

Legend

Mean Rating	Interpretations	
4.5-5.0	Strongly Agree	Very Good
3.5-4.49	Agree	Good
2.5-3.49	Neutral	Fair
1.5-2.49	Disagree	Poor
1.0-1.49	Strongly Disagree	Very Poor

3.3. Comparison of Pre-test and Post-test Average Scores

Pre-test was administered to gather baseline information on what students knew before the exposure to the instructional module, and the post-test measured the student's learning after a specific lesson. Table 3 shows the average scores of BSEd students in the pre-test and post-test on STS.

Table 3. Average Scores of BSEd Students in the Pre-test and Post-Test on STS

LESSONS	Pre-Test	Post-Test
LESSON 2	5.220	6.512
LESSON 3	6.383	6.723
LESSON 4	4.956	5.62
LESSON 5	5.388	6.112
LESSON 7	5.414	5.986
LESSON 8	5.858	6.255
LESSON 9	6.001	6.357
LESSON 10	5.752	6.426
LESSON 11	7.369	7.658
LESSON 13	7.899	8.734
LESSON 14	5.646	5.884
LESSON 15	6.344	7.529
LESSON 16	6.732	6.845
LESSON 17	4.853	4.891

NOTE: Assessment in Lesson 1 was not included for being a subjective type. Weeks 6, 12, and 18 are Summative Assessments.

The absolute value of the computed t-stat (-5.515) is greater than the absolute value of the t-stat tabular/critical t-stat (1.771) for a one-tail distribution and (2.160) for a two-tail distribution. In both instances, the hypothesis that there is no significant difference between the means of the pre-test and post-test is rejected. Therefore, there is a significant difference between the pre-test and post-test means. Further, the mean of the post-test (6.538) is significantly higher than the mean of the pre-test (5.987). This shows that post-test results were higher than the pre-test, indicating the effectiveness of the developed instructional material.

Modular instruction,as one of the latest innovationsin the educational system, especially in Philippine Education, has become the innovative approach for the continuity of delivering instruction during the pandemic in several educational institutions in the Philippines. Guido (2014) defined a module as a self-contained and independent unit of instructional activitiesto help students accomplishwell-defined learning objectives. The developed instructional module in STS emphasized the analysis and application of concepts, including learning objectives, pre-tests, instructional activities, and post-tests. A high-quality self-learning module must contain sufficient activities to stimulate students'self-directed learning (Torrefranca, 2017).

4. CONCLUSION

The developed instructional module on STS is considered as good and is, therefore, valid. The scores on the pre-test and post-test indicate the effectiveness of the instructional modulethat can contribute to the student's quality of learning on science, technology, and society (STS) and improved scientific content.

Considering the utilization of the developed instructional module during the pandemic, which was then uploaded through the Virtual Learning Portal (VLP), it may suffice to say that the developed instructional module is a potent material to be used by students taking STS subject as a general education course.

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