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# Integrating Indigenous Practices in Chemistry Instructional Material for a Culturally Responsive STEM Curriculum

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**Abstract.** Integration of STEM approach and cultural practices and preference of students will work as a means of contextual learning that helps non-IP teachers connect to students and; achieve cultural responsiveness and instructional congruency to avoid students being challenged in their own cultural ways of knowing. The major aspiration of this study is to construct a proposed Chemistry instructional material integrating indigenous practices of the Subanens for a culturally responsive STEM curriculum for Grade 10 learners. Structured interview schedule and observation were used in obtaining the data which are necessary as inputs to the proposed instructional material. Results showed that IP learners and teachers put forward to integrating culturally responsive teaching for three reasons (1) *cultural preservation* because Subanen practices and language are getting lost, (2) *strengthen cultural identity* that is to prevent young people from feeling of being discriminated, (3) *better teaching-learning experience* for teachers to choose strategies that are suitable and relatable to student's experiences that are mostly relevant to their culture. Meanwhile, attending to their water practices it was found out that residents sourced-out water from *"Bhuwal"* a subanen term for spring through the use of bamboo water drain called *"Sheluyong"*. Water source, accessibility, availability, river activities, sanitation, quality and health relation as part of water practices were the domains of investigation. Succeeding to the perusal is the development of the proposed instructional materials, the first version (v1) of the lesson was validated by experts. Considering their comments and suggestions, a second version (v2) was crafted having achieved a rating from experts of 3.70 out of 4.0 points and a content validity coefficient of 0.90 out of 1.0 which is an indicative of a very good, valid instructional material and recommended for utilization.

**Keywords:** Indigenous, Culturally, STEM education

## 1. Introduction

Meaningful chemistry learning occurs when content is related to context and everyday phenomena, from a students' perspective [11]; [27]. Problems would occur when chemical concepts do not align with the context of students' experiences, the curriculum concepts that must be mastered, and the learning of chemistry that tends to be memorized [5]; [1]; [19]. Culturally responsive STEM pedagogy is a method where two approaches are merged together bringing an upbeat and promising result. Culturally responsive

teaching (CRT) is defined as using the cultural knowledge, prior experiences, frames of reference, and performance styles of ethnically diverse students to make learning encounters more relevant to and effective for them [8]. In a culturally responsive classroom, effective teaching and learning occur in a culturally supported, learner-centered context, whereby the strengths that students bring to school are identified, nurtured, and utilized to promote achievement. Meanwhile, conceptualized idea of teaching and learning in STEM education was suggested by Williams (2019) as cited by Sutaphan & Yuenyong, (2019). He provided some practical ideas of STEM teaching and learning which focuses on processes and engagement of students in collaborative activity. He discussed that the principles of teaching and learning in STEM Education: (i) involves the integration of science, technology and mathematics, (ii) is student centered, (iii) engages students in collaborative activity, (iv) focusses on processes, (v) occurs within the curriculum (is not extra-curricular), and is project and/or problem based. STEM Education stimulate higher-level thinking skills and problem-solving since, STEM education focuses more on process rather than content [28]; [23].

These approaches clearly have an interconnection between the policy given by the state which mandates to encourage indigenous learning systems (Art. XIV, Sec. 2.4), to "recognize, respect, and protect the rights of indigenous cultural communities to preserve and develop their cultures, traditions, and institutions" (Art. XIV, Sec. 17) [20], and; the aims of science education which are to develop scientific literacy among learners that will prepare them to be informed and participative citizens can make judgments and decisions regarding applications of scientific knowledge that may have social, health, or environmental impacts [4] .

With regard to Philippine Education among 79 countries, Filipino learners rank lowest in reading comprehension and second lowest in math and science, according to the Programme for International Student Assessment (PISA) [24]. Grade 10 scores suffered a downward trend, from 53.77 in 2014 to 44.08 in 2017, only minimally inching upward to 44.59 in 2018. Both grade levels are now in the "low mastery" category due to their latest NAT scores. Consequently, no less than Department of Education Secretary Leonor Briones said, that the performance of Filipino students in large scale assessment- which is the NAT "gravitates towards the low proficiency levels" especially in Science, Math and English [14].

Moreover, Philippine Senator Lacson when he cited the "The Borgen Project' report in 2019, he said the Philippines has the highest dropout rate among countries in the Association of Southeast Asian Nations (ASEAN) at 6.38 percent among elementary students and 7.82 percent among secondary school students [12]. In connection to the concerted effort of Philippine Institute for Development Studies (PIDS) President Celia Reyes presented that Mindanao ranks low in terms of enrolment rates in basic education, literacy, and school completion (from grades 1 to 6), while it ranks high in terms of school dropouts. Regions 9, 10, and BARMM have the lowest completion rates in basic education and the highest dropout levels compared to other non-IPs across the country [17]. As backgrounder, 61% of the 14- 17 million Indigenous Peoples (IPs) belonging to 110 ethno-linguistic groups in the Philippines are concentrated in Mindanao, according to the United Nations Development Programme.

Main factors that account for the low performance in science of the Filipino students include the lack of support for a scientific culture reflected in the deficiencies regarding the school curriculum [8]; the inadequate teaching learning process, insufficient instructional materials and lack of teacher training. For instance, the lack of good and engaging textbooks and lack of science equipment have hindered the conduct of scientific investigations and hands-on activities among Filipino learners [7]; [8]. To address these

issues and improve education for indigenous people in the Philippines, it is important to adopt culturally responsive teaching practices and materials, as well as provide language support and accommodations for indigenous students [10].

However, based on the reviewed literatures conducted, gaps in affording Culturally Responsive STEM curriculum to learners have been identified such as obtaining instructional materials and laboratory equipment that are necessary to facilitate teaching-learning processes, retooling of teachers on teaching strategies that help them realize the interconnectedness of science, technology, engineering and mathematics through themes specific to STEM, teaching it as an integrated whole, emphasizing not only on content but also skills development and cultural connections.

Hence, to provide a viable solution to the gaps mentioned on the lack of resources to implement culturally responsive curriculum, to strengthen connection among science concepts learned, cultural practices, and experiences of the learners, promotes skills development, utilization of results gathered of such investigation have encouraged the researcher to develop chemistry instructional material that is culturally responsive among Indigenous people (IP) Subanen learners as well as STEM education related.

## 2. Methods

The procedure performed in gathering the research data was composed of three phases: Phase I: The Preparatory phase, Phase II: The Need Assessment phase and the Phase III: The Development of the STEM-Chemistry Culturally Responsive Instructional Material (STEM-CCRIM).

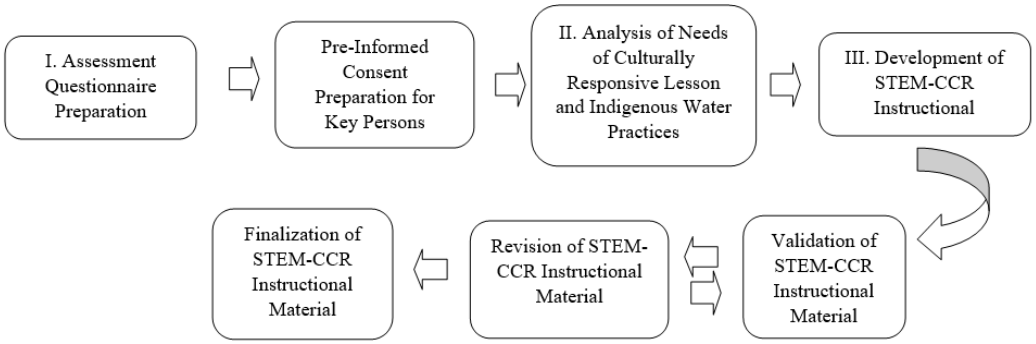


**Figure 1.** Development of STEM-CCR Instructional Material

*2.1.1. Phase I. The preparatory phase consists of (a)Preparation of the Research Instruments and (b) Seeking approval to conduct the study from appropriate authorities.*

*(a) Preparation of the Research Instruments.* Needs Assessment Interview Schedule Questionnaires on water practices and indigenous practices that served as inputs to STEM-Chemistry Culturally Responsive Instructional Material were crafted. Meanwhile, critiquing, establishing reliability and validation of the instruments by experts were also undertaken.

*(b) Seeking approval to conduct the study from appropriate authorities.* Letters requesting permission and approval to conduct the study were delivered personally to the Officer-in Charge of the School Division, the School Principal and the Grade 10 Science Teacher of the School. Since this research was conducted in one of the barangays in the locality, a pre-informed consent was also sought from the Local Government Unit (LGU) informing them and requesting permission to conduct the study, in particular to interview

some of the residents of the Barangay, and to visit and interview also personnel in-charge of the Barangay Rural Health Center.

*2.1.2. Phase II. Conduct of the needs assessment using the interview schedule instruments to draw the indigenous practices of the Subanens.* After the permission and approval to conduct the research was obtained from the appropriate authorities, the interviews with the pre-selected interviewees were conducted. Using the interview schedule for water-related practices, five families who were randomly chosen from the barangay where they reside were interviewed to draw their practices on water sourcing, use and water-related ailments experienced if any as a result of in their use of water taken from the source. Likewise interview with randomly chosen students and teachers were also done to elicit their indigenous practices and needs for a culturally responsive instruction. Their responses would be integrated in the proposed instructional material for a STEM- Chemistry Culturally Responsive Curriculum.

*2.1.3. Phase III. Development of the STEM-Chemistry Culturally Responsive Instructional Material (STEM-CCRIM).* The data collected from the interview were content-analyzed which served as the basis in the development of the indigenous practices-integrated Chemistry instructional material for the Grade 10 learners. Series of revisions were made in consultation with STEM-Culturally Responsive Curriculum experts. Initially, the validation process was addressed to assure the validity of the developed Chemistry instructional material which integrates the indigenous practices of the Subanen respondents. Concerted efforts were sought from validators where two (2) experts in pure chemistry of the Chemistry department perused the developed resource material for the correctness of the content and one (1) expert in chemistry education of the Science and Mathematics Education department for the pedagogical aspect, respectively. Five (5) STEM curriculum experts were further tasked to assess the pedagogy involved in the lesson. Two (2) Subanen experts in their language translation validation. This was to assure that the lessons and activities in the developed instructional material were aligned to the features and meets standards of a culturally responsive Science, Technology, Education and Mathematics (STEM) curriculum.

## 3. Results and Discussions

*3.1. Needs Analysis.* Conduct of Needs analysis was done to identify the need for Culturally Responsive Teaching approach and Indigenous Water Practices among Subanen Participants.

*3.1. Needs Analysis for the need of integrating culturally responsive teaching as basis on the pursuit of developing STEM-Chemistry Culturally Responsive Instructional Material*

The analyses of the qualitative data were carried out through content analysis in which the presence of words, concepts or contents were summarized by counting their presence on the data. The contents were then organized by codes and themes, also the description of results was presented in line with the research question which is to determine the cultural practices of Subanen exhibited while exposed to teaching learning process. Based on the interview responses, there were three main reasons why culturally responsive teaching is important to be integrated in teaching learning process these were for; *(1) cultural preservation, (2) strengthen cultural identity, and (3) better teaching-learning experience.*

**Table 1. Need of Culturally Responsive Teaching identified among the participants**

| Quotation | Codes and Sub-Codes | Themes |
|---|---|---|
| "Their practices are getting lost. They are Subanen's but most of them use Bisaya as their language. That is why we encourage them to talk in their native language however, maybe they're embarrassed. There are some who are Subanen's by blood, can understand Subanen language but do not know how to talk", (Respondent 1).<br><br>"Most of the youths forgotten their cultures which they came from like for example, he/she is a Subanen. (Respondent 3). | Influence of Cultural Assimilation<br><br>1. Struggle on speaking native language.<br>2. Some youths fail to care their cultures | I. Apply culturally Responsive teaching *for cultural preservation* |
| "…It looks like they are ashamed of their tribe, because even though they are not Bisaya they use Bisaya as their language and…. there are youths who do not respect the elders because they were not taught to" R3 | Lack of identification of one's culture<br><br>1. Feeling discriminated<br>2. Loss respect to elders | II. Apply culturally Responsive teaching *to strengthen cultural identity.* |
| "Understand the child and where he came from. So that we can give attention to those who need it, because if we only teach without gauging the background of the child, there is a tendency for the child to be neglected and the worst is he will be discriminated, especially if we are teaching in a barrio", (Respondent 2).<br><br>"As for the part of the teacher, it will be easier to handle the child without violating the child's rights. Also, it will be easier for the teacher to teach if he/she knows the experiences of the child and can teach and adjust the lessons effectively if the teacher knows the | Teachers presumed reasons for suggesting such pedagogy.<br><br>1. Handle child without violating their rights.<br>2. Apply for reliable and effective teaching strategy that is relatable to the students' background.<br>3. Knowledge on students' language, culture, values, family and home environment can make teachers' job easier.<br>4. Offer a support that students' need.<br>5. Receive more support from home. | III. Apply culturally Responsive teaching *for better teaching-learning experience.* |

| | |
|---|---|
| child's background. These are the leading factors that the teacher should be able to understand not just by mastering the lesson", (Respondent 4). | |
| "The more you learn about where your students come from, the easier your job will become. This includes learning more about their language, culture, values, family, and home environment. This knowledge will help you to better support your students in the classroom and to receive more support from home", (Respondent 5). | |
| "It is necessary to gauge the background of an individual especially those students from other cultures once you look at their situation then you can think what strategy you are going to use that is suitable and relatable to their experiences and activities mostly related to their cultures", (Respondent 9). | |

As for the "cultural preservation" theme, cultural assimilation among indigenous people has been very influential resulting to (a) Struggle on speaking native language; and (b) Some youths fail to care their cultures. Which is clearly a dissociation of the goal of UNESCO that is to safeguard culture.

Concerning on "strengthen cultural identity," the gathered responses were (a) to prevent young people from feeling of being discriminated of their identity, and (b) youths lose respect to the elders and neglect their teachings. This result is similar to the SOCCSKSARGEN Regional Development Plan 2017-2022 by which they contend that promoting Philippine culture and values, discrimination and insensitivity to culture and traditions of the indigenous tribes are part of the challenges that IP's have encountered.

Moreover, as for the "better learning encounter" theme, teachers presumed reasons for suggesting such pedagogy were gathered, (a) Handle child without violating their rights; (b) apply for reliable and effective teaching strategy that is relatable to the students' background; (c) knowledge on students' language, culture, values, family and home environment can make teachers' job easier; (d) offer a support that students' need; and (e) receive more support from home. The result is in consonance with the contention of New York State United Teachers (2019) where they explained that through Culturally responsive teaching, it creates an optimal learning environment and reshapes curricula to better reflect the increasingly diverse populations of students being served.

*3.1.2. Indigenous Water Practices among residents*

Subanen practices on sourcing out water for their daily activities were sought through informal interview along with the survey questionnaire with the identified five (5) residents. Table 2 noted the summarized responses made by the participants.

**Table 2.** Water Practices Identified among Indigenous people of Zamboanga del Sur

| Water Practices | English Translation | Local Translation | Subanen Translation |
|---|---|---|---|
| *Water Source for drinking, cooking and other domestic use* | Spring<br>Bamboo Water Drain | Tubod<br>Sandayong | *Bhuwal*<br>*Sheluyong* |
| *Accessibility* | An average of 48 minutes to access | Gibana bana 48 minuto para makasag-ob | *Peg bhana- bhana pat pulo bu walo minoto para mahesegeb* |
| *Availability* | Spring. It doesn't go out of water, water flow just weakens during summer.<br>Community Faucet. Water flows once a week. | Tubod. Dili cya mahubsan, mohinay lang ug agas kung ting-init.<br>Moagas kas-a sa isa ka simana. | *Bhuwal, ghende matyan ,mehenay lak bha ghemperis*<br>*Maggugayas minsa de shahaprian* |
| *River Activities* | Wash clothes twice a week | Manglaba kaduha sa isa ka simana | *Minsan de shahaprian*<br>*Mangadak Marwa de shahaprian* |
| | Bathe once or twice a week | Maligo kas a or kaduha sa isa ka simana | *Mlego Minsa o Marwa de shahaprian* |
| *Sanitation* | Has own toilet shared only to family members | Naay kaugalingong kasilyas para sa pamilya | *Dun kaugalingon gurwan para den dyanen pamilya* |
| | Defecate to water bodies and Grasslands once in a week. | Malibang sa mga katubigan ug kasagbutan kas a sa isa ka semana | *Muro dig tubigan bhu gambunusan minsan de shahaprian* |
| *Quality* | Has water quality monitoring once a year | Naay nagasubay sa kalidad sa tubig kada tuig | *Dun mhetuntay mahatag dehapya ren thubig kada thon* |
| *Health relation* | Experiences water-related diseases | Nakasinati ug mga sakit tungod sa tubig | *Mehebatik mga meset mahatag ghanat reg thubig* |

Participants claimed that major source of water for drinking and domestic use is from natural spring through the use of bamboo water pipes known as *"sandayong"* in Bisaya while called *"Sheluyong"* in their language. However, problems exist on this water source, during summer the water flow weakens while when rain pours so hard the water turns to be cloudy and muddy; and the access would take almost an hour. While, the community has running water from the faucet, but was available and distributed only once a week that

lasts for an hour only. When this happens, the people rush to fill their water containers for drinking purposes and for their other domestic activities. Since the community water system cannot suffice their daily needs.

Moreover, part of their water practices investigated was their river activities wherein participants used to wash their clothes in the river twice a week depending on the vacant time and amount of laundry they got. Some used to do laundry in deep wells during rainy season but when dried up by the heat of the sun and by the number of users, tendency is people advance to the river as their resort. Youngsters and young adults enjoy to bathe in the river as well. They claimed to bathe mostly during weekend while their parents used to do laundry or after they themselves did the laundry and there is no class. Furthermore, participants admitted that they defecate nearing the water bodies since water is just an arm stretch away, while others in grasslands where they can use grass leaves like *"hagonoy", (Chromolaena odorata L.)* as wipes. These following practices were not just made by IP's but by non-IP's people as well.

In terms of sanitation, toilet facility is salient since this promotes health, allowing people to dispose of their waste appropriately; preventing contamination of their environment and reducing risk to themselves and their neighbors. Meanwhile, it has been found out that participants have their own toilets shared only to their family members. This can be concluded by the program of the Department of Health (DOH) which is "zero open defecation" by ensuring basic toilet facilities in every Filipino household, even before 2022. Through giving and helping household owners to build their own toilet. However, participants still admitted that they defecate nearing the waterways and fields. For some, especially the elders are not used to utilizing toilet bowls.

In terms of water quality monitoring in the area, this is done once a year at best. Monitoring has been implemented in accordance to Clean Water Act of the Philippines (RA 9275), providing for a comprehensive water quality management and for other purposes. Likewise, water quality parameters that must be tested are physical, chemical and biological components. As for the frequency of the testing, this depends on the type of water bodies being tested.

Concerning on health in relation to water quality, it is noted that people also experience water-related diseases like diarrhea and stomach ache; these incidences associated by participants to most of the children and elders since their resistance to such diseases is not well-established. According to them, when medicine was not so advanced and not accessible to upland people, health and mortality is a real issue. They even had this saying *"Dili mag pasingulan kay ang Subanen, sip-on ray kamatyan"* in English *"Don't let yourself get rained on because Subanen people could just die in cold"*, which means that death is very easy for them, simple colds could potentially cause death and this is due to inaccessible medicine as well as the lack of faith to science according to them. However, as time goes by and mainstreaming is evident this issue has been gradually combatted.

Owing to these findings were used as bases to the development of instructional material where there is an apparent connection to real-life situation. In this sense, learners can initiate addressing issues in their community just like the need for water system facility, that is accessible, viable, sustainable and can secure clean water.

### 3.3 *Development of STEM-Chemistry Culturally Responsive Instructional Material both lesson plan and module*

The development of the instructional material follows the STEM Education Learning approach to curriculum design integrating, culturally responsive teaching (CRT) pedagogy. The basic concept to STEM teaching approach is that, it is sensitive to the issues in the community and offers solution to problems, hence, connecting concepts in school to real world experiences. This in turn can enhance motivation for learning and improve

student interest, achievement, and persistence. It helps address calls for greater workplace and college readiness as well as increase the number of learners who consider a career in a STEM-related field [16]; [9].

Accordingly, STEM teaching approach consists of 7 stages. This includes (1) Identification of social issues, (2) Identification of potential solution, (3) Need for knowledge, (4) Decision-making, (5) Development of prototype or product, (6) Test and evaluation of the solution, and (7) Socialization and completion decision stage [23].

*3.3.1. Identification of Social Issues.* Identification of social issues is the foundation of the lesson as this is used as guide in accomplishing the general objective, i.e., the development of science process skills, the integration of culture (indigenous water practices) to achieve culturally responsive education, to be conscious of the problems in the community and to exercise and contribute to solution.

This lesson started by researching about water accessibility and quality in the context of the Barangay, the importance of water and quality water in to them. Considering the grade level of learners, the topic chosen has been aligned to the DepEd for grade 10 to integrate the topic on water quality and treatment in the subject matter "evidence of chemical reaction". In the activity on water treatment, on test for acidity, evidence of chemical reactions can be observed, i.e., change in color during determination of pH using camote top extract, evolution of gases during electrocoagulation stage, change in color in many other stages.

As shown in the STEM-CCR Instructional Material, this stage starts with a game called 'four pics one word' wherein the word is water. The learners processed the game through question-and-answer method. The purpose of this game is to elicit from the learners pressing issues confronting the community. The students were asked to identify the problem and choose which among those in their list that which is the most important to be brought into discussion. The teacher facilitates the discussion after the students are in consensus to single out the most pressing problem of their community which is on water and its source. In order to process this stage in the development of the instructional material, the students may dramatize the issue in order to highlight further the gravity of the issue where the students may form realization to bring the issue to the second stage of the development of the instructional material.

*3.3.2. Identification of Potential Solution.* After identifying the problem in water accessibility and potability, the students were led to identify potential solution to the problem. At this stage, the teacher then opens up the topic: "If the learners are engineers, how can they design a prototype that can help them to have an accessible and potable water utilizing materials available within their place? The students are instructed to group themselves into small groups and brainstorm on the situation presented to them. The teacher may present different tasks to be done and suggests and encourage that each member of the group may choose a task to work on individually or in pair. To make it more fun, motivating and have the feel of being in an expert role. (ego-boosting) the students may be given titled roles like Engineer, Mathematician, Chemist and so on. Then, through think-pair-share (1-2-4 All) strategy their discussion will be guided by the questions: (i) How can we re-utilize our waste water so that our work like fetching water from water source will be optimized? (ii) How can we make sure that the water we drink is clean and is safe? (iii) How can we conserve water so that scarcity of clean water will be lessened? To give an additional idea to the learners, a short video entitled: "What happens to waste water" will be shown to them. In processing the class transaction, oral recitation will be utilized; the students will share what transpired in their small group discussion including their realization on the short video shown to them.

Guided with five major aspects as stressed by Guarin et al., (2018); Villaruz et al., (2018): physical, financial, social/technology, human and natural aspects [9]; [21]; and cultural aspects was also integrated in keeping with the aim of this research to develop a culturally responsive STEM instructional material for chemistry the learners in a group of six brainstormed the design of their prototype water treatment system based on their research and on the video shown to them earlier.

*3.3.3. Need for Knowledge.* The third stage in the development, "Need for knowledge" is important. The concepts built-in serves as a foundation and direction of the learning process, the activities provided should be related to the knowledge and information raised by the learners in the identification of potential solutions stage. The learning activities need to be organized and provide integration of knowledge (Sutaphan and Yuenyong, 2019). Discussing 'evidence of chemical reaction' from DepEd competency and integrating current water treatment processes in the locality and/or in the national setting, highlighting their pros and cons, and identifying areas for improvement of the process help the learners come-up with relevant decision in relation to the problem presented. Providing the students with work activities that help them test and validate their previously brainstormed and researched materials they planned to use in their water treatment prototype would fine-tune the steps they take to put into realization their plan. Additionally, as the students gain more information and knowledge that leads them to solve problems, they would be challenged to think and decide on their own and as a group while giving justification of their research activity during the identification of potential solution stage.

At this stage of the development of the instructional material, it is not only providing the students with content knowledge but also to develop smooth interpersonal relationship not only among themselves but also with people in the community, local government officials, other agencies, etc. whom they can ask for help in putting up their prototype project and other concerns. For example, they should know from where to get the materials they need or even perhaps the maturity of the bamboo they would use if they consider durability and longevity as one of their criteria.

*3.3.4. Decision-making Stage.* In this stage providing the students with guidelines will help learners to apply all the knowledge in making the right decision to solve real-life problems. Students need to be reminded to access intellectual property database for existing patents which can be considered as prior arts and design of their prototype through Google patent. At this stage also, the students who were performed individual task in stage 2 (Identification of potential solution) may be regrouped such that similar task that they performed in stage 2 will be done in tandem thus: the scientist and anthropologist could team-up, the engineer and technologist may work together and the mathematicians will team up. Each team should collaborate in making decision for the task they are assigned. Scientist and Anthropologist team will collaborate on the task on finalizing the kind of organic materials to be used in water treatment considering its health benefits and effectiveness, applying culture in their prototype for its aesthetic value. Mathematicians' team determine the sizes, types and quantity of their materials and possible sources of the materials and make the cost-analysis of their prototype. Engineers and Technologists team are responsible on the finalization of the design of their prototype and make a sketch their proposed prototype.

The outputs of the students in the decision-making stage will be collated by the group and present it in class in the form of project presentation. Each group is asked: "Which of the STEM-CCRIM process they like the most and think to be important in the designing of the prototype?" After each group is finished with their report the learners in a group share their final decision to produce their prototype. Guided on: a.) Pros and cons of using

such materials/chemicals and b.) Prototypes' impact regarding on the 6 major capitals that needs to consider.

*3.3.5. Development of Prototype or Product.* This stage is both important and critical. This is the time of making realization of their ideas and the application of the theories they found from the preceding activities they performed, teamwork and in their research. In short, this would be the development of their final prototype. In this lesson, learners will be guided with the following questions during their activity: What are the materials you are using in your prototype? Why you chose that material? Cite the specific sizes like diameters and length and number of materials you used. What are the durability and health consequence of your prototype out of the materials you used?
In the proposed instructional material, research-based possible versions of prototypes were included as a reference for the learners on the prototype they will construct. The prototypes of the learners that they develop may vary in materials, organic chemicals to be used in disinfection, metals to be used in coagulation, materials to be used in filtration, more creative style of water dispenser, and the like.

Since this is an inquiry-based instruction the learners are free to use their preferred and trusted materials that they believe to be more effective, more accessible and healthier base on their research. The prototype water treatment system that they construct may also reveal the creativity of the students as they are free to create their own design and use water purification materials however it should be emphasize that the treated water that the product would meet the set standards for water quality. It is important that the teacher monitor every student's discussion, researched-supported ideas and activities throughout the instructional process. Through the monitoring process the learners' process skills they exhibit and may be guided to the "how" and "why" rather than the "what" in the course of their learning.

*3.3.6. Test and evaluation of the solution.* This stage is to make sure and answer the basic question "Is it working?" The learners will test and evaluate the developed prototype before they promote to the community by purifying water either from the river, wells, springs, faucet, puso etc. according to the following parameters: Total dissolved solids (TDS), color, odor, pH using probe and pH using camote top extract. Also, the learners will determine if after treatment, the tested parameters will be within the acceptable range. The teacher will once again present the current acceptable values for potable water in the country and in other countries, which could lead to a wider applicability of their prototype. Moreover, it will also be evaluated by its durability, cost-effectiveness and aesthetic value of their prototype using a Prototype Rubric.

Consequently, in processing the activity, the learners will present their data, explanations, and challenges in creating their prototype. The teacher will also ask: "Which of the STEM-CCRIM process that is most helpful to you in completing the task?" "After developing your prototyping, how are you going to promote these outputs to the community?" Since, this stage would also be used to prepare learners for the proceeding stage to pass which is the socialization and completion stage.

*3.3.7. Socialization and completion decision stage.* To commence the STEM lesson, the learners will conduct promotional campaign by explaining their creation to 10 families through house-to-house visitation which should be done after school hours or during their free time. The families are then asked to give feedback and reactions on the prototype. The collected feedback will be their basis for the further refinement of the prototype and final promotion and product proposal to be submitted to agencies that can support such ingenuity like the Barangay research department. Other, prototypes will be used as an entry in their Science fair exhibit. Likewise, this stage is the most exciting part, wherein, this is

designed to allow learners to validate their values and STEM-CR knowledge of solutions during their sharing in the society.

3.4 *Experts Rating on the STEM-Chemistry Culturally Responsive Instructional Material*

The STEM-CCR instructional material was further evaluated based on STEM features of the lesson requirement among content experts. The scoring rubrics for evaluating the STEM-CCR instructional material was used in the assessment of the instructional material. Perhaps, the developed STEM-CCRIM resulted to an excellent rating in accordance with the learning objectives, learning content, degree of culturally responsiveness and STEM lesson stages.

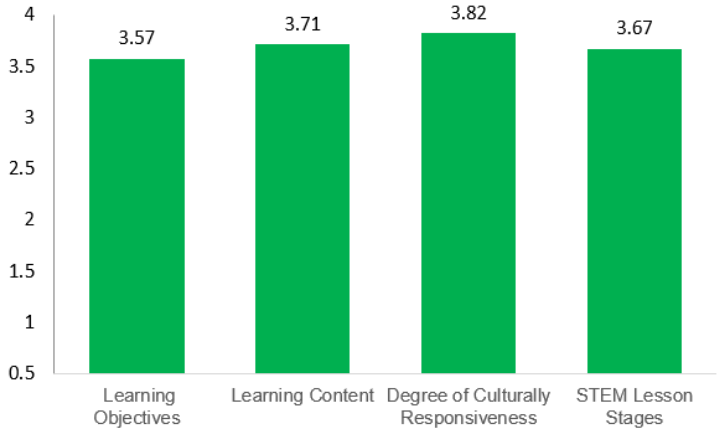


**Figure 2. Expert's rating on the developed STEM-CCR Instructional Material**

Furthermore, Aikens content validity was also identified in order to have better clarity of the evaluation on the content validity of the developed proposed instructional material which integrates indigenous practices for a culturally responsive STEM Chemistry curriculum. The summarized computed validity coefficients of each criterion indicator are presented in Table 3 below.

**Table 3. Summary of Content Validity Coefficient (Aiken's V) of the final form of STEM-CCRIM**

| Rubrics' Parameter | Aiken's V (Content Validity Coefficient) |
|---|---|
| A. Learning Objectives | 0.86 |
| B. Learning Content | 0.90 |
| C. Degree of Culturally Responsiveness | 0.94 |
| D.STEM Lesson Stages | 0.89 |
| Over-All Validity Coefficient | 0.90 |

A scrutiny of the validity coefficient of each criterion in the grouped themes starting with learning objectives, it can be seen that the lowest is on the criterion "The learning objectives were expressed in behavioral terms" which registered 0.81, Likewise, on learning content, the indicator "Organization of content is in logical order" had 0.86 as content validity coefficient, on the degree of responsiveness, "Lesson incorporates cultural values of the chosen locality" with 0.81 and on lesson stages, two of the criterion statement had quite low coefficient of content validity although these are above 0.52 which is considered as the borderline for a good content. The coefficient of content validity values

denotes the quality of the crafted instructional material, The criterion statements which have coefficients of content validity that were low in comparison with the other criteria in every category of the instructional material being evaluated may show what aspect needs more improvement. On the whole, however the developed proposed instructional material had posted coefficients of content validity which meet the standards for a good learning material that is ready for utilization.

## 4. Conclusion

Culturally responsive STEM curriculum creates a significant impact to indigenous people (IP) learners in terms of asserting their cultural identity and stressing 'All' in Education for All through culturally responsive teaching (CRT), and; unleashing their 21st century skills through Science, Technology, Engineering and Mathematics (STEM) Education Approach. On the basis of the findings gathered from need analysis, IP students and teachers put forward of a curriculum that is culturally responsive for three main reasons; *a) cultural preservation, b) strengthening cultural identity, and c) better teaching-learning encounter*. Some of the IP learners feel discriminated when showcasing their cultural practices in school and have the tendency to embrace cultures of those in the mainstream society. Meanwhile, attending to their water practices as way of investigating water crisis in the area, served as important input of creating an instructional material that helps students to become aware of issues in the society and probing for solutions in their own simple and creative ways, this as well could have a significant impact on promoting their skills. The developed Chemistry instructional material that integrates indigenous practices has a potential to be used as instructional material in teaching Chemistry concepts based on the expert's evaluation, having been rated very high in its content validity. The features of the developed instructional material meet the standards set by the DepEd.

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