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Level of Acceptability of Human Circulatory System Model for Non-Biology Major and Biology Major Teachers

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***Abstract*—** This study aimed to develop and determine the acceptability of a Human Circulatory System Model for Grade 9 Biology education in Sorsogon Province, Philippines. The model was designed to address misconceptions and enhance understanding of the circulatory and respiratory systems' interrelationship. The study employed a Descriptive Developmental Research Design and purposively selected Science teachers, both Biology and Non-Biology majors, as validators. The model's acceptability was evaluated along four factors: Concept Quality, Instructional Quality, Technical Quality, and Accuracy. Results showed that both groups of teachers rated the model as Very Satisfactory across all factors, indicating its high acceptability and potential effectiveness in teaching. The study found no significant difference in the acceptability ratings between the two groups of teachers. The researchers concluded that the unidirectional mechanism of the model could effectively simulate blood circulation and oxygenation processes. They recommended further enhancements to the model and its adoption in other schools and grade levels to improve students' understanding of human body mechanisms.

***Keywords*—** teacher, education system, teaching, grade 9 biology.

INTRODUCTION

Biology as a subject has great potential to be implemented using a scientific approach for the students to be able to understand the scientific phenomena in everyday life (Widiyana et al., 2021). Biology materials at school were very important especially if the topic tackles about Circulatory System. Students often found misconceptions with regards on this topic based on the previous studies that have been conducted. According to Lee & Kim (2014) students are unable to comprehensively explain the links between organs of the Circulatory System that's why they don't understand the main concepts of Blood circulation.

Misconceptions of the students in the topic of the Circulatory System is one of the most common challenges to be addressed inside the classroom among different grade levels (Özgür, 2013). As the students have stepped up to their current grade level, their misconceptions about this topic show different tendencies that hinder their understanding and interpretations. The existence of alternative conceptions (AC's) with regards on this topic by the students affect their correct understanding that is because their learning becomes more difficult as they jump up to the next grade level (Vosniadou, 2013).

Instructional resources guarantee maximum value and effectiveness in the teaching and learning process (Babalola, 2021). The instrument of instruction is a form of communication that's why it must be skillfully designed and developed as a key component for a successful teaching. Models have many potential applications (Albanese, Cheng, Ursino, & Chbat, 2015). It serves as an educational tool that illustrates and explain the concept of the topic such as cardiorespiratory relationships and other complex topics in a Science education.

According to Valeeva et al. (2023), most studies showed that learning models used in Science education had positive impact on both cognitive, affective, social, and cultural factors. Models are often used by teachers to help explain difficult concepts or demonstrate how different components interact with each other (Aseeva, 2021). Such practice of developing and using models is noted as having the largest impact on student learning outcomes due to its ability to promote inquiry (Chen et al., 2021; Inkinen et al., 2020). Other studies showcase effective teaching strategies where modeling is found to improve students' abilities to reason with evidence (Barth-Cohen et al., 2021). It promotes Science integration skills (Chang, 2013) and help the students to view the Science phenomena in the context of a system (Hmelo-Silver et al., 2017).

Circulatory System was one of those topics in Biology which was being taught in junior and senior high school

students in the Philippines on a spiral progression. Based on the DepEd's curriculum guide and Most Essential Learning Competencies, this topic was being focused in Grade 9 in which it was being tackled in accordance with its interrelationship with Respiratory System. As stated on the study of Favaron et al., (2017), teaching Biology at school nowadays is mainly tied to transmissive method based on the behaviorist theories in which the student is seen as a person who passively absorbs knowledge transmitted through textbooks, to be learned by heart. On this scenario, this subject seems to be extremely tedious and tricky for students since the concepts which was being taught is abstract and undeniably grayscale in terms of distribution of idea.

The Percentage of Learnings (PL's) of the Grade 9 students in the 3 purposively chosen public secondary schools were gathered and analyzed. Based on the results, it was undeniably lower than the passing rate of 75%. Grade 9 students of Juban National High School got 37%, Biriran National High School got 69%, and lastly, Lajong National High School got 67% PL on their 1st quiz also about Circulatory System.

Those PL's of these 3 schools were below the average PL of 75%, which only means that an appropriate innovation should be made for possible enhancements of the academic performance of the Grade 9 students . Based on the researchers' observation to the physical facilities of the schools they had visited during the Validation Phase of the study, some schools have only charts and diagrams as instructional materials in teaching the Circulatory System while others have don't any in which the teachers there only relied on the models which were encrypted only on the textbooks.

On this light, the researchers have developed a physical model of Circulatory System as an instructional material. As what Babalola (2021) has said, a key component of a successful teaching is the choice of instructional materials that address the issues of the students that's why the model which the researchers have created presents the basic interrelationship of Circulatory and Respiratory system to address the gap of misconceptions of the students with regards on this topic which got a lower percentage of leaning during the first assessment in the 1st grading period.

OBJECTIVES OF THE STUDY

This study aimed to develop and to determine the acceptability of a Human Circulatory System Model for Biology Education of Grade 9 students of Juban National High School, Division of Sorsogon Province for school year 2022-2023. Specifically, it aimed to: (1) develop a Human Circulatory System Model in teaching Biology; (2) determine the acceptability of the developed Human Circulatory System Model as evaluated by Non-Biology and Biology Major teachers in terms of concept quality, instructional quality, technical quality, and accuracy; (3) determine the significant difference in the acceptability of the developed Human Circulatory System Model of the respondents along the identified variables.

METHODOLOGY

2.1 Research Design

The researchers employed Descriptive Developmental Research Design. According to Gillaco (2014) it was used to collect real facts that works primarily on the description, comparison, analysis and interpretation of data that exists in relation to a current situation. This research design was used specifically for the development and validation of the Circulatory System Model for grade 9 students.

2.2. The sample

The samples of this study were purposively chosen which were composed of Science teachers in Sorsogon Province and Sorsogon City. These Science teachers were composed of Biology Major teachers and Non-Biology Major teachers which came from 4 different schools in Sorsogon composing of Juban National High School, Lajong National High School, Biriran National High School, and Sorsogon State University – College of Midwifery. Some validations were held on a house-to-house basis which are from the Municipality of Casiguran and Sorsogon City. These sample respondents served as the validators of the acceptability of the developed Circulatory System Model by the researchers.

There are a total of 11 Biology major teachers (51%) and 10 Non-Biology major teachers (49%) who had participated in the said validation phase of the study. These teachers served as the validators of the developed model of Circulatory System by the researchers wherein they had evaluated its basic mechanisms and functionality through the use of validating sheets adapted from DepEd LRMDS

2.3 The instrument

To determine the level of acceptability of the developed Human Circulatory System Model, it has undergone through Validation Phase of the study. The researchers have utilized the expert's validating sheets adapted from DepEd LRMDS (Learning Resources Management and Development System) to determine its acceptability through evaluations of the purposively selected Science teachers.

2.4 Data Analysis Procedure

For the data analysis procedure, the gathered data by the researchers were treated statistically. These are presented systematically according to the specified problems on this study.

The statistical tools that were used by the researchers include frequency count, percentage, weighted mean, and Mann-Whitney U-test. These tools were used to determine the acceptability of the model in a classroom setting for the Science experiments and discussions.

After the collection of the responses through the validating sheets, a frequency count of the responses by the validators were prepared and organized. Weighted mean for each component of the validating sheets were computed and its average was also calculated and interpreted.

The Mann-Whitney U-test was used to analyze the 4 key factors on the expert's validating sheet composing of rating scales. These rating scales are Very Satisfactory, Satisfactory, Poor, and Not Satisfactory. Each of these rating scales has a prescribed number of rating which signify the level of satisfaction that the validators have experienced as they evaluate the model.

Descriptive Scale	**Numerical Scale**
Very Satisfactory	3.50 – 4.00
Satisfactory	2.50 – 3.40
Poor	1.50 – 2.40
Not Satisfactory	1.00 – 1.40

Based on the above rating scales, 3.50 – 4.00 was the highest average rating that only signifies that the validators had experienced very satisfactory as they evaluate the model. This scale also implies that the model is highly acceptable and recommended by the validators to be used in a classroom instruction. 2.50 – 3.40 average rating signifies that the validators had experienced satisfactory as they evaluate the model and it only implies that the researcher needs a slight development to be done on the model. 1.50 – 2.40 was the second to the lowest average rating that only signifies that the validators have rated the model poor based on its performance which only implies that it needs to be modified. Lastly, 1.00 – 1.40 was the lowest average rating that the validators can give. This only signify that they did not experience satisfaction on the performance of the model and it was not termed to be acceptable to be used as an instructional material.

The 4 factors which were rated by the validators with these rating scales were composed of Concept Quality, Instructional Quality, Technical Quality, and Accuracy.

Concept Quality pertains to the contribution of the model to the enrichment, reinforcement, or mastery of the learning objectives. Instructional Quality is for the materials that were used in the model which were evaluated if it achieved its defined purpose to the model. Technical Quality pertains to the overall mechanisms of the model which were tested and evaluated also by the validators.

The last factor pertains to the Accuracy of the model which tackles about the perceived errors with regards on the conceptual, factual, and system errors of the model which need to be innovated and troubleshoot by the researcher.

RESULTS

This chapter tackles the Level of Acceptability of Non-Biology and Biology Major teachers of the developed Human Circulatory System Model by the researchers. It also includes analysis and interpretation of the data gathered based on the statement of the problem and the conceptual framework of the study.

Concept Quality

On this factor, 10 indicators were tested and validated. The Science Teachers had used the expert's validating sheet that was adapted by the researchers to the DepEd Learning Resource Management and Development System (DepEd – LRMDS) in order to evaluate the model based on its concept in promoting the learning to students. Table 1 shows the ratings obtained of the model through validating sheets along with the Concept Quality.

Table 1. *Evaluators' Rating on Concept Quality*

Indicators	Non-Biology		Biology	
	WM	Desc	WM	Desc
The concept was inclined to the content standard prescribed in MELC	3.90	VS	4.00	VS
The concept can contribute to enrichment, reinforcement, or mastery of the learning outcome in Biology	3.90	VS	4.00	VS
The concept is up-to-date	4.00	VS	3.91	VS
The concept is accurate	4.00	VS	3.82	VS
The concept is logically developed and organized	3.60	VS	3.82	VS
The concept stimulates and promotes critical thinking	3.80	VS	4.00	VS
The concept is relevant to real-life situations	4.00	VS	3.91	VS
The concept is simple and easy to be learn and understood	4.00	VS	4.00	VS
The information which provides by this concept is effective and helps to encourage learning	4.00	VS	3.91	VS
This concept has all the functions and capabilities to understand the basic gist of Circulatory System and its interaction with the Respiratory System to transport oxygenated blood throughout the body.	3.90	VS	3.64	VS
Overall	3.91	VS	3.90	VS

Legend: WM – Weighted Mean Desc - Descriptive Rating VS - Very Satisfactory

As shown in the table on Concept Quality, there were different gathered results between Non-Biology Major teachers and Biology Major teachers. On Non-Biology Major Teachers, the indicator which pertains to the concept is logically developed and organized obtained the lowest score of 3.60 which has a descriptive rating of very satisfactory (VS). Although this descriptive rating pertains to a good results, its score has not reached the perfect score of 4 which only means that there's a slight problem that should be address on the model.

Based on the comment of the Non-Bio A which says that "Put more emphasis on the function of other organs in relation to the Model of Circulatory System and Respiratory System", it only means that the researcher should put more emphasis on the discussion about the functions of the organs which were part of the model. On this scenario, the researcher should put an extra effort on his presentation by researching more accurate details to enhance his skills in explaining the main mechanism of the Circulatory System in collaboration with the other body system which is the Respiratory system which involves the Lungs. In addition, the researcher has also put labels on organs and tissues compartments for an additional guide to the users.

The 2nd indicator which pertains to the concept stimulates and promotes critical thinking got a weighted mean of 3.80 which was second to the lowest rating. As what Non-Bio B has said, "The model should be covered with a cardboard that was painted with a human model before reveling its organs to the audience" that's why the researcher has added another feature of the model which are the compartments that were necessary to cover the whole components of the model. Through these compartments, it will serve as an additional mystery challenge to the students as it will ignite their critical thinking ability through imaginations on what's inside of the compartments which pertains to Human Circulatory System.

The indicators which pertain to the concept was inclined to the content standard prescribed in MELC, the concept can contribute to enrichment, reinforcement, or mastery of the learning outcome in Biology, and this concept has all the functions and capabilities to understand the basic gist of Circulatory System and its interaction with the Respiratory System to transport oxygenated blood throughout the body got the weighted mean of 3.90. This rating only says that there should be an additional effort to be conducted to ensure that the target audience of this study can get the main concept of the Circulatory System.

As what Non-Bio C has said on her comment, "Presenting the output is good for students but always secure their safety and feedback should be given to them to check their understanding with regards on the topic". In response to this, the researcher has added Goggles, Lab Apron, Surgical Gloves, and

Facemask on the User's Manual to remind the users to wear this safety gears before handling the model. As it was also said on the comment, feedbacking should also be one of the mainstream of the instructions. Since this research was still in the validation phase of the study, feedbacking would be the next step if it was presented to the students on the actual classroom setting.

Indicators about the concept is up to date, the concept is accurate, the concept is relevant to real-life situations, the concept is simple and easy to be learn and understood, and the information which provides by this concept is effective and helps to encourage learning got a perfect score of 4 which has a descriptive rating of very satisfactory. As it was said by Non-Bio D on her comment, "The model of the Circulatory System presented is relevant and highly recommended for the teaching and learning process. It will definitely ensure the learning of the students. Great job!". This comment only implies that the created model is relevant for classroom instruction most specially if the topic is all about the interaction of Circulatory System and Respiratory System.

With the given weighted means, the responses of the Non-Biology major teachers with regards to Concept Quality has an overall weighted mean average of 3.91. This rating was very satisfactory based on the LRMDS Guidelines of DepEd which only means that this model was recommended for possible use in public schools.

On the other hand, Biology major teachers have also evaluated the Concept Quality of the Circulatory System Model. Their responses have slight differences on the responses of Non-Biology major teachers. As it was shown on the table above, the lowest rating which was given by Biology major teachers was 3.64 which pertains to the indicator about the concept which has all the functions and capabilities to understand the basic gist of Circulatory System and its interaction with the Respiratory System to transport oxygenated blood throughout the body.

It was suggested by Bio A on his comment, "Revise the discussion on the flow of the blood from the Heart to the Lungs", it only means that the discussion pertaining about the Blood flow and how it was being oxidized as it goes through the Lungs must be explained further. Since the basic mechanisms of the model was unidirectional, the researcher should discussed this factor beforehand in order for the audiences to know the expected main flow of the Blood as it flows in the Blood vessels going to the Lungs for oxygenation processes. Moreover, every steps that happens in the model should be explained to audiences in order for them to understand the basic mechanisms of Circulatory System in collaboration with the Respiratory System.

Indicators about concept is accurate and the concept is logically developed and organized has got a weighted mean of 3.82 which was second to the lowest rating. This only means that there should be an appropriate effort to be done with regards on adding some appropriate feature in the model that will lead to mastery of the user and the audiences.

Bio B has said that "Improve the labels on the components of the model". Since the researcher's self-made model was made out of plastic bottles, labels most specially to the organs and tissues involved must be evident to avoid confusion of the intended users and to the target audiences. As a response, the researcher of this study has put labels with sample pictures of the organs and tissues for an additional feature of the model.

Three indicators such as the concept is up to date, the concept is relevant to real-life situations, and the information which provides by this concept is effective and helps to encourage learning have gained a weighted mean of 3.91. These indicators can be related also on labelling. Since the components installed on the model were made of empty plastic bottles, appropriate guide like labels were made by the researcher in order to depict the actual organs and tissues for further enhancement of learning. These labels will also guide the intended user on the step by step process of circulation and oxidation that happens on the model.

Four indicators which were also under concept quality got a perfect rating of 4 which has the descriptive rating of very satisfactory. These indicators include: The concept was inclined to the content standard prescribed in MELC, the concept can contribute to enrichment, reinforcement, or mastery of the learning outcome in Biology, the concept stimulates and promotes critical thinking, and the concept is simple and easy to be learn and understood. These 4 indicators only imply that although the Human Circulatory System Model was not yet perfect as it is, its basic features can still contribute to the understanding of the students.

Based on the comment of Bio C, "The model can help the students to have a better understanding of the lesson about the coordination of Circulatory and Respiratory System", on this matter, it only signifies how important the model on the delivery of the lesson with regards on these two systems of the body. Most importantly, this model may also serve as the best aid for teaching the body processes such as Blood circulation and oxygenation through simulation.

Based on the weighted means, the overall rating of the Biology major teachers on the Concept Quality of the model was 3.90 which was somehow lower with 0.01 point compared to the overall rating which was given by Non-Biology major teachers. Despite of this result, this overall rating was still regarded very satisfactory based on the LRMDS Guidelines of DepEd and this model was also regarded to be accepted in public schools.

These results can be related to the study made by Christ, Gekle, and Thews (2020). Based on these researchers, their created model which was also accepted to be used in a laboratory served as a guide for the students to work with the complex hydraulic system of Circulatory System through simulations.

Knoops et al. (2016) has also the same objective in designing a realistic Circulatory System Model that would serve also as valuable instrument for students in studying the Blood circulation in the body. This objective also supports the aim of Amirullah and Susilo (2018) which says that teachers should play a role on developing the skills of the students through the use of this kind of technology that can ensure the skill and knowledge development of each student inside the classroom.

Instructional Quality

To 10 indicators were also validated on this factor. The materials that were used in the model were evaluated by the Science Teachers as if it achieved its defined purpose to the overall design and function of the model. Its level of difficulty was also tested if it really scaffolds the student's level of understanding about the interrelationship of Circulatory and Respiratory System.

The Table 2 below shows the ratings obtained by the researchers along with the instructional quality of their created Human Circulatory System Model. It was rated by Non-Biology and Biology Major teachers from 4 different schools in Sorsogon which they personally visited to present their innovation through a live interaction. Validations were held for 5 days depending on the availability of the Science teachers on a particular school or in a particular municipality.

Table 2. *Evaluators' Rating on Instructional Quality*

Indicators	Non-Biology		Biology	
	WM	Desc	WM	Desc
Purpose of the material is well defined.	3.70	VS	4.00	VS
The materials which were used have achieved its defined purpose.	3.80	VS	3.91	VS
The learning objectives are clearly stated and measurable.	3.80	VS	3.82	VS
Level of difficulty is appropriate for the intended target user.	3.80	VS	3.73	VS
The dyes which were used for the coloration of the liquid was appropriate.	3.90	VS	3.91	VS
The model was enjoyable, stimulating, challenging, and engaging.	3.90	VS	4.00	VS
The model effectively stimulates creativity of target user.	3.90	VS	4.00	VS
Target user can control the rate and sequence of operating the model.	3.80	VS	3.91	VS
The model is integrated with the target user's previous experience on teaching Circulatory System.	3.70	VS	4.00	VS
The interface on this model is pleasant.	4.00	VS	3.82	VS
Overall	3.83	VS	3.91	VS

Legend: WM – Weighted Mean Desc - Descriptive Rating VS - Very Satisfactory

Based on the Table 2, the indicators depicting about the purpose of the material is well defined and the model is integrated with the target user's previous experience on teaching Circulatory System has got the weighted mean of 3.70 which was the lowest rating given by Non-Biology major teachers on instructional quality.

Just like Non-Bio B has said to other factor, putting a cover to the model could be used to enhance its feature. As a response to this, the researcher has crafted a cover made of plywood for this model. This idea could be integrated to the user's previous experience as this cover represents the human body which composes of different body systems inside just like Circulatory and Respiratory system which were being taught since elementary.

Four indicators got the same weighted mean of 3.80 which has a descriptive rating of Very Satisfactory (VS). These indicators pertain to the materials which was used has achieved its defined purpose, the learning objectives are clearly stated and measurable, level of difficulty is appropriate for the intended target user, and the target user can control the rate and sequence of operating the model. Non-Bio E has said to her comment, "The model of Circulatory is well-operated. Recycled materials such as plastic bottles were used which are very creative and resourceful. The actual model is well assembled according to its function".

As it was stated on the above comment, it was said that the model was well operated and the materials which were used were working according to its function. But based on the rating, it was shown that it was quiet low that's why the researcher has tried to figure out the pitfalls that should be addressed. As it was studied upon, the researcher has saw that the problem could be related to the comment of Non-Bio A which tells about the emphasis that should be work upon in discussing the model.

Although the Model of Circulatory System was well assembled as stated above, a preliminary intro should be take into consideration in order for the audiences to know the main function of the components involved in the model and how it was being operated by using the power buttons/switches. The discussion should also be concrete and aligned to the prescribed objectives in order to discussed thoroughly the simple circulation of the Blood in the Blood vessels and how it was being oxidized by the Lungs before it was being perfused to the organs and tissues to perform it basic functions. Through this, the target audiences will be guided to capture the main gist of the concept that could help them to understand the interaction between the Circulatory System and the Respiratory System.

Indicators such as the dyes which were used for the coloration of the liquid was appropriate, the model was enjoyable, stimulating, challenging, and engaging, and the model effectively stimulates creativity of target user have got the same weighted mean ratings of 3.90 which was second to the highest rating on Instructional Quality factor. These indicators can be related to the comment of Non-Bio D which says that the model is relevant in the teaching and learning process and most of all, it can ensure the learning of the student. But as it was said by Non-Bio A, putting an extra effort on the discussion most specially on the organs and tissues is necessary to avoid confusions and misconceptions among the students.

Lastly, the indicator which was rated by Non-Biology major teachers under instructional quality depicts about the interface on this model is pleasant has got the highest rating of 4.00 which was very satisfactory in a descriptive rating. As it was stated by Non-Bio F to her validating sheet, "You did a great job with your presentation of your Circulatory System Model", it only signifies that the presentation of this model can brought an impact to the intended users in which it makes them more knowledgeable on the interaction of this system to other systems in the body like the Respiratory System.

With all the ratings involved in the Instructional Quality factor, the overall rating of Non-Biology major teachers was 3.83. This overall rating was regarded as very satisfactory and acceptable for used in teaching.

Biology major teachers have also rated the Instructional Quality of the model. Based on the Table 2, the indicator that has the lowest weighted mean that was rated by Biology major teachers was all about the level of difficulty was appropriate for the intended target user. It has the rating of 3.73 which was the lowest among the 10 indicators in instructional quality factor.

Bio D has some suggestions that could help the researcher to enhance the rating of his presentation which includes; "Indicating the target population for implementation (year level), describing the expected event per step on the model, and using colored tubes on the model". As a response to these suggestions, the researcher has to be discussed the main population involved in the study before the main presentation of the model in order for the next validators to be informed on how and why do they had selected as the main respondents of this study.

Another problem that was addressed is on the technical aspect of this study wherein the step by step explanations on the User's Manual was revised and was added with pictures on every steps from preliminaries up to dispensing operations of the model in order to guide the users on operating the model. The last factor that was also addressed based on the suggestion of Bio D was the color of the tubes which were used as Blood vessels on the model. As a response, the researcher has used Blue colored aquarium air hose to represent the Blood vessel that will carry Deoxygenated Blood during the dispense of its sample and a transparent levelling hose to represent the Blood vessels that will carry an Oxygenated and Deoxygenated Blood during the circulation and oxygenation processes in the model. By this terms, the audiences can easily identify on what particular Blood vessel carries an specific kind of Blood during the operations of this model.

Indicators depicting about the learning objectives are clearly stated and measurable and the interface of the model is pleasant had both got a weighted mean of 3.82 which was second to the lowest rating that was given by Biology major teachers. In response to this, the researcher has clearly discuss first the main objective of the study to the next validators so that before they rate the created model of the researcher, they had already the idea about the main goal of this study which is to create a simulation model. And as it was also stated by Bio D on the previous indicators, emphasizing the colors of the tube that were use in the model were also a big help to guide the intended users of this instrument that's why the researcher of this study has done this improvement to the model to show the interface of Circulatory and Respiratory System.

Three indicators got a weighted mean of 3.91 with a descriptive rating of very satisfactory. These indicators pertain to the materials which were used have achieved its defined purpose, the dyes which were used for the coloration of the liquid were appropriate, and target user can control the rate and sequence of operating the model.

As it was stated Bio E on her comment and suggestion to the validating sheet, "The model designer confidently demonstrate his masterpiece. Use other medium colored liquid coming from natural extracts."

These statements seem to be positive feedback but a pitfall was also observed by the validator that should be addressed by the researcher. This pitfall tackles about using the natural extracts as a natural coloration of the Blood. Unfortunately, through trial and error, there were no such extracts that were suitable to be processed by the model because of some factors. 1st factor is that some extracts can cause stains to the tubes that hinder that actual processing of the Blood in changing its color. 2nd factor is that since the original medium of coloration of the Deoxygenated Blood to transform into Oxygenated Blood was made out of powdered dye, it is impossible to change further the actual mechanism of the oxygenation of the Blood since the original mechanism which was developed has undergone through several trial and error experimentation to become perfectly mixed.

Indicators such as purpose of the material is well defined, the model was enjoyable, stimulating, challenging, and engaging, the model effectively stimulates creativity of target user, and the model is integrated with the target user's previous experience on teaching Circulatory System have got a perfect score of 4.00 with a descriptive rating of very satisfactory.

As it was said by Bio F, "The model is very effective in Science lesson. It is portable and convenient to use. The source of power of the model should last long and should be replaced with sustainable one." Based on these comments and suggestions, the self-made model of the researcher was recognized as effective, portable, and convenient to use. But like the other comments, this model has also slight pitfall that should be addressed. As it was suggested, the model should have a power source that will last long most specially if it was intended to be used on a classroom setting. As a response by the researcher, he has purchased a portable Power Station that has the capacity to supply a convenient amount of electricity to the model. This Power station can be installed or detached from the model in which it serves as a backup supply of electrical power if uncertain power interruption has occurred.

The overall rating with regards to instructional quality factor by Biology major teachers was 3.91 which was a little bit higher compared to the overall rating of Non-Biology major teachers. This weighted rating was regarded as very satisfactory and was acceptable to be used during classroom instructions based on the guidelines that was set by DepEd LRMDS.

The results that were gathered on this factor was somewhat related to the study of Knoops et al. (2016)

who also made a model of Circulatory System out of latex that answers the wide range of questions of the students about the pulmonary side of hemodynamics.

This objective was somewhat the same to the main goal of the present study which is to make a Human Circulatory System Model out of recyclable materials that would enhance the knowledge of the students with regards on the interrelationship of the Circulatory and Respiratory system which depicts about Blood circulation and oxygenation processes. Through this objective, it could help the students to grasp the instructional quality that could give by the created model of Human Circulatory System which has the ability to perform simulations through the use of the installed electronic components on it.

Moreover, Hernat (2014) has also added that models are vital tools in education. This claim was proven to be effective as he has discovered that models as an instructional material improves the scientific thinking skills of the students.

Technical Quality

This factor was also composed of 10 indicators. These indicators were also tested and validated by the Science Teachers. The overall mechanism of the model was the main focused on this factor wherein its features were evaluated based on its possible impact to the intended audiences which are the students. The Table 3 below shows the ratings obtained by the researcher on his innovated model through validations along with the Technical Quality.

Table 3. *Evaluators' Rating on Technical Quality*

Indicators	**Non-Biology**		**Biology**	
	WM	Desc	WM	Desc
The hydraulic system of the model enhances the understanding of the Circulatory System.	3.90	VS	3.82	VS
The combination of colors of the dyes is clear and can be easily understood.	3.90	VS	3.82	VS
There is a complete synchronization of the electric motors and the other parts of the model.	3.90	VS	3.82	VS
The liquid pressure that mixed the dark red liquid (deoxygenated blood) and yellow coloration (which will act as oxygen) is effective for instructional purposes.	4.00	VS	3.82	VS
The color of the oxygenated blood was uncluttered and aesthetically pleasing.	3.70	VS	3.91	VS
The design of the model allows the target user to navigate freely through the material.	3.90	VS	4.00	VS
The model can be easily brought from one place to another.	3.80	VS	3.91	VS
The model will run using minimum system requirements at low cost.	3.90	VS	3.73	VS
The model is free from technical problems.	3.70	VS	3.73	VS
The model can easily and independently be used by the user	3.90	VS	4.00	VS
Overall	3.86	VS	3.85	VS

Legend: WM – Weighted Mean Desc - Descriptive Rating VS - Very Satisfactory

Based on the Table 3, Non-Biology major teachers had come up with the different results with regards on validation on Technical Quality of the model. 3.7 was the lowest weighted mean obtained which pertains to the color of the oxygenated blood which is unclutter and aesthetically pleasing and the model is free from technical problems.

According to Non-Bio G, "Labelling of the different tissues and organs involved. Perhaps, the containers that act as Lungs and Heart may already contained dye with water which is in invisibility state. Containers may have the ability to block or release the liquid that flows through the silicone tube by this saturated solution or blockage can be presented." Based on this statements, the problems seem to be proactive measures that the researcher should work on to prevent such unnecessary issues.

As a proactive response, the researcher has already purchased a Power Station as a backup source of electricity for an efficient supply of electric power to the model just in case there's unexpected brownout that occurred. The electric motors relied too much to the

power source in order for it to work on putting pressure to the fluid that's why a Power Station is very important component to the model that is because without it, the electric motors may stop to function. If this happens, the fluid mechanisms as well as the mixing of 2 colors of liquefied fluid of dyes will be interrupted and may cause blockage and discoloration since the mixtures will be saturated as it was stated by Non-Bio G.

Another problem which was spotted by Non-Bio G was the painted plastic bottles that represent the Lungs. The Lungs were equipped with a Yellow dye which were not visible to the user as well as to the viewers. To address this concern, the researcher has made a rectangular scratch at the back side of the Right Lung since it was the 1st receiver of Deoxygenated Blood from the right chamber of the Heart. This rectangular scratch serves as the Fluid Volume Indicator in order for the user to monitor the amount of fluid that was delivered in the Right Lung before it was release to the Left Lung for further oxygenation.

The indicator that pertains to the model can be easily brought from one place to another got a weighted mean of 3.80 which was 2nd to the lowest rating given by Non-Biology major teachers. The workmanship of the model as it was stated and explained by the researcher was made out of plastic bottles. But the main base in which the model was installed was made out of plywood with a thickness of 3/4" and has a weight of 5kg. Its dimensions were ranging to 24 x 27 ½ inches which was very huge and more than that, the main structural foundation of the model was made out of steel rods which was slightly heavy with an estimated mass of 7 kilograms. With these indicated mass and dimensions of the main structural unit of the model, it would be difficult for a single person to take this instructional material from one place to another. But during classroom instructions, the burden of manipulating this model was lessen that is because it has 4 mini transport wheels which helps the user for an easy maneuver of the model during the classroom discussions. Moreover, this transport wheels would also lessen the extra effort of the user in showing every part of the model to the expected viewers that is because these wheels can help to rotate the model for about 360 degrees which can show its whole structure to the intended audiences.

Six indicators under technical quality factor had got the same weighted mean rating of 3.90. The first two indicators that pertain to the hydraulic system of the model enhances the understanding of the Circulatory System and the combination of colors of the dyes is clear and can be easily understood, shared a common idea about the problem that was stated by Non-Bio G which pertains to the mixture of colors of the dye that was being processed by the model which may cause a blockage to its tubes. This scenario was possible only to happen if and only if the water pressure brought by the electric motors had stopped on working. This problem may occur only if there's an inadequate supply of power source to the electric motors. That's why using a Power Station as a backup source of electricity may hinder such problems.

The third indicator which pertains to there is a complete synchronization of the electric motors and the other parts of the model may be related to the comment which was stated by Non-Bio E which says that the model of Circulatory System is well operated and its parts are well assembled according to its functions. It may seem a positive comment of appreciation but the weighted mean of the responses on this indicator was only 3.90 which was a little bit short for the perfect score of 4. On this matter, the researcher has tried to figure out the main problem and through rigorous analysis, the problem that was found out was all about on how it was being discussed on the validators.

As it was stated by Non-Bio A, putting emphasis to the parts which was involved to the model was very important. In accordance to this, the researcher has put emphasis on the discussion of each component of the Circulatory System Model on how it works together to make simulations of the Blood circulation and oxygenation.

The last 3 indicators that also got a weighted mean of 3.90 tackles about the design of the model allows the target user to navigate freely through the material, the model will run using minimum system requirements at low cost, and the model can easily and independently be used by the user.

As it was stated by Non-Bio H, "The concept is ok, easy to be understood by the students. Congratulations! Great presentation!". This comment was like a positive feedback with regards to the presentation of the model but like the other indicators, it was rated slightly short to the perfect score of 4 that's why the researcher has tried to figure out the main problem. Like the other comments and suggestions, this problem may also link to the

suggestion of Non-Bio A which stressed out the emphasis that should be put on in the explanations about the usability of the model most specially to its features.

Lastly, the only indicator that got a perfect rating of 4.00 under technical quality factor which was validated by Non-Biology major teachers pertains to the liquid pressure that mixed the Dark Red liquid (deoxygenated blood) and yellow coloration (which will act as Oxygen) is effective for instructional purposes. As it was stated by Non-Bio D, the functionality of the model is effective and relevant for the teaching and learning process. It also signifies that it can ensures the understanding of the students with regards to the relationship between the Circulatory System and Respiratory System since the complexity of this topic was rarely addressed since the last few decades (Albanese, Cheng, Ursino, and Chbat, 2015).

The overall rating of Non-Biology major with regards to technical quality factor of the model was 3.86 which was very satisfactory according to the LRMDS guidelines prescribed by DepEd. This rating signifies that the model was recommended for teaching.

Biology major teachers have also evaluated the technical quality of the Circulatory System Model. Based on the table 3, the weighted mean rating of Biology major teachers differs to Non-Biology major teachers. Indicators pertaining to the model will run using minimum system requirements at low cost and the model is free from technical problems have got the same rating of 3.73 which is much lower compared to the perfect score of 4.

One of these Biology major teachers is Bio G, which has focused on the technical aspects of the model that were prescribed on the User's Manual. These aspects according to him include explaining the direction on the manual on how to use the model, putting pictures to every step on the manual, and using Liter instead of Cubic Centimeter as the volume scale of the fluid to be used in the model.

Just like what is said by Non-Bio A, putting emphasis on the explanation was also an important factor in order to make a better understanding of the concepts. In view of this statement, the researcher has done the same thing on the directions on how to operate the Human Circulatory System Model in which he makes it clear and specific on the manual in order for the user to follow the technical operations of the model without consuming large amounts of dye which was the primary material in operating the model.

Another pitfall which was observed was the absence of pictures that will give clear directions to the user from the preparation up to the last step of operating the model. In view of this, the researcher has added images that would show the important steps in operating the model which would guide the user to its overall mechanism. The unit of measurement for the fluid to be used in the model was also revised from Cubic Centimeters (CC) to Liters (L) that is because this unit was a common unit of volume that can be easily recognized by the user as well as the viewers.

4 indicators got the same weighted mean ratings which refer to the hydraulic system of the model enhances the understanding of the Circulatory System, the combination of colors of the dyes are clear and can be easily understood, there is a complete synchronization of the electric motors and the other parts of the model, and the liquid pressure that mixed the dark red liquid (deoxygenated blood) and yellow coloration (which will act as oxygen) is effective for instructional purposes has got a weighted mean of 3.82 which was second to the lowest rating given by the Biology major teachers.

As suggested by Bio H in the validating sheet, the researcher should emphasize the overall mechanism of the model which was unidirectional in which the blood flows in a unidirectional path. As a response to this, the researcher has explained thoroughly this concept before going to the main discussion of the Circulatory System in order for the students to be informed on how the Blood circulates and how it was being oxidized through the dyes which were mixed by high pressure motors before it was released for perfusion on the organs and tissues.

Indicators pertaining to the color of the oxygenated blood is uncluttered and aesthetically pleasing and the model can be easily brought from one place to another have both got a weighted mean of 3.91 and have a descriptive rating of very satisfactory. Suggestions from Bio E could be related to the problem about the Blood coloration in which she has said that the researcher should try another medium for the Blood representation. Using natural colors which were available on the natural surrounding was another option to be adopted. Although

it was a good suggestion to be considered, there's some pitfalls that may arise.

Pitfalls would be the availability of the color extracts that were suitable as blood coloration because some of these extracts were flowering plants and some of it were seasonal to bloom like the Bougainvillea that blooms only in summer. Another one was the preparation of such extracts was a little bit challenging because of its natural components that made it not suitable for a certain amount of time. Lastly, some of these extracts may cause stains on the tubes and compartments of the model that may hinder the actual circulation and oxygenation of the Blood. On these scenarios, this innovation of using natural extracts on the model should be further studied and experimented before taking it into practice to prevent some technical errors that may possibly arise on the model.

Another indicator that has also got a weighted mean of 3.91 tackles about the model can be easily brought from one place to another. This indicator can be related to the comments prescribed by Bio F. Although this validator has positively said that the model is portable, this model cannot be transferred to distant places by one person only but rather a minimum of 2 persons can lift up this model. Since the main base of the developed model has a large dimension and somewhat heavy to carry, the researcher has installed four transport wheels on it for an easy maneuver during the presentation. Through these wheels, the model can also be easily pushed from one place to another without exerting so much force or effort.

The last 2 indicators under technical quality factor have got a weighted mean of 4.00 which was a perfect rating based on DepEd LRMDS guidelines. These indicators pertain to the design of the model allows the target user to navigate freely through the material and the model can easily and independently be used by the user. Comments of Bio F can also be the baseline of these indicators wherein it was said that the model was effective, portable, and very convenient to use.

Overall, the average weighted mean rating of Biology major teachers with regards to the technical quality of the model was 3.85. This rating was regarded also as very satisfactory which only proves that the developed model of the researcher was applicable on a classroom and laboratory setting for science experiments and researches.

These results of the validation on the Technical Quality factor of the developed model can also be related to the study of Christ, Barowsky, Gekle, and Thews (2020). These researchers had also focuses on the overall mechanical properties of the Circulatory System Model wherein they had concluded that this model can offer a wide range of opportunity to the students with regards on the basics of the interrelationship of Circulatory System to the other systems of the human body.

Accuracy

This factor was the most crucial baseline on validating the acceptability of the Human Circulatory System Model that is because it focuses on the perceived errors found in the model. Unlike the other factors which were composed of 10 indicators, Accuracy was composed only of 4 indicators which pertains to Conceptual Errors, Factual Errors, System errors, and Other Errors (e.g. visual errors, synchronization errors, etc.).

Table 4. *Evaluators' Rating on Accuracy*

Indicators	**Non-Biology**		**Biology**	
	WM	Desc	WM	Desc
Conceptual errors	3.90	NP	3.64	NP
Factual errors	4.00	NP	3.45	PBVM
System errors	3.60	NP	3.73	NP
Other errors (e.g. visual errors, synchronization errors, etc.)	3.80	NP	3.55	NP
Overall	3.83	NP	3.59	NP

Legend: WM – Weighted Mean PBVM-Present but very minor VS - Very Satisfactory Desc - Descriptive Rating

Table 4 shows that one of the four indicators in the Accuracy factor which was validated by Non-Biology major teachers has got the lowest weighted mean of 3.60 and has a descriptive rating of Not Present based on LRMDS guidelines of DepEd. This descriptive rating only signifies that there's no major defects found in the

model. This rating tackles about on the indicator which pertains to System Errors. Based on Non-Bio G, System Errors such as blockage of the tubes and saturation of the dissolved medium may occur during Blood circulation and oxidation. As what the researcher has said, this problem may occur only if there's a limited supply of electricity that is because the electric motors will stop the fluid pressure. As a proactive response to prevent such complications on the Blood circulation and oxygenation, the researcher has purchased a portable Power Station that could supply 220V of power just in case there's a limited supply of electricity. Through this, the electric motors will continue to operate even on the time of power interruptions to maintain the fluid pressures on the model.

Other errors such as visual errors and synchronization errors has got a weighted mean of 3.80 which was second to the lowest rating given by the validators with a descriptive rating of Not Present. As it was said by Non-Bio B, the model should have compartments that will act as a human torso before revealing the main parts of the Circulatory System. In view of this, the researcher has made such compartments with an attached human torso so that the audiences may think critically as they saw the model.

Conceptual errors with a weighted mean rating of 3.90 signifies the problem prescribed by Non-Bio A which tackles about the emphasis that should be put on in the discussion about the function of other organs involved in the model. To address this problem, more research studies were reviewed by the researcher to put more weights on his discussion most specially on the technical aspects of his presentation. Among the 4 indicators which was tested and validated, only the Factual Errors has got the perfect rating of 4.00. The comments by Non-Bio H could be related on this rating that is because this validator has said on her evaluation that the concept which was created by the researcher was good and can be easily understood by the students which was tallied to what the result of the validation has signified.

Based on the results of the validation of Non-Biology major teachers under Accuracy factor, their overall rating on this factor was 3.83 which only means that major errors on the model were Not Present based on the guidelines prescribed by DepEd LRMDS.

Biology major teachers had also made a validation of the model wherein they had also inspected the errors that could possibly happen as the model was being operated. Based on the Table 4, the Factual Errors has got the lowest weighted rating which was 3.45 and this rating was PBVM or Present But Very Minor according to DepEd LRMDS. Suggestions/Recommendation by Bio A and Bio H would explain why such rating was given during the validation phase of this study. These 2 validators have said the same thing about the presentation of the model which tackles about the revision on the discussion on how the Blood flows in the Blood vessels and how it was being oxidized by the Lungs. The researcher should also emphasize that his self-made Circulatory System Model was unidirectional which only means that the Blood that circulates all over it flows in a unidirectional path. In view of this, the researcher should explain this information beforehand in order for the observers to be informed of the expected outcomes as the model was being operated.

Other Errors (e.g. visual errors, synchronization errors, etc.) has got a rating of 3.55 which only means that major errors are Not Present. According to Bio D, the tubes which were used as Blood vessels should have colors for an easy identification of the viewers that's why the researcher has used transparent tubes and colored tube to represent the Blood vessels found in the model. The transparent tubes were used to represent the main vessels of Circulatory System where rich Oxygenated Blood and poor Deoxygenated Blood flows. The Blue colored tube on the other hand represents the vessel that dispenses the Deoxygenated Blood before and after the circulation and oxygenation processes.

Another error which was inspected by Biology major teachers was the descriptions on every expected event on the manual of the model. As a response to this problem, the researcher has added some images with appropriate explanations of the technical mechanisms of the model in order for the user to be guided for the rest of its mechanical operations.

Indicators pertaining to Conceptual Errors which got a weighted mean of 3.64 and System Errors which got a weighted mean of 3.73 may also be linked to what it said by Bio A and Bio H which tackles about the proper delivery of the discussion pertaining to the unidirectional flow of the Blood. In view of this, the researcher has to make some revisions most specially to the concepts that should be tackled about the Circulatory System. Additional information that was supported by

necessary reviewed literatures and studies were collected by the researcher in order to give a concrete explanations of the concepts to the intended audiences.

With all of these ratings under Accuracy, the researcher has got an overall weighted mean rating of 3.59 from the Biology major teachers for his self-made model of Circulatory System. Compared to the rating which was given by Non-Biology major teachers under this factor, it was a little bit short of 0.24 that's why some development and improvement should be taken into action by the researcher in order to make the model more functional to the audiences.

Although this last factor of the validating sheet was not a perfect score in an average, its descriptive rating was still Not Present. This descriptive rating only means that the model was recommended for use in public schools as it was suggested and validated by the Science teachers. These claim was according LRMDS guidelines prescribed by DepEd.

Like the previous studies, this present study has also used research stages to avoid unforeseen errors as the model was used or operated in a classroom setting. Astino-Perdana, Sidabutar, and Sungkono (2020) have made use of research stages which include planning, design, and development to make their study more reliable in terms of its valid results. They also purposively chosen the Science teachers as their respondents to validate the usability of their created model just like what the present researcher has did in which he has also chosen the Science teachers as experts to evaluate his self-made Model of Circulatory System in order to test its functionality and also for the researcher to troubleshoot the perceived errors in the model.

CONCLUSION AND RECOMMENDATIONS

Based on the findings, the researchers were led to conclude that the main mechanism of the developed Human Circulatory System Model was unidirectional. This mechanism only means that the Blood that flows on each organs, tissues, and Blood vessels of the model circulates on a unidirectional path. Moreover, through validations of the model, the researchers have found out that Non-Biology and Biology Major teachers have rated the developed model of Circulatory System by the researchers as Very Satisfactory along the Concept Quality, Instructional Quality, Technical Quality, and Accuracy. These descriptive rating only implies that these Science teachers had highly recommend this model for a classroom instruction and these validators also believed that this developed Circulatory System Model can ensure the learning and understanding of the students with regards to the interrelationship of Circulatory and Respiratory System.

With regards to the significant difference in the acceptability of the developed Human Circulatory System Model of the respondents along with the identified variables of the study, the researchers have found out that there's no significant difference in the acceptability of the developed Human Circulatory System Model of the respondents along the identified variables that were prescribed on the validating sheets. This statement was based on the computed U values of the 4 factors which pertains to the perceptions of the Science teachers between those 4 factors in the evaluation sheet.

As for the recommendation, it was recommended by the researchers that additional upgrades can be done for the model in order for it to function accurately in terms of Blood circulation and oxygenation. Since the developed model by the researcher was composed of only one Pulmonary Artery that was connected from the right chamber of the Heart going to the Right Lung, future developers and researchers should put an additional Pulmonary Artery that would connect the left side of the Lung to the right chamber of the Heart for a quick and accurate oxidation process of the Blood. Moreover, this developed model may serve as a new utility tool to be used by other schools and grade levels most specially by grade 9 students in studying the Blood mechanisms in the human body.

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