



Heuristic approach with teacher-made worksheets in general biology 2: A classroom innovation in distance learning

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ABSTRACT

Learning science is the most exciting part of being a high school student. The fun learning through exploration and laboratory experiments is the best part of science. This study aimed to test the effectiveness of the heuristic approach with the teacher-made worksheets as a teaching innovation in distance learning in helping the respondents to understand the topics of General Biology 2. This research employed a mixed-method; the qualitative data were evaluated using the phenomenological technique, while the quantitative data were processed using the Statistical Package for Social Sciences version 25 (SPSS v.25). The researcher used a pretest, five teacher-made worksheets, a posttest, and a delayed posttest as tools. Also, focus group discussion was considered to find out the common problems encountered by the students and the researcher himself. All the gathered data was recorded digitally and through field notes and discreetly handled. There are 10 enrolled students in Science, Technology, Engineering, and Mathematics (STEM) during the school year 2020–2021, and they were all chosen purposefully. This study involved the five-week topics in the second semester of the 3rd quarter. Results revealed an increase in the respondents' learning performance based on the mean percentage scores of the posttest. Based on the increase in the mean of the delayed posttest, the innovation promotes retention for the students. The researcher and the students had technical problems because of a power outage and unstable internet connections. Still, respondents face the challenges of output management and helping their parents first before learning. There is a significant difference in the respondents' performance before and after implementing the innovation. The heuristic approach to teaching improved the performance of the STEM students at San Felipe High School under the subject General Biology 2. It is recommended that teachers use the heuristic approach to teach students how to work in a digital world.

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INTRODUCTION

Learning science in high school is the most exciting part of being a student. The fun learning through exploration and laboratory experiments is the best part of science (Dela Fuente, 2019). The students are learning hands-on, and they can discover their potential in scientific learning on their own with the supervision of the teacher. Learning by doing is learning from one's actions. In other words, it is a way for students to actively participate in their education (Mekonnen, 2020). The student's active participation could make their learning lifelong and even apply what they have learned while discovering new things in their natural environment by thinking critically about a situation, carefully executing plans, and making good decisions. Lifelong learning is obtaining and extending information, skills, and attitudes throughout one's life to maintain or improve one's well-being (Laal & Salamati, 2012).

In school, teachers can guide the students to discover ideas and knowledge and eventually apply their learning in the real world and its challenges. However, because of the rapid spread of the coronavirus, the difficulties in learning science become more extreme, making the schools closed and making the teachers and students continue the teaching and learning process distantly. According to United Nations (Engzell et al., 2021), governments worldwide have taken steps to halt face-to-face instruction in schools, affecting approximately 95% of the world's student population—the most significant disruption in education history. Globally, most countries implemented non-pharmaceutical interventions to mitigate the spread of the virus, such as the closure of land, sea, and air borders, closure of schools, non-essential shops, and prohibition of gatherings and visiting nursing homes (Haug et al., 2020). Despite that, the teaching and learning process can continue with the help of technology. Still, teachers' supervision and students' hands-on learning experience becomes limited due to government restrictions brought by Covid-19.

The Philippine educational sector is one of the most affected by Covid 19. According to United Nations, Educational, Scientific, and Cultural Organization (Landicho, 2021), school closures affect over a billion children or 61% of the global student population. However, the Department of Education adopted blended learning, shifting from the traditional face-to-face classroom lecture to continue teaching and learning. The Department of Education advocated using online learning, a modular approach, and radio-television approaches (Tupas & Linas-Laguda 2020). Teachers, students, and stakeholders deal with the new challenges of online teaching and learning. Not to mention, noise/environmental distractions, technological obstacles, and a poor internet connection were among the students' most pressing concerns (Cabual & Cabual, 2022). In the Philippines, classes resumed on Monday, October 5, 2020, even though campuses remained closed and face-to-face lessons remained suspended due to the COVID-19 pandemic (Magsambol, 2020). Department of Education has released a set of standards that field implementers and private schools will use in the school year 2020-2021. To address the educational problems posed by Covid-19, the Basic Education Learning Continuity Plan (BE-LCP) exposes learners to a variety of modes of instruction, one of which is printed modular distant learning (Geroso & Aloba, 2021). The Most Essential Learning Competencies (MELCS) will allow the department to concentrate on the most critical skills that students must learn (Ravina & Mendoza, 2021). Distance learning is an excellent challenge to all Filipino students under the new normal. According to a survey conducted by the multisectoral group Movement for Safe, Equitable, Quality, and Relevant Education (cited in Magsambol, 2021), 86.7 percent of students in modular learning, 66 percent in online learning, and 74 percent in blended learning said they "learned less" when compared to the traditional face-to-face setup.

Moreover, the study also indicated that only 5.4 percent of blended, 5.7 percent modular, and 9.1 percent of online learners "learned more." The survey result can be challenging for the education sector in making innovations and addressing the learning needs of diverse students. Innovations in teaching are the best strategy to address some challenges of teaching and learning. Innovation can be as easy as doing things differently in education, necessitating new techniques, processes, products, or strategies (McMillan, 2021). Innovations in teaching are not only limited to the use of technology but in many forms as long as how it best serves students in learning. Teaching innovation based on Huang et al. (2019) means having imagination and demonstrating vivid and vibrant teaching tactics to make students interested in learning.

Science is one of the fun subjects to learn in high school, but in the new normal, science subjects are undeniably one of the hardest because some topics require hands-on learning. Nevertheless, science is one of the subjects that can be observed and applied almost every day. Science study engages students by offering them the opportunity to test their ideas and construct their understanding (Wisanti et al., 2021). For the students to understand science, teachers should not stop innovating and relate their teaching to the environment and interests of the learners. Green (2016) emphasized that the best way to make the subject worthwhile for the students is to show how it would be helpful to them in the future.

The application of learning in science is better if the teachers help the students to accept responsibility, making them understand that they are responsible for learning. Moreover, the role of teachers in ensuring the teaching and learning strategies that are used can attract students to get interested in a subject (Jamal et al., 2017). Learning is crucial for progress, yet development usually starts with oneself. Students should learn how to learn, find solutions on their own, and develop critical thinking skills independently. The heuristic method is aligned with learning by doing, and teachers serve as the facilitator. The Heuristic approach can maximize the ability of the students to learn independently while taking responsibility. Abonyi and Umeh (2014) introduced that Heuristics are rules of thumb, educated guesses, intuitive judgments, or common sense. The researcher is interested in making innovations in teaching science using the Heuristic approach to discover or use their common sense in dealing with the science subjects. Previous studies have reported the effectiveness of utilizing the Heuristic approach in different subjects has been tested and claimed that the students in the experimental group performed well than the control group based on the result of a posttest (Al-Fayez & Jubran, 2012, Nwafor et al., 2019, and Yusuf et al., 2020). This means that students in the experimental group utilized their ability to discover the answers themselves and performed well in the subjects they were under. Tambunan (2018) mentioned in his study that the heuristic strategy affects students' abilities in each Higher Order Thinking (HOT) indicator, including their capacity to comprehend concepts, be creative, communicate mathematically, solve problems, and reason. Most of the research regarding the Heuristic Approach was conducted during the old normal, and only a few focused on the new normal in education, particularly in science teaching.

Through proper dissemination of enough information, students could use their educated guesses or intuitive judgments in learning under the new normal. The Covid-19 pandemic forced teachers and parents to adapt to distance learning (Goudeau et al., 2021). Distance and blended learning are the only approaches left in the education system. Poverty limits the online teaching process, leaving the students with an incomplete understanding of the lessons. This reason pushes the teacher-researcher to develop contextualized worksheets containing enough knowledge without spoon-feeding information to the students. Additionally, all worksheets will be in google form format and disseminated through google classroom to ensure the student's safety from the danger of Covid-19. The researcher believes that the Heuristic approach with worksheets is a good combination for innovation in keeping the quality of learning science constant, making the students exhaust all resources they have to discover and learn. Incognizant of the information above, the researcher wanted to test the effectiveness of the Heuristic approach with teacher-made worksheets in students learning in General Biology 2 through classroom-based action research in distance learning. The problems encountered in implementing the said innovation under the new normal are another concern.

Objectives

This study aimed to test the effectiveness of the Heuristic approach with teacher-made worksheets as an innovation in teaching General Biology 2 in the new normal. Specifically, the following questions guided this study:

1. Does the innovation improve the understanding of the students in the topics of the subject General Biology 2?
2. Does Heuristic Approach with teacher-made worksheets promote learning retention as measured by the delayed posttest?

3. Is there a significant difference between the students' performance before and after the implementation of the innovation?
4. What are the challenges encountered by the teacher and students during the implementation of the innovation?

Hypothesis

Question number 3 was hypothesized at a 0.05 level of significance; there is no significant difference between the students' performance before and after the implementation of the innovation.

METHODS

Research design

This action research employed a mixed method. The quantitative part focused on the numerical data, and the qualitative section focused on the challenges encountered during the implementation of the innovation. One-group pretest-posttest experimental design was used in this study.

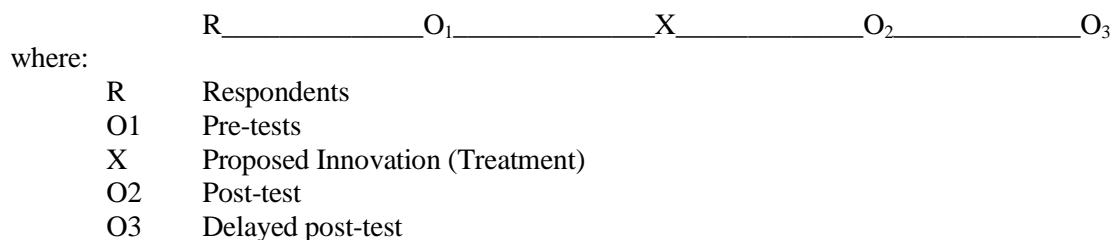


Figure 1. Experimental set-up

The quantitative data was gathered through focus group discussion and transcribed manually through thematic analysis. The participants' direct quotations were used to complete the research process. The quotations are incorporated into the analysis and pertain to the study's topics. The direct quotations have been rendered in English from Ilocano. The translation to English clarifies the analysis using direct quotations from respondents, resulting in coherent reading experiences free of distraction (Dlamini, 2016).

Respondents and sampling method

Before the innovation occurred in teaching, there were only ten students enrolled in STEM during the school year 2020-2021. Thus, ten respondents had been purposively selected and encouraged to become active participants. According to Etikan (2016), purposive sampling, also known as judgment sampling, is the deliberate selection of a participant based on the qualities the participant possesses. It is a non-random technique that does not require underlying theories or a predetermined number of participants.

Data collection

This study was conducted during the third quarter of the school year 2020-2021, covering the 5 Most Essential Learning Competencies for five weeks (e.i 1 MELC per week). The 25-point quiz items for pretest and posttest were generated based on the table of specifications. The specification table, also known as the test blueprint, is a document that assists teachers in aligning objectives, instruction, and assessment (Alade & Omoruyi, 2014). Thus, the purpose of the table of specifications is to construct the test items that focus on the critical areas based on their importance.

For the quantitative data, the researcher employed the pretest, 25 quiz items that contained the topics good for five weeks to know the prior knowledge of the respondents. With the 25-point scoring rubric, five contextualized worksheets (1 per week) were disseminated for the students to accomplish. The worksheets are activity type, and the students are free to pull all the resources they have. After they had completed the 5th worksheet, the posttest was circulated. The delayed posttest was dispersed among the respondents the week after the posttest again; the test items were all based on the table of specifications. The quantitative result can determine the effectiveness of the teaching innovation and the learning improvement of the respondents. The quizzes were validated by three Master Teachers of different schools. The average computed mean of the validators was 4.10, or valid, as described in the table below.

*Table 1. Validation means range and description
(Adopted from Meimban, cited in Cacay, 2019)*

Mean range	Description
4.21-5.00	Highly Valid
3.41-4.20	Valid
2.61-3.40	Moderately Valid
1.81-2.60	Fairly Valid
1.00-1.80	Not Valid

The qualitative data was gathered through focus group discussion via google meet during online “*kumustahan*” once a week. The topic was focused on the problems that respondents encountered in the length of the implementation of the innovation. This strategy was used to find out the challenges met by the respondents and the researcher during the implementation of the innovation. The focus group discussions are commonly employed as a qualitative technique for developing a thorough grasp of social issues (O.Nyumba et al., 2018). The challenges encountered by the participants and researcher were recorded digitally and through field notes. The researcher used in-depth interviews as the primary data collection method by using an unstructured interview question.

Data analysis

The researcher presented and summarized; first, the quantitative data followed by the qualitative interpretation aligned with the set objectives. The mean percentage score (MPS) was considered to describe the scores of the students in their pretest and posttest and the delayed posttest results. The paired sample t-test was utilized to determine the significant difference between the students' performance before and after implementation. Phenomenological analyses were being used for the challenges encountered by the respondents and the researcher regarding the implementation of innovation. The qualitative data were organized, and the emerging trends were discussed thematically.

Ethical consideration

The names of the respondents, including the qualitative and quantitative data involved in this study, were withheld to protect their identities. The students do not know they are under this research, so the results will not compromise. Further, the study ran based on the regular schedule of the respondents, and the division office approved the conduct of this study.

RESULTS

The improvement of the respondents in understanding the topics of General Biology 2 through the proposed teaching innovation

The respondents are used to having a face-to-face discussion and hands-on learning through laboratory experimentation. Due to government restrictions, students are experiencing more challenges in accomplishing their

outputs and understanding their lessons. The teaching innovation is believed to develop a habit of inquiring and investigating and a scientific attitude among students. Since face-to-face class and laboratory experiments are prohibited, the students can pull every available resource in their convenient places. On the other hand, the pretest, posttest, and delayed posttest were streamlined through the google form to keep the students safe from the danger of Covid-19.

Table 2. Pretest and Posttest Scores (n=10)

Quiz/Test	Lowest Score Obtained	Highest Score Obtained	Highest Possible Score	Mean	MPS
Pretest	4	10	25	3.52	36.50
Post-test	20	25	25	9.00	90.20

The table shows the lowest and highest scores obtained by the respondents in both the pretest and posttest. Note that the MPS (Mean Percentage Scores) of the posttest (90.20) is higher compared to the MPS of the pretest (36.50), expressing improvement of the respondents undergone to the innovation. The Heuristic Approach with the teacher-made worksheets enabled the students to be more engaged by pulling all the resources available to learn from each topic based on the MELC.

Table 3. Teacher-made worksheets Scores (n=10)

Quiz/Test	Lowest Score Obtained	Highest Score Obtained	Highest Possible Score	Mean	MPS
Worksheet 1	19	25	25	8.84	85.10
Worksheet 2	15	25	25	8.80	88.24
Worksheet 3	20	25	25	8.96	89.1
Worksheet 4	18	25	25	8.80	88.24
Worksheet 5	16	25	25	8.64	86.67

From the researcher's first to the last worksheet, the mean scores are improved (8.84, 8.80, 8.96, 8.80, and 8.64). The teacher observed that 100% of the students communicate through Facebook messenger and Google Classroom after distributing the worksheets every Monday of the third Quarter. The above table shows that the score of each worksheet is above average, and the highest possible score has been obtained. This further indicates that the teaching innovation promoted learning and improved the respondents' understanding of General Biology 2, even in the pressure of distance learning. To further measure the effectiveness of the Heuristic approach and the worksheet, the researcher administered the delayed posttest after a week through google form to find out if the said innovation promotes retention among the respondents.

Heuristic approach with teacher-made worksheets promotes retention of learning.

To determine if the teaching innovation promotes learning retention, the researcher provided a delayed posttest a week after the dissemination of the posttest. Table 4 below shows the obtained scores by the respondents:

Table 4. The posttest and delayed-posttest scores of the respondents

Quiz/Test	Lowest Score Obtained	Highest Score Obtained	Mean	MPS
Post-test	20	25	9.00	90.20
Delayed Post-test	19	25	8.88	89.02

The mean percentage scores (MPS) of the delayed posttest (89.02) is close to the MPS of the posttest (90.20). This means that the Heuristic approach, with the help of the worksheets, promotes learning retention among the students. The respondents did everything to understand the topic and answer the given worksheets independently. The mean (9.00) and the MPS (95.20) garnered on the posttest and the delayed posttest (8.88, 89.02, respectively) are close to each other, retention of information, knowledge, and learning is evident.

The performance of the students before and after the implementation of the innovation

Table 5. Differences in the Students' Performance

Tests	Mean	t-value	p-value
Pretest – Post-test	-13.700	-11.141	.000

The above table shows that the pretest and posttest administered to the respondents were below the set value of 0.05 alpha level of significance. The null hypothesis that there is no significant difference between the students' performance before and after implementing the Heuristic Approach with the teacher-made Worksheets is rejected. This result explains statistically that through the Heuristic approach with the worksheets, improvement of the respondents is visible as they promote independent learning among themselves.

The problems encountered by the teacher and the respondents during the implementation of the innovation

At the end of each worksheet, the students can write their reflections and problems they encountered during the independent learning approach. The researcher also has his field notes to jot down his observations and difficulties encountered during the implementation of the innovation. Further, the researcher conducts online “*kumustahan*” once a week to check on the students' progress in all of their subjects and, at the same time, get their lived experience with the proposed innovation through unstructured interview questions. Data from the interviews and field notes revealed four major themes: output management, power interruptions, unstable internet connections, and helping their parents.

DISCUSSION

Improving students' performance in General Biology 2

Comparing the result of the pretest (36.50) and posttest (90.20) clearly shows that there was an improvement in the respondents' understanding of the topics of General Biology 2. Since the approach used was Heuristic, the students figured out how to learn independently by only using the available materials. This supports the study of Hoon et al. (2013), students were able to solve mathematical problems using a heuristic approach that

included representation, making a calculated guess, and following the process. The Heuristic approach helps the students discover things necessary to accomplish the teacher-made worksheets. The possible resources they had were the internet, previous lecture notes and books, and even asking their relatives about a particular topic. As denoted by the MPS of the posttest, the improvement shows that students are learning while accomplishing the worksheets. The worksheets were contextualized based on the students' living environment as possible for them to relate to the objectives per topic efficiently and, at the same time, lighten up the pressure in accomplishing the worksheets without spoon-feeding them. However, there are some topics related to evolution and DNA that are hard to connect to the active environment of the respondents. Still, they can learn these online by opening their previous lecture notes. It was also observed that most of the students satisfied the objectives of the activities by following the scoring rubrics and obtained the highest score possible. Contextualized instructional materials enable learners to master various competencies required for education and learning (Jimenez, 2020). The Heuristic Approach with the teacher-made worksheets helped the students be more engaged by pulling all the resources available to learn from each topic based on the MELC. Thus, they improved their understanding of the General Biology 2 subject topics by accomplishing the task in their way.

Innovation promotes the retention of students.

Even a week after taking the delayed posttest, the student's understanding of the subject's topics is still evident. The statistical evidence that the heuristic approach promotes learning retention is supported by the findings of Rayakaew (cited in Satchakett & Art-in, 2014) that students who were taught using a heuristic approach had a higher level of learning achievement and retention in learning. Buniel and Monding (2021) and Dela Fuente (2021) believed that students aided by the worksheets did better than those taught using a conventional approach. With the combination of the Heuristic Approach with teacher-made worksheets as teaching innovation, the students' learning was retained because they made decisions on how to finish the given activities on the worksheets. Foregoing findings collaborate with the discoveries of Stephenson & Sadler-McKnight (2016) and Taylor (2021) that Science Writing Heuristic (SWH) approach is practical at fostering critical thinking development. Thus, with the close results of the posttest and delayed posttest (90.20 and 89.02, respectively), and by the students as active participants in their learning, the innovation also promoted critical thinking among the students since this study used the same approach, which is the Heuristic.

The performance of the students before and after the implementation of the innovation.

Pretest (MPS 36.50) was utilized to predetermine the students' initial understanding of the topics of General Biology 2 in the third quarter of the school year 2020-2021. After implementing the innovation, a posttest (MPS 90.20) was conducted. Statistically, the computed p-value (.000) is below the 0.05 alpha level of significance; it is clear that the innovation improves the students' understanding. Given the difficult situation of community restrictions, the respondents are allowed to use all the resources they had and understand the worksheets independently. Students better understood the topics since they discovered the answers by using their capabilities to exhaust only their available resources. The students' dedication to understanding the topic is based on their exchange of dialogue online (group chats and google classroom), even late at night.

The challenges encountered by the teacher and the respondents during the implementation of the innovation

Every week, an online “kumustahan” or meeting was organized weekly. This allows conducting a close group discussion for the researcher to determine the common challenges experienced by the respondents by using unstructured interviews. This opportunity was taken to respect the school guidelines and students' schedules. The difficulties encountered by the respondents were triangulated to the challenges experienced by the researcher, recorded using field notes.

Theme 1. Output Management. General Biology 2 was not the only subject that the respondents had. The respondents must deal with at least eight subjects, including general biology 2, and all required outputs to submit based on the requirements mandated by their teachers. According to the respondent, “*we need to accomplish our outputs to other subjects*” this makes sense because there are times that some students submit their worksheets late online. The researcher openheartedly accepts the outputs understanding the situation we were all under. Some students said, “*sometimes we unintentionally submit our accomplished worksheet late because we were busy facing other requirements*” basically, students had no idea how to manage their outputs in accomplishing them during this time because everyone was still adapting to the new normal state of learning considering that we do not use to live under the challenges of distance learning making them that could make them unhappy. Giving a break and a chance to submit their outputs even if it is late without score deduction is a great help to the student's mental health. The COVID-19 pandemic has severely impacted Filipino children's mental health, and children are more vulnerable to these ills (Malolos et al., 2021). Based on the study by Kecojevic et al. (2020) that depression was associated with difficulties concentrating on academic work and unemployment losses.

Theme 2. Power Interruption. This challenge in distance learning is the most common among all students and teachers. Since the researcher and the respondents of this study are residents of the same municipality, we had no choice but to accept when there is a power interruption. This challenge can also result in the delay of either the submission of the worksheets or module online or the output of the students. One of the students said, “*I have no power bank to recharge my phone*” Power interruption has been part of our economic system. Having this problem under the new normal is a great challenge, especially for those students who are less fortunate to purchase a power bank but want to learn and accomplish their outputs. Other respondents stated, “*I have no choice but to wait for the electricity to return*” Power outages impede students' ability to complete activities due to frequent connection loss, which forces them to exit the online session (Agaton & Cueto, 2021).

Theme 3. Unstable Internet Connection. Before the new normal, the internet connection has been inconsistent, and the speed is slow. The Philippines' internet connectivity lags behind other contemporary developing countries in Asia, with an average Internet speed of 2.8 megabits per second, ranking the country 104th out of 160 countries (Salac & Kim, 2016). With the current situation in distance learning, internet connection and electricity are crucial to the productivity of the respondents and the teacher academically. Asio et al. (2021) concluded in their study that students' access to the internet will be a significant barrier to their online learning. This concept also applies to the institution, the administration of the school, the faculty, and the staff.

Theme 4. Helping their Parents. Most of the respondents of this study were poor and poor students were one of the most affected by the new normal. Our municipality is agricultural, and most of the students, not only in STEM, need to help their parents earn money before they can face other things like studying. One of the respondents commented, “*I need to help my father in our rice field*” this reason alone can affect their focus on learning, especially since there had eight subjects to attend. Some of them needed to earn money to afford internet data. Because of poverty, this challenge is not new in the education sector. Parental involvement in children's education is critical to the academic success of young children (Garcia, 2018). However, poor students do not receive adequate support in countries with high poverty rates and a deficiency in basic education. Generally, the researcher gives the respondents chances to submit their accomplished worksheets without any score deduction. This is to show respect for the unimaginable challenges they have been through brought by Covid-19 and distance learning.

CONCLUSION

Based on the garnered data and analyses, the Heuristic approach of teaching improved the STEM students' understanding of the topics under General Biology 2. The researcher based on the results of the pretest and posttest. Additionally, the teaching innovation promotes retention to students as indicated on the mean of delayed posttest from the posttest. The common challenges experienced both by the teacher and students are primarily technical problems, namely power interruption and unstable internet connection. On the other hand, students' common challenges are output management and helping their parents earn money.

RECOMMENDATION

In line with the conclusion and the data presented in this study, it is recommended that a secure internet connection and a power bank are needed to ensure continuous learning when experiencing service interruptions. Lighten the approach to the students under the new normal to give way to their responsibility to accomplish first. The teachers should talk to the respondents' parents to monitor their online activities.

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