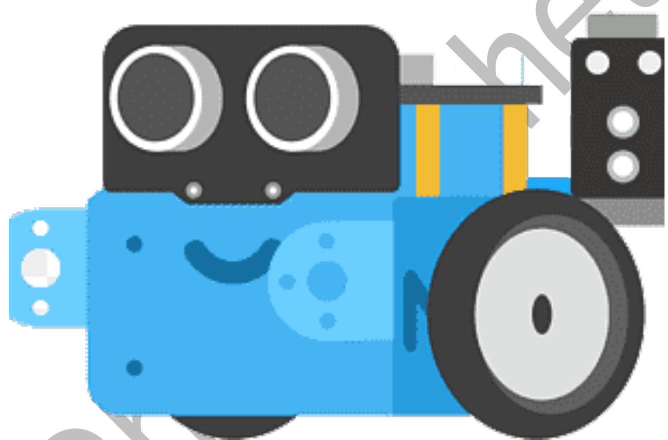
Assembly and Programming of mBOT Neo A STEM Robot

INSTRUCTIONAL DESIGN FOR
K-5 PRESERVICE TEACHERS



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INTRODUCTION

The following instructional design report outlines instructional strategy and materials for the assembly and programming of mBot Neo, a STEM robot, intended for preservice teachers. The report includes a thorough instructional analysis including learners and context analysis. Furthermore, learner's performance objectives as well as assessment plan and evaluation process (formative and summative) for the instruction is included in the report.

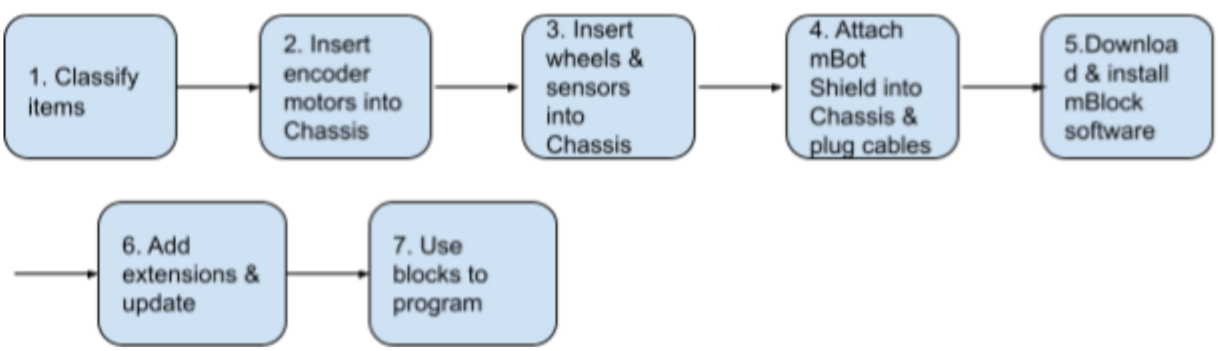
INSTRUCTIONAL GOAL

Goal Statement:

Upon receiving instruction, K-5 preservice teachers will be able to assemble and program mBot Neo- an educational robot to teach and integrate elements of computational thinking within children's curriculum.

Goal Analysis:

The goal for this instruction is aimed at equipping pre-service teachers with skills to successfully assemble and program mBot Neo robot. Following are the main steps or superordinate skills pre-service school teachers must demonstrate in order to achieve the instructional goal.



Learning Domain:

Intellectual and Psychomotor Skills

Learning Outcomes:

Upon showcasing the mastery of following superordinate skills, learners will have successfully assembled mBot Neo robot from scratch. The learners will also update and boot the robot with mBlock software making it ready for (programming) use.

1. Classify and arrange items in mBot Neo kit according to name, type, and size
2. Insert cables into the Encoder motors and fix the motors into the Chassis
3. Insert the wheels and sensors (RGB & Ultrasonic sensor) into the Chassis
4. Attach the mBot Shield into the chassis and plug all the cables
5. Download and install the mBlock software
6. Add extensions and update
7. Use blocks to program

INSTRUCTIONAL ANALYSIS

Sub Skills Analysis:

In order to achieve aforementioned superordinate skills, the learner needs to achieve following subordinate skills within each superordinate skill:

1. **Classify items in mBot Neo kit according to name, type, and size** ***(Intellectual domain)***

   1.1 Unbox mBot Neo and all the parts that is in the box

   1.2 Identify items as per the label and pictorial description in the mBot Neo kit 1.3 Arrange item parts according to type and item size (cables, screws)

2. **Insert cables into the Encoder motors and fix the motors into the Chassis** ***(Psychomotor)***

   2.1 Insert the two mbuild cables (10 cm cables) into the encoder motors (one on each motor)

   2.2 Insert the motors into the chassis and route the cables through the square opening

2.3 Use the 8mm screws (the shortest screws) in the kit to screw the motors in the chassis

3. **Insert the wheels and sensors (RGB & Ultrasonic sensor) into the Chassis** *(Psychomotor)*
   3.1 Insert wheel hubs into tires. Check whether you still see the gears of the wheel hub after the assembling.
   Yes >> continue to push the hub gears into the slick tires. No >> Proceed to 3.2
   3.2 Install the wheels using the 12mm Phillips head screws. Flip your screw's driver bit to the Phillips side for this process.

4. **Attach the mBot Shield into the chassis and plug all the cables** *(Psychomotor)*
   4.1 Install the mini wheel and light using 14 mm screws (medium length screws in the kit).
   4.2 Attach the 10cm four wire cable to the light sensor and route. The exposed side of the cable tip should be facing down.
   4.3 Attach the ultrasonic sensor using 14 mm screws. Be sure to note the correct orientation of the chassis. When plugging in the 10cm cable to the ultrasonic sensor, the exposed side of the cable tip should face outward toward the front of the chassis.
   4.4 Plug the other 10cm cable into the ultrasonic sensor. The end going to the ultrasonic sensor is the slightly smaller end and the exposed side should be facing outward like in the previous step.
   4.5 Attach the mBot shield using 25mm screws (the longest screws in the kit). Make sure the right motor is plugged into the right slot of the shield and the left motor is plugged into the left slot.
   4.6 Plug the 10cm cable extending from the ultrasonic sensor to the mBot shield. The exposed side of the cable tip should be facing down.
   4.7 Attach the CyberPi controller to the top of the mBot shield.

5. **Download and install the mBlock software**

(Intellectual)

5.1 Use the USB cable later to connect the mbot to a computer, charge it before turning it on

5.2 Download and install Makeblock PC version firmware for Windows or Mac using the link below: https://mblock.makeblock.com/en-us/download/

6. **Add extensions and update mBot Neo**

   (Intellectual)

   6.1 Open mBlock application in the computer

   6.2 Use the + icon below Cyber-pi to add devices of your choice. Green arrow means your device needs to be updated. Click on the green arrow for firmware update and click restart after the download is completed to install the updates

   6.2 Mbot Neo requires adding extensions to control the additional features of Cyber Pi such as motion detector, color detector etc. Click on + (add) extension to add Device Extensions: i. mBot2 Shield, ii. Ultrasonic Sensor 2, iii. Quad RGB Sensor (beta)

   6.3 Click connect after adding these extensions

7. **Use blocks to program your mBot Neo**

   (Intellectual)

   7.1 Drag and drop blocks from the left-hand side to the white space on the right to program your bot

   7.2 Switch the mode from Live to Upload to upload saved codes 7.3 If you see the 'Connect' button, click Connect

   7.4 Click the upload button to upload and run the Code

Entry behaviors:

- Students are proficient in using computer applications including download and upload of software
- Students are able to identify and use tools such as screws, screw drivers, cables and tools included in mBot Neo kit.

LEARNERS & CONTEXT ANALYSIS

Learner Analysis:

The learners are Pre-service teachers enrolled in University of South Alabama. The participant demographic is predominantly white and female students aged 17-23. The participants have been chosen as a part of the NSF project that aims to integrate computational thinking across the curriculum for Pre k-6 grade students by training pre-service teachers in that area.

Performance Context Analysis:

Computer Science as a stand-alone subject is not taught in Pre K-6 grade students within the US. In this context, learners who are Pre -K service teachers are being trained to integrate concepts of computational thinking, algorithmic processes within Science, English, Math, and Social Studies curriculum teaching using STEM educational robots such as mBot Neo and mTiny.

Majority of the learners themselves do not have a STEM background and do not have basic knowledge and skills on coding, programming, and computational thinking. In this context, learning to assemble and work with coding robots can be intimidating as well as challenging for the learners. The learners will have to think creatively about ways to utilize those robots within their lesson plans.

Learning Context Analysis:

Learning will take place within online learning management system of the University of South Alabama Canvas site where learners will be enrolled in the PEPTICC Seminar course. The course side will be uploaded with the instructional design for assembly and programming of mBot Neo. The canvas site will have resources such as Job-Aid, powerpoint presentation, and micro learning videos of the assembly and programming process. The learners will be provided with mBot Neo robot.

Constraints:

- Two instructional products- Job-aids and Powerpoint presentation guiding the assembly and programming of mBot Neo will be used. Technological difficulties and internet issues can hinder the presentation.
- Malfunctions in mBot Neo robots can pose a challenge during instruction.

PERFORMANCE OBJECTIVES

	Superordinate & Subordinate Skills	Performance Objectives
1.	Classify items in mBot Neo kit according to name, type, and size *(Intellectual domain)*	Given the mBot Neo kit (CN), classify and sort mBot Neo parts (B) by item type and size (CR)
1.1	Unbox mBot Neo and all the parts that are in the box.	Given the mBot Neo kit (CN), unbox all item parts (B) and place it in the desk (CR).
1.2	Identify items as per the label and pictorial description in the mBot Neo kit 1.3 Arrange item parts according to type and item size (cables, screws)	Given the mBot Neo kit (CN), arrange the items (B) by type and size (CN).
2.	Insert cables into the Encoder motors and fix the motors into the Chassis (Psychomotor)	Given the Encoder motors (CN), assemble the motors (B) and place it securely in Chassis (CR)
2.1	Insert the two mBuild cables (10 cm cables) into the encoder motors (one on each motor)	Given the two mBuild cables (10 cm cables) (CN), insert the cable into the encoder motors (B) one on each motor (CR)

2.2	Insert the motors into the chassis and route the cables through the square opening	Given the encoder motors with mBuild cables are ready (CN), route the cables (B) through the square opening in the chassis (CR)
2.3	Use the 8mm screws (the shortest screws) in the kit to screw the motors in the chassis	Given the 8mm screws (CN), screw the motors in the chassis (B) and secure/fix the motors to the chassis (CR)
3.	Insert the wheels and sensors (RGB & Ultrasonic sensor) into the Chassis (Psychomotor)	Given the wheels and sensors (CN), insert the RGB and Ultrasonic sensor (B) into the chassis (CR)
3.1	Insert wheel hubs into tires. Check whether you still see the gears of the wheel hub after the assembling. Yes >> continue to push the hub gears into the slick tires. No >> Proceed to 3.2	Given the wheels and tires (CN), insert the wheel hubs into the tires (B) until the gears of the wheel hub is completely under the tire (CR)
3.2	Install the wheels using the 12mm Phillips head screws. Flip your screw's driver bit to the Phillips side for this process.	Given the wheels and the Phillips head screws (CN), flip your screwdriver to the Philip side and insert the wheels using the 12mm screws (B) until the wheels are secured in the chassis (CR)

4.	Attach the mBot Shield into the chassis and plug all the cables (Psychomotor)	Given the mBot Shield and Chassis (CN), attach the mBot Shield into the chassis and plug all the cables (B) until mBot Shield is securely attached with correct plugs (CR)
4.1	Install the mini wheel and light (RGB) sensor using 14 mm screws (medium length screws in the kit).	Given the mini wheel, RGB Sensor (CN), install the wheel and sensor using 14 mm screws (B) and secure it in the correct orientation as shown in the presentation (CR)
4.2	Attach the 10cm four wire cable to the light sensor and route. The exposed side of the cable tip should be facing down.	Given the 10 cm cable and light sensor (CN), attach the cable to the sensor (B) and route it through the chassis as shown in the presentation (CR)
4.3	Attach the ultrasonic sensor using 14 mm screws. Be sure to note the correct orientation of the chassis. When plugging in the 10cm cable to the ultrasonic sensor, the exposed side of the cable tip should face outward toward the front of the chassis.	Given the ultrasonic sensor and 14mm screws (CN), attach the sensor to the chassis (B), and secure it in the correct orientation as shown in the presentation (CR)
4.4	Plug the other 10cm cable into the ultrasonic sensor. The end going to the ultrasonic sensor is the slightly smaller end and the exposed side should be facing outward like in the previous step.	Given the 10cm cable and ultrasonic sensor (CN), plug the cable into the sensor (B) and secure it in the correct orientation as shown in the presentation (CR)

4.5	Attach the mBot shield using 25mm screws (the longest screws in the kit). Make sure the right motor is plugged into the right slot of the shield and the left motor is plugged into the left slot.	Given the mBot Shield and 25mm screws (CN), attach the mBot Shield to the chassis using the screws (B) making sure the motor and plug orientation matches (right motor cable into right slot and left motor cable into left slot) (CR)
4.6	Plug the 10cm cable extending from the ultrasonic sensor to the mBot shield. The exposed side of the cable tip should be facing down.	Given the 10cm cable extending from the Ultrasonic sensor (CN), plug the cable into mBot Shield (B) making sure the exposed side of the cable tip is facing down as you plug (CR)
4.7	Attach the CyberPi controller to the top of the mBot shield.	Given the CyberPi controller CN), attach the controller on top of mBot Shield (B) ensuring the correct orientation of Cyber Pi (CR)
5.	Download and install the mBlock software	Given the assembled mBot Neo, USB Cable, and computer (CN), download and install 'makeblock' application (B) and make sure it is open and running (CR)
5.1	Use the USB cable later to connect the mBot to a computer, charge it before turning it	Given the USB cable, mBot Neo, and computer (CN), use the USB cable to connect mBot to a computer and charge it (B) ensuring mBot is ready for use
5.2	Download and install Makeblock PC version firmware for Windows or Mac using the link below: https://mblock.makeblock.com/en-us/download/	Given the computer and internet access (CN), download and install Makeblock PC firmware (B) and make sure it is up and running in your PC (CR)

6.	Add extensions and update mBot Neo (Intellectual)	Given the Makeblock firmware is functional in the PC (CN), add extensions and update mBot Neo (B) ensuring its readiness for use (CR)
6.1	Open mBlock application in the computer	Given your PC and mBlock application (CN), open the mBlock app (B), and make sure it is running in your PC (CR)
6.2	Use the + icon below Cyber-pi to add devices of your choice. Green arrow means your device needs to be updated. Click on the green arrow for firmware update and click restart after the download is completed to install the updates	Given your PC and internet connection (CN), use the +icon to update firmware and restart to install the updates on mBot Neo (B).
6.3	Mbot Neo requires adding extensions to control the additional features of Cyber Pi such as motion detector, color detector etc. Click on + (add) extension to add Device Extensions: i. mBot2 Shield, ii. Ultrasonic Sensor 2, iii. Quad RGB Sensor (beta)	Given your PC, mBot Neo, and internet access (CN), add extensions i. mBot2 Shield, ii. Ultrasonic Sensor, iii. Quad RGB Sensor (B)
6.4	Click connect after adding these extensions	Given your PC, mBot Neo, and internet access (CN), click connect on your computer (B)
7.	Use blocks to program your mBot Neo *(Intellectual)*	Given your PC, mBot Neo, and internet access (CN), use mBlock application to program mBot Neo (B)

7.1	Drag and drop blocks from the left-hand side to the white space on the right to program your bot	Using mBlock application (CN), drag and drop blocks from the left-hand side to the white space on the right to program (B)
7.2	Switch the mode from Live to Upload to upload saved codes 7.3 If you see the 'Connect' button, click Connect	Using mBlock application (CN), switch the mode from Live to Upload to upload saved codes and click Connect (B)
7.3	Click the upload button to upload and run the Code	Using mBlock application (CN), click the upload button to install and run the code (B)

INSTRUCTIONAL MATERIALS

1. mBot Neo robots
2. Laptops/computers to boot/program mBot Neo
3. PowerPoint slide
4. Job-Aids

Using the aforementioned materials, the instructor will equip the preservice teachers with resources needed for the assembly and programming of mBot Neo STEM robot. The seminar participants will have access to PowerPoint presentations on Canvas which walks the participants through a step by step process for the assembly and programming. Furthermore, the PowerPoint will also be embedded with videos demonstrating the procedure for every step. The instructor will also provide job-aids for the seminar participants outlining steps for assembly and programming as a reference material.

Given the learning domains for the instruction here is largely psychomotor and intellectual, demonstration of the assembly process is apt to guide the learners in a step-by-step process. PowerPoint and Job-aids will further aid in the retention and transfer of new knowledge and skills acquired.

ASSESSMENT PLAN

This project will use Pretests to ascertain the level of familiarity and knowledge preservice teachers have on computational thinking and Posttest to gauge their knowledge post instruction and see what worked and what did not. Pretests here can also be used to gain information on entry skills learners may or may not possess and made comprehensive to that end.

In addition to the pre and posttests, the designer will use Product Assessment where the learners will be asked to demonstrate the assembly of mBot Neo robot in sequential steps and lastly produce a basic code for mBot Neo to run on. Product assessment here can aptly capture student's progress in the assembly process of mBot Neo whereas coding mBot Neo to run would successfully gauge student's both psychomotor and intellectual learning aspects of the learners. A rubric for assembly process outlining the sequential steps and code produced (evaluating its quality and functionality) will be used for product assessment.

A summative assessment - final project evaluation to determine the overall effectiveness of the PEPTICC program and its long-term outcomes will be carried out at the end of the PEPTICC Seminar roll-out. Similarly, formative assessment surveys, interviews, and field-trials will be conducted with participants to improve instruction as it is being rolled out.

INSTRUCTIONAL STRATEGY

1. **Gain Attention:** Send out announcement regarding upcoming seminar, location and time. During the seminar, draw the attention of preservice students by standing in front, raising voice, and informing them of the beginning of mBot Neo assembly session. Given the session will ensue a PowerPoint presentation, put up the multimedia screen with an introductory slide projected.

2. **Describe the Goal:** Prior to starting the presentation, the instructor will describe the goal for the session which is the preservice students will have successfully assembled and programmed mBot Neo by the end of the session. The instructor will also mention that upon successful assembly and programming of the robot, they can apply and practice computational thinking via coding.

3. **Stimulate recall of prior knowledge:** Here the instructor will try to connect previous experiences and learnings of students with new information to be presented by asking questions such as if the students have had any experience with the assembly of any equipment, furniture? If the students have had any

experience of coding? If they are familiar with the concept of computational thinking and algorithmic processes? The instructor will then connect the experiences shared with what they are about to learn.

4. **Present the material to be learned:** The instructor will present the students with mBot Neo robot toolbox and ask them to unbox it. The instructor will then walk the students through the PowerPoint slides explaining the assembly process in sequential steps. Once the robot is assembled, the instructor will then walk the students on how to boot and program the robot.

5. **Provide guidance for learning:** As the instructor presents the slides, they will also demonstrate the assembly process. Once the robot is assembled, the instructor will show how to boot the program and the software used for that.

6. **Elicit performance "practice":** The instructor asks the students to follow their lead with each step of the assembly process. The instructor also asks the students to download the software, boot and program their robots.

7. **Provide informative feedback:** The instructor walks across the room and checks in with students on their progress and helps problem solve whenever students are unable to follow the step correctly.

8. **Assess performance:** The instructor will gauge the students' performance based on the final product i.e., mBot Neo robot post assembly process and its functionality after it is programmed.

9. **Enhance retention and transfer:** The instructor presents students with job-aid which provides step by step direction on assembly and programming of the robot to enhance retention. The instructor will ask the students to experiment, practice and create their own codes for mBot Neo.

EVALUATION

Formative Evaluation:

The designer conducted one-to-one evaluation followed by small group evaluation to gain feedback on the instruction and instructional product designed for the assembly and programming of mBot Neo. Following is a summary of the process and brief findings from both evaluations.

One-to-One Evaluation:

The designer touched base with one of the prospective participants for PEPTICC (Preparing Elementary Pre-Service Teachers to Integrate Computing across the Curriculum) Seminar who was required to work with mBot Neo- the STEM robot as a part of the seminar. The objective of conducting one-to-one evaluation was to get a thorough feedback on the instruction process including the use of instructional strategy and product and gauge its effectiveness. The one-to-one evaluation allowed the designer to determine whether the instructional materials used were appropriate to facilitate learning and if the materials were adequate in meeting the instructional goal. The one-to-one evaluation also allowed the designer to determine if the intended learner comprehends the instructional material, whether they are engaged with the instructional material and if it meets their learning needs.

The participant for one-to-one evaluation was randomly selected from students who had enrolled for PEPTICC Seminar whereby the cohort consisted of 30 preservice teachers. They were contacted via email asking for their willingness to participate in one-to-one evaluation. Those who volunteered were contacted to schedule the evaluation. The three main criteria for one-on-one evaluation were to determine the clarity, impact, and feasibility of the instructional material (Carey, Carey, & Dick, 2021). Whether the instructional material is able to deliver the message and content clearly to its users, does it have an impact on learners' knowledge and skill level, and if the instructional material does what it is supposed to do with given resources were some of the questions evaluators sought answers for via one-on-one evaluation.

The designer created a pre and post survey on mBot Neo Assembly process to see the change post instruction in knowledge level and learner's ability to follow the instruction. The survey questions consisted of both closed and open-ended questions asking learners' experience assembling and programming the mBot Neo. The survey asked the participant to state their reaction to the instruction content, structure, what worked and what did not work. The designer and the learner went through the pre and posttest responses for each question and delved in detail about the why and how behind each question.

Outcomes:

The learner found the PowerPoint slides on the assembly process useful in guiding through the assembly process. The breakdown of the assembly process as sequential steps was helpful. The learner's feedback pointed to the need of further breaking down of some steps which had multiple moving pieces. For e.g., inserting wheels and two sensors (RGB and Ultrasonic) was too much at once. A further breakdown of that step into three parts, insertion of wheels, insertion of RGB sensor, followed by Ultrasonic sensor as three separate steps would have been clearer and more succinct. The learner also provided feedback on labeling each part with photographs to help guide the assembly process.

The instruction met the objective as it guided the learner through assembly and programming of mBot Neo. The instruction however took more time than imagined, with few instances where learners had to trace back their steps, re-do certain steps, problem-solve and move forward. The designer took note of those steps that were confusing. The learner gave feedback on the use of screenshots and pictures in the PowerPoint and Job-Aid to be more focused close-up shots, with clear use of signs and arrows pointing the orientation while installing parts of mBot Neo. The post-test results revealed that the instructional material was mostly successful in meeting the learning objective as the students felt competent in assembly and programming after having used the instruction. While some of the steps outlined in the presentation were confusing, overall, the students were able to problem solve and assemble the robot. Similarly, the students had access to PowerPoint presentation on Canvas ensuring its accessibility and usability by the learners.

Small Group Evaluation:

Following the one-on-one evaluation, the designer implemented most of the feedback after careful reflection and analysis. Once the changes had been made, the designer then conducted a small group evaluation on the instructional material. The designer further selected participants from the same PEPTICC cohort and reached out to them via email asking them to volunteer their time and participation in the evaluation process. The purpose of conducting small group evaluation was to determine if the revisions made after one-on-one evaluation was effective in facilitating learning. The small group evaluation also allowed the designer to see if the learners were able to use the instruction without any setbacks or need for assistance. Furthermore, the group evaluation allowed the designer to assess the instruction delivery cost in a real setting and average time needed to complete the instruction and the required performance measures.

Given the PEPTICC seminar participants are fairly a homogenous group, the small group evaluation was set up with 8 participants who agreed to be a part of the evaluation process. The evaluator briefed the participants about the purpose and objective of the evaluation and how the instructional product is in its formative stage of development. The evaluator then explained that their feedback on the instruction will be critical in revising and refining the instructional material. The evaluator used pre-test and post-test to measure the change in knowledge level. In addition, the evaluator held a debriefing session at the end asking about their experience with the instruction and use of instructional materials, strengths, weaknesses, and areas of improvement.

Outcomes:

The small group evaluation gave the designer a good idea on the amount of time the learners need to follow the instruction and exhibit the performance. The designer had previously allocated 30 minutes for the assembly and programming but saw the group members take up to 45 to 50 minutes by the time they completed instruction and had their robots assembled and programmed for use. One of the things that came up during the debriefing session was integration of bite sized videos for each step of the assembly process in conjunction with the steps outlined in the PowerPoint so that the learners could self-assess and compare their progress as they moved along the assembly steps. The learners appreciated the frequent check-ins and feedback the evaluator gave as they were implementing the instruction. In a nutshell, the learners found the instruction to be clear and in alignment with the learning objective. They were able to follow the instructions and build the robot from scratch. The learners also felt confident once they had programmed and started the robot using mBlock application. The learners cited the need for more practice sessions with mBot Neo to gain confidence and fluency in using it.

Based on the findings from the group evaluation, the designer decided to allocate 1 hour for the assembly and programming of mBot Neo. Furthermore, the designer will integrate bite sized content for each step of the assembly process within the PowerPoint and use microlearning strategy for the instruction.

Field Trials:

For this project, the designer will use the instructional material in one of the scheduled PEPTICC Seminars at University Commons. A pretest prior to giving the instruction will be administered to all participants asking them questions on their knowledge of mBot Neo, skills in assembling and programming a STEM robot. The students will then be handed out the mBot Neo toolkit and the instruction asking them to assemble and program. The seminar comprises upto 30 students per cohort. Following the completion of instruction and performance, the students will be asked to fill out the posttest survey testing their knowledge level post instruction. The survey will also include open ended questions asking for their overall feedback and suggestion. The evaluator will observe the participants as they are implementing the instruction and take field notes.

Summative Evaluation:

Following the formative evaluations (one-on-one, small group, and field trial), the designer will make necessary changes and revisions to the instruction after which the instruction will be used by target groups in real world setting. Once the instructional material is implemented in actual context, the evaluator will conduct summative evaluation to gauge the overall merit and worth of the instruction. The objective of conducting a summative evaluation is to determine whether the instruction was able to facilitate learning that resulted in transfer ensuing change in performance. Impact Assessments, Outcome Harvesting are some of the types of summative evaluation that can be carried out to document the evidence of uptake from the instruction. For PEPTICC Seminar, the designer will conduct impact assessment and case studies to document the effects and outcomes from the instruction such as integration of computational thinking, improved algorithmic thinking skills etc. among participants.

REFERENCE

Carey, J. O., Carey, L., & Dick, W. (2021) The systematic design of instruction, 9th ed. Pearson.