Think – Pair – Share: A Case Study in an Electrical Engineering Class

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***Abstract*—Think - Pair - Share is a pedagogical practice that aims at increasing and varying student participation in the classroom. Research has shown that this method encourages increased student participation and higher levels of student thinking and questioning. This paper will present a case study in which two problems involving a non-inverting and an inverting operational amplifier are presented in class. In the first problem, the students are asked to calculate the gain of the non-inverting amplifier on their own and then the instructor solves the problem on the board. In the second problem, the students are asked to think about the question for 3 minutes and pair with the person sitting next to them in order to solve the problem together. Once they complete the first step, the paired students will turn to the group behind them to discuss the solution. This case study, involving a small shift in teaching method, showed that in the second approach students generated a greater number of questions for the instructor and questions of a more penetrating nature of the topic. The paper will present the case study in addition to the questions generated by the students.**

***Index Terms*—Electrical engineering education, student experiment**

I. Introduction

THe think – Pair – Share strategy aims at providing a learning medium where all students participate in the classroom. This strategy was developed by Lyman in 1981 [1] as an effort to increase students' response in classroom discussion. Additional studies have found that students' learning is enhanced when they have many opportunities to elaborate on ideas through talk [2]. Moreover, research has shown that ideas are best retained when they are processed, organized and discussed [3]. By taking the steps of thinking, discussing, and sharing conclusion with other classmates the student is processing, organizing and discussing a topic which will help him/her retain it. Additional benefits of using the think, pair, and share strategy include building students' self-confidence and respect to each other's ideas. Through this process students will exercise formulating their thoughts before talking and build experience in listening and learning from others. Finally, this strategy ensures that no student is left out of the discussion. Even the students who are not comfortable with having the whole class as an audience, are offered a very small audience and can practice the above skills.

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Introductory electrical engineering classes focus on introducing students to a set of new concepts which can be applied for practical purposes. In such classes students are expected to understand a concept and be able to put it into practice. The 'Think – Pair – Share' strategy can be a beneficial tool for retaining and processing the new concept since it will allow the student to process, organize and discuss the topic with a classmate. This paper will present an example where the students were asked to find the gain of a non-inverting and an inverting operational amplifier using the traditional teaching method and the 'Think – Pair – Share' method, respectively. The paper will show the two examples and discuss students' performance on both examples.

II. PROCEDURE

The instructor starts the class by defining an operational amplifier and its applications. The instructor then derives the equation of gain of a non-inverting operational amplifier under non-ideal conditions. The second part of the class involves asking the student to find the gain of an inverting and non-inverting amplifier under ideal op-amp conditions using the traditional teaching method and the 'Think – Pair – Share' method.

A. Traditional Teaching Method

The students are asked to spend 7 minutes on their own solving the following problem:

Find the gain expression of the non-inverting amplifier shown in fig. 1. Assume the amplifier is under ideal conditions (i_p=i_n= 0 and vp = vn).

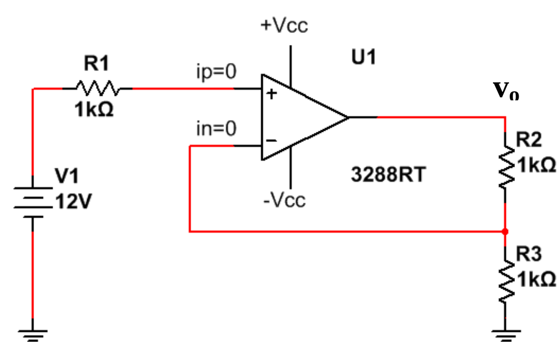

Fig. 1: Non-inverting amplifier

After the 7 minutes have passed, the instructor solves the equation on the board and asks if there are any questions. The solution is presented below:

Apply node – voltage analysis at node v_p:

$$\frac{v_p - V1}{R1} = 0 \qquad (1)$$

Since this is an ideal op-amp i_p = 0 and thus there is not voltage drop across R1 the above equation simplifies to:

$$v_p = V1 \qquad (2)$$

Apply node – voltage analysis at node v_n:

$$\frac{v_n - v_o}{R_2} + \frac{v_n}{R_3} = 0 \qquad (3)$$

Since this is an ideal op-amp:

$$v_n = v_p \qquad (4)$$

Solving (1-4) results in the following gain

$$G = \frac{v_o}{V1} = \frac{R_2 + R_3}{R_3} \qquad (5)$$

B. Think – Pair – Share Method

In this pedagogy method, the students are asked to solve a very similar problem as above, however, they are instructed to think about the problem for 3 minutes, pair with the person sitting next to them to figure out the solution (4 minutes) and finally share the results with the group sitting behind them (4 minutes). The instructor times each activity and signals to the class to move to the next activity. The problem statement is given below:

Find the gain expression of an inverting amplifier shown in fig. 2. Assume the amplifier is under ideal conditions (i_p=i_n= 0 and vp = vn).

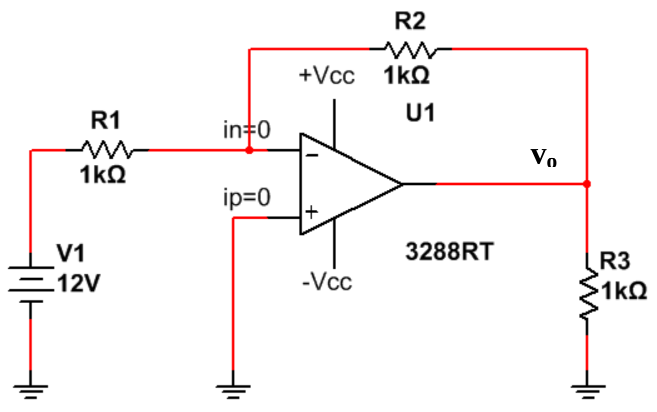

Fig. 2: Inverting amplifier

After time is up (11 minutes) the instructor presents the solution on the board which is as follows:

Apply node – voltage analysis at node v_n:

$$\frac{v_n - V1}{R_1} + \frac{v_n - v_o}{R_2} = 0 \qquad (6)$$

Apply node – voltage analysis at node v_p:

$$v_p = 0 \qquad (7)$$

Solving (6-7) results in the following gain

$$G = \frac{v_o}{V1} = -\frac{R_2}{R_1} \qquad (8)$$

III. RESULTS

The results below are an observation of students' interaction, behavior and questions to the instructor. The observations are a comparison between the traditional teaching method and the think – pair – share method.

A. Traditional teaching method:

When the students were asked to solve the problem on their own it was noticed that some students took some time to start with the problem. Some students didn't work on the problem but rather waited for the instructor to write the solution on the board. The class was quiet and seemed unenthusiastic. After the solution was presented on the board, no questions were asked to the instructor. This method took approximately 7 minutes not taking into account the time needed to present the final solution to the student.

B. Think – Pair – Share method:

When the students were asked to solve the problem using the think – pair – share approach, it was noticed that there was some confusion at the beginning. Some students asked who they should work with. After about a minute, the students started to engage in discussion. It was noticed that some were listeners where others took the role of discussing and presenting solutions to other groups. This method took 11 minutes to complete. Once the time for the activity was over the instructor presented the solution on the board. As the solution was laid out, students asked the following questions:

1) Why can't we write the nodal analysis at V_o ?

   Under the ideal op-amp model, it is not possible to compute i_o, the current that flows into the op-amp from the output current v_o. Hence, it is inappropriate to apply node –voltage analysis at V_o.

2) Why can't we figure out the current I_o?

Inside the op-amp there is a circuit that consists of a resistor R_i, a resistor R_o and a dependent voltage source with the value of $A(v_p – v_n)$. The current I_o is the output of the above circuit. When the op-amp is considered to operate under ideal conditions it is assumed that R_i is equal to infinity and $R_o = 0$. Based on the above assumptions we cannot determine I_o.

3) Are V_{cc} and $–V_{cc}$ part of the nodal analysis?

V_{cc} and $–V_{cc}$ are the dc – power supply to the op-amp. Their main role is to determine the linear operating range of the op-amp. They are not considered to be part of the node – voltage analysis.

The same questions could have been asked in the non-inverting amplifier problem. One of the reasons that could have prompted the above questions was that the students compared solutions and approaches. There was more discussion among each other and this discussion helped the professor address misconceptions that would have been hidden otherwise. It was observed that some of the students that didn't work on the first problem were part of the discussion and were participating. It was also noted that two of the students preferred to work by themselves.

IV. CONCLUSION

The paper presented solving an electrical engineering exercise in two different pedagogy methods: the traditional method and the 'think – pair – share' method. The second method allowed students to discuss their solution and approach among each other. It also prompted students to ask questions that helped them understand the topic better and helped the professor clarify certain misunderstandings.

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