# A Study Of Student Perceptions Of Team-Based Learning in Electromagnetic Induction

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## Abstract

Team based learning is an amalgamation of various practices - strategically formed teams, readiness assurance tests, application activities and peer evaluation, that reinforce one another to achieve an effective instructional effect. We employed team based learning on the teaching and learning of Electromagnetic Induction to Grade 10 students in National Junior College, Singapore. A unit plan which includes a pre-reading segment, readiness assurance test questions, and an application activity was included in the team based learning package. We found that there is a high level (96.9% of the students) of student engagement in the team based learning activities, resulting in an increase (96.9% of the students), and deeper (93.2%), understanding of an AC generator. Students had also responded positively on their perceived effectiveness of the readiness assurance tests on learning (96.3%), and that the readiness assurance tests has corrected their mistakes and improve their understanding of the concepts (96.3%). Overall, the team based learning package on electromagnetic induction has brought about high students engagement and depth of understanding in the topic.



## Keywords

Team Based Learning, Flipped Classroom, Electromagnetic Induction, Student Perceptions, Engagement, Conceptual Understanding

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## Introduction

Team based learning (TBL) is an active learning and small group instructional strategy that employs a sequence of activities in providing students opportunities to collaborate and apply their conceptual knowledge (Michaelsen & Sweet, 2007). The primary goal of TBL is to support a wide breadth of content learning, enhancing students' application of content in problems and scenarios, and developing students' interpersonal and team skills (Fink, 2004). Team based learning is based on the assumption that students construct knowledge for themselves, in a directed approach guided by the tutor. It has been reported in literature that a guided discovery approach is generally more effective than a more authentic unguided discovery approach in student's learning and transfer of learning (Mayer, 2004).

The process of TBL has been well described in many papers. In summary, the instructional method hinges on three phases: Phase 1 is the learning of basic concepts by the students prior to the application lesson. The learning of basic concepts can be done individually by students through assigned readings or e-lessons, or in a didactic lecture style. Phase 2 is the indiviudal readiness assurance test (iRAT) that assesses the knowledge that should have been gained by the students in phase 1. The correct answers for the questions in iRAT will not be revealed. The second part of phase 2 includes a team readiness test (tRAT), for students to discuss and decide amongst their peers the correct answers to the iRAT questions, followed by a discussion with the instructor, and a appeal process. In phase 3, student teams will be involved in applying the concepts to solve a problem. The effectiveness of TBL hinges on the importance of accountabilty and interactive discussions (Michaelsen &

Sweet, 2008), and is brought about in phase 3 by designing and implementing an application problem based on the four S's: significant problem, same problem, specific choice and simultaneous reporting (Michaelsen & Sweet, 2008).

TBL has been successfully implemented in a variety of institutions, predominantly for undergraduate students, with positive impacts in terms of student performance (Wiener & Marz, 2009; Zgheib, Simaan, & Sabra, 2010) and students' perception towards the effectiveness of the instructional method (Abdelkhalek, Hussein, Gibbs, & Hamdy, 2010; Vasan, Defouw, & Compton, 2009). Our motivation, however, is on a target audience that is much younger – more specifically Grade 10 Physics students, to investigate their perception towards the instructional method.

We have successfully implemented TBL in the teaching of electromagnetic induction for Grade 10 students in National Junior College, Singapore, with the aim of examining the perceptions of Grade 10 students towards the instructional strategy and methodology.

## Methods

### *Activities*

A flowchart of the team based learning package on electromagnetic induction is shown in Figure 16. The instructional unit started with phase 1: treatment of the basic concepts – Faraday's and Lenz's Law – during curriculum time. Students were then tasked to view an e-lesson on alternating current (AC) generator uploaded onto the students' learning management system, to learn the basics of how an AC generator functions. Learning objectives were stated explicitly in the student handouts. The lessons contained information on the pre-requisite concepts and ideas needed to solve the application problem in phase 3.

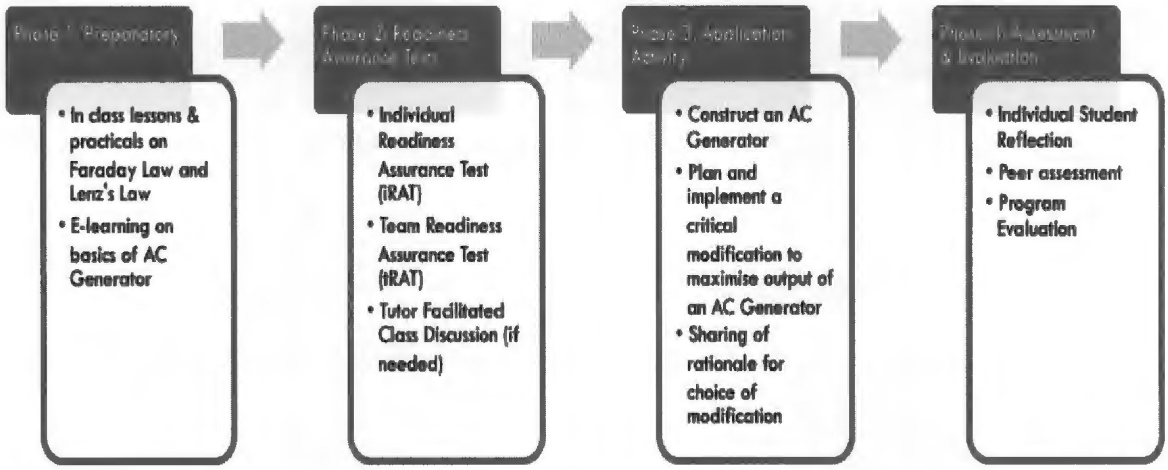



Figure 16: Team Based Learning Package on Electromagnetic Induction

Phase 2 was proceeded with the individual readiness assurance test (iRAT) consisting of 5 multiple choice questions, for each student to answer on his/her own. The 5 multiple choice questions tested students on the learning objectives that were supposed to be learnt in phase 1. Objective of the individual readiness assurance test is to assess whether students have a sound understanding of the key concepts learnt in phase 1.

After the individual readiness assurance test (iRAT), students were grouped based on their abilities. We tried to ensure that none of the group was polarized with students who were of higher ability as high ability students would be able to peer-teach within the group. In line with many literature on the benefits of colloborative learning (Boud D J, 1988), this is done because students can learn better when they are teaching or learning from one another while they are sharing knowledge in their teams. The students then proceeded to a team readiness assurance test (tRAT). With the same questions, the team sought to select a team answer through a consensus-building discussion. Immediate feedback was given through a self-made self-scoring scratch card made using correction tape on cardboard, modeled after the official intermediate feedback assessment technique (IF-AT) answer sheets. Our self-made scratch card contained boxes marked A, B, C and D for each question. Teams scratched off the box representing their agreed option for each question. The correct option for each question was represented by a printed asterix behind the correction tape. The scratch card allowed students to identify incorrect answers immediately and proceed on with further discussions, without the need for tutor's intervention. Teams were able to work at their own pace without the need to wait for the tutor to disclose the answers. Teams were awarded 4 points for every correct answer they got on the first try, and 2 points for every correct answer they got on the second try.

The discussions during the team based readiness test allowed the students to correct their misconceptions, and gave them a chance to make their thinking visible during the team discussions, when students attempted to convince their team mates their rationale for the selected answer. The competitive nature of the scratch card meant that groups would most likely put in their best to obtain the highest score, and this meant that students would tend to ask more questions to challenge the validity of their team mates' assumptions and assertions if they were not convinced of their team mates' answers and explanations. The ability to continue scratching the card after a wrong attempt allowed students to test the validity of their explanations and assumptions. The use of scratch cards reinforced and dampened the positive and negative behaviours respectively, required for an effective team discussion. Dominating team members would think twice to push their points across without careful consideration as for fear of not finding an asterix behind the scratches, and quiet members would be called upon to voice their opinions should the first scratch initiated by a dominant member be wrong. The scoring system on the scratch cards allowed the tutor to view easily which questions were challenging for the group, and a class discussion on the question could be initiated by the tutor if there were a lot of groups with the same mistakes. The tutor would have a chance to clear any major misconceptions with the class.

One advantage of the preceeding processes was the amount of curriculum time spent on going through content in class. The onus would be on the students to learn the basic concepts themselves, and precious class time could be accorded to discussions on the most challenging part of the unit, which could differ for classes of different ability. The time saved could be used also, in the discussion for the application problem in phase 3. Variance in students ability level would be addressed during the team discussion in the team readiness assurance test portion as the more abled students in the team would be able to teach and lead the weaker students. It was therefore pertinent for the grouping of the students to be deliberate, and for each group to be made of students of mixed ability.

Phase 3 involved the students in a challenging application problem based on the 4 S's – (1) addressing a Significant problem that demonstrates the concepts learnt, (2) making a Specific choice among clear alternatives, (3) working on the Same problem as other teams and (4) reporting their decisions Simutaneously. The Significant problem undertaken by the student would be to build and optimize an AC generator to generate the highest voltage output. Students were given a variety of materials to build their basic generator and they would have to construct and evaluate their prototype built. In the process, they would have work collaboratively as members of a team in addressing the factors required to maximise the voltage output of a generator. Given the myriad of apparatus and modification means, teams had to discuss and conclude on a Specific choice for their chosen critical modification to maximise voltage output, supported with justification. All groups were working on the Same problem, with the Same objective in mind. Critical modifications identified and implemented by the team were reported Simultaneously in real time on A1 size papers, with the corresponding root-mean-squared voltage output, and everyone in the class were able to view the progress and results of other groups. A class sharing was done at the end of the class where each group presented their chosen modification and rationale for the chosen modification followed by an individual student reflection, peer assessment and perception survey.

### *Participants*

There were 200 Grade 10 students from National Junior College who participated in the team based learning approach in the learning of electromagnetic induction as part of their Physics module. They were students in the 6 years Integrated Programme from Grade 7 to Grade 12. Students chosen for Integrated Programme are acadmically strong, and the Integrated Programme provides an integrated secondary and junior college education where students can proceed directly to junior college without sitting for the GCE O Level Examinations in grade 10 (Ministry of Education, 2012).

### *Evaluations and Analysis*

Students completed a 19 item evaluation questionnaire at the end of the team based learning activities. The questions measure course content knowledge (4 items), perception towards pre-reading and individual readiness assurance test (3 items), perception of attitudes in team discussions (7 items) and perception of learning in team discussions (5 items).

Students were asked to indicate the extent to which they agreed to the statements, and they rated the statements on a 4-point Likert scale ranging from 1 – strongly disagree to 4 – strongly agree. Mean scores and standard deviations for each item were calculated.

## Results

### *Quantitative Results*

Out of the 200 students, 38 respondents were not used due to missing data. A total of 162 (81%) respondents' data was analysed. One student was absent for the phase 3 team activity session and hence, did not respond to items 10 to 19.

The mean score of the 19 items is 3.34, and it ranges from a maximum of 3.55 to a lowest of 3.15, indicating a high degree of satisfaction on all items.

The average mean score of the various categories of items are:

students understanding of course content knowledge: 3.33

perception towards pre-reading and individual readiness assurance test: 3.20

perception of attitudes in team discussions: 3.40

perception of learning in team discussions: 3.33

Table 3 shows the results of the responses.

**Table 3: Students Perception of Team Based Learning in the learning of Electromagnetic Induction**

| Item | Category | Question | Strongly Agree | | Agree | | Disagree | | Strongly Disagree | | Mean(SD) | Category Mean |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | *n* | % | *n* | % | *n* | % | *n* | % | | |
| 1 | Course Content Knowledge | The TBL package has helped me increase my understanding of on AC generator. | 63 | 38.9% | 94 | 58.0% | 5 | 3.1% | 0 | 0.0% | 3.36 (0.60) | 3.33 |
| 8 | | I learned useful additional information during the TBL sessions. | 51 | 31.5% | 100 | 61.7% | 11 | 6.8% | 0 | 0.0% | 3.25 (0.62) | |
| 11 | | The activity on building an AC generator allowed me to apply my learning. | 66 | 41.0% | 92 | 57.1% | 3 | 1.9% | 0 | 0.0% | 3.39 (0.59) | |
| 12 | | I have gained a deeper understanding of an AC generator after the activity on building an AC generator. | 64 | 39.8% | 86 | 53.4% | 11 | 6.8% | 0 | 0.0% | 3.33 (0.65) | |
| 2 | Perception towards Prereading and iRAT | I have completed 100% of the required prereading. | 48 | 29.6% | 93 | 57.4% | 21 | 13.0% | 0 | 0.0% | 3.17 (0.68) | 3.20 |
| 3 | | Individual readiness assurance test (IRAT) is useful for my learning. | 56 | 34.6% | 98 | 60.5% | 8 | 4.9% | 0 | 0.0% | 3.30 (0.61) | |
| 4 | | I generally felt prepared for the IRAT. | 39 | 24.1% | 108 | 66.7% | 15 | 9.3% | 0 | 0.0% | 3.15 (0.61) | |
| 10 | Perception of attitudes in team discussions | I feel confident in speaking out my opinions during the GRAT discussions. | 46 | 28.6% | 106 | 65.8% | 9 | 5.6% | 0 | 0.0% | 3.23 (0.59) | 3.40 |
| 13 | | I am actively engaged in the team based learning activities. | 71 | 44.1% | 85 | 52.8% | 4 | 2.5% | 1 | 0.6% | 3.40 (0.63) | |
| 14 | | My teammates are activity engaged in the team based learning activities. | 81 | 50.3% | 79 | 49.1% | 1 | 0.6% | 0 | 0.0% | 3.50 (0.58) | |
| 16 | | My team worked well together. | 90 | 55.9% | 69 | 42.9% | 2 | 1.2% | 0 | 0.0% | 3.55 (0.59) | |
| 17 | | I contributed meaningfully to the TBL discussions. | 41 | 25.5% | 117 | 72.7% | 3 | 1.9% | 0 | 0.0% | 3.24 (0.53) | |
| 18 | | I paid attention most of the time during the TBL sessions. | 65 | 40.4% | 96 | 59.6% | 0 | 0.0% | 0 | 0.0% | 3.40 (0.56) | |
| 19 | | There was mutual respect for other teammates' viewpoints during TBL. | 82 | 50.9% | 79 | 49.1% | 0 | 0.0% | 0 | 0.0% | 3.51 (0.57) | |
| 5 | Perception of learning in team discussions | Team readiness assurance test (tRAT) and discussion are useful for my learning. | 67 | 41.4% | 89 | 54.9% | 6 | 3.7% | 0 | 0.0% | 3.38 (0.62) | 3.33 |
| 6 | | I learn better from small group discussion than in a class setting. | 61 | 37.7% | 70 | 43.2% | 31 | 19.1% | 0 | 0.0% | 3.19 (0.77) | |
| 7 | | Solving problems in a group is an effective way to learn. | 72 | 44.4% | 81 | 50.0% | 9 | 5.6% | 0 | 0.0% | 3.39 (0.65) | |
| 9 | | The tRAT discussions allowed me to correct my mistakes and improve understanding of the concepts. | 56 | 34.6% | 100 | 61.7% | 6 | 3.7% | 0 | 0.0% | 3.31 (0.60) | |
| 15 | | Building the AC generator with my group is an effective way to practice what I have learned. | 70 | 43.5% | 86 | 53.4% | 5 | 3.1% | 0 | 0.0% | 3.40 (0.61) | |

### *Qualitative Comments*

22 students offered qualitative comments on what they feel about the team based learning lesson packages. 19 (86%) of these students commented positively on team based learning and the AC generator challenge activity being a great learning experience which they have enjoyed. 3 (14%) of the students commented that working as a team allowed more learning to be done. 2 (9%) students commented that more time is needed for them to embark on further modifications to their AC generator.

## Discussion

The combination of quantitative and qualitative approaches in the programme evaluation increases the confidence in the results. Analysis of student qualitative comments provided support for the quantitative data and added valuable information for improving the team based learning package. We obtain mean values of more than 3 for all items in the student perception survey, implying a high level of satisfaction on all items.

### *Students Engagement*

The main strength of our application of the team based learning package would be students' engagement in the activities, with the highest categorical mean of 3.40 (Perception of attitudes in team discussions, Table 1). 156 (96.9%) students stated that they were actively engaged in the team based activities, and 160 (99.4%) students stated that their teams were actively engaged in the team based activities. This is further supported with the qualitative comments given by 18 of the students. We quote one of the students in her comment: "*I found this activity exceptionally useful for learning about how an AC generator works, and it* *was a fun and engaging practical as it didn't just involve us in following instructions and recording data: there was quite an amount of challenge as to how we were going to perform the experiments (i.e. the modifications). I learnt a lot! Thank you (: P.S. This activity was also made the generator concept seem much less complicated to me. and that was very useful.*"

It should be noted that the typical National Junior College student is accustomed to group based discussions as part of the instructional strategy. 152 (94.4%) students felt confident in speaking out their opinions during team discussions, 159 (98.8%) students felt that their team worked well together, and 161 (100%) students felt there was mutual respect for one another during the discussions. This can be attributed to our Science curriculum in National Junior College where emphasis is placed on inquiry based learning and collaborative learning. In view of this, students were still highly engaged in the team based learning package, implying the effectiveness of the team learning package in raising engagement level in students who are already accustomed to group based learning.

*Learning of Course Content Knowledge*

There is a very positive student perception on the effectiveness of learning through the team based learning package. The categorical mean for items probing on students learning of course content knowledge is a high 3.33. 157 (96.9%) students stated that the team based learning package has increased their understanding of an AC generator, and 150 (93.2%) students stated that the application activity on modifying an AC generator allowed them to gain a deeper understanding of an AC generator. 156 (96.3%) students has stated that the team readiness assurance test had allowed them to correct their mistakes and improve their understanding of the concepts.

Further quantitative proof of students' conceptual understanding will be collected after the summative assessment in October 2014, and can be use to further support the perceived effectiveness of our team based learning package on the learning of AC generator.

Given that only basic knowledge about an AC generator was given to students in the pre-reading phase of the package, we observed remarkable depth in students' level of understanding of the concepts inherent in an AC generator from their reflection. Students were able to make good analysis of their creations and factor in the multiple, and possibly conflicting, effects of a modification, and were able to reason that it was important to figure out what is the dominant effect of a modification. We quote the students: "*There are many factors in play so it is important to determine the dominant factor. For example, using a bigger PVC pipe would mean a bigger area, however it would mean an increased distance between the magnets and the coil.*", "*Changing an item (e.g. small magnet to big magnet can affect more than one variable, as the (increased) mass affects velocity and magnetic field strength.*", and "*By changing a factor, we have to look at the effects it has on the other variables. For example, by changing the size of the PVC core, not only will the number of coils be affected but so will the area covered by the coils.*"

*Perception of Learning in Readiness Assurance Tests*

Students have very high positive perceptions towards the usefulness of the readiness assurance tests. It must be noted that only 141 (87%) students have completed the assigned pre-reading, and 147 (90.8%) students felt prepared for the individual readiness assurance test. Despite some of the students being not prepared for the individual readiness assurance test, 156 (96.3%) students found the team readiness test and discussion useful for their learning, and 156 (96.3%) students has stated that the team readiness assurance test had allowed them to correct their mistakes and improve their understanding of the concepts.

### *Areas for Improvement*

A possible area of improvement will be to increase the time allocated to the phase 3 challenge activity on modifying an AC generator to allow for deeper development and ranking of the factors that affects the voltage output of an AC generator.

## Conclusion

In conclusion, there is a high level (96.9% of the students) of student engagement in the team based learning activities, resulting in an increase (96.9% of the students), and deeper (93.2%), understanding of an AC generator. Students had responded positively on their perceived effectiveness of the readiness assurance tests on learning (96.3%), and that the readiness assurance tests has corrected their mistakes and improve their understanding of the concepts (96.3%). We believe that we time and experience, team based learning will prove to be an effective pedagogical approach to increase engagement and depth of learning in high school students.

*References*

Abdelkhalek, N., Hussein, A., Gibbs, T., & Hamdy, H. (2010). Using team-based learning to prepare medical students for future problem-based learning. *Medical Teacher*, *32*, 123–129. doi:10.3109/01421590903548539

Boud D J. (1988). Developing Student Autonomy in Learning. In Boud D J (Ed.), (2nd ed., pp. 17–39). London: Kogan Page.

Fink, L. D. (2004). BEYOND SMALL GROUPS : Harnessing the Extraordinary Power of Learning Teams †. In and D. F. Larry Michaelsen, Arletta Knight (Ed.), *Team-Based Learning: A Transformative Use of Small Groups* (pp. 3–25). Stylus Publishing.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *The American Psychologist*, *59*(1), 14–9. doi:10.1037/0003-066X.59.1.14

Michaelsen, L. K., & Sweet, M. (2007). The Essential Elements of Team-Based Learning, (116). doi:10.1002/tl

Michaelsen, L. K., & Sweet, M. (2008). Fundamental principles and practices of team-based learning. In L. Michaelsen, D. Parmelee, K. McMahon, & R. Levine (Eds.), *Team-based learning for health professions education* (pp. 9–34). Stylus Publishing.

Ministry of Education. (2012). Integrated Programmes (IP).

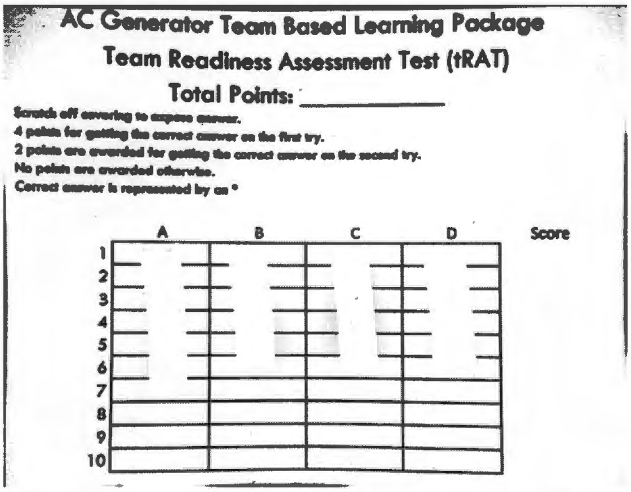
Vasan, N. S., Defouw, D. O., & Compton, S. (2009). A Survey of Student Perceptions of Team-Based Learning in Anatomy Curriculum : Favorable Views Unrelated to Grades. *Anatomical Sciences Education*, *155*(August), 150–155. doi:10.1002/ase.91

Wiener, H., & Marz, R. (2009). Team-based Learning in Intensive Course Format for First-year Medical Students. *MEDICAL EDUCATION*, *50*, 69–76. doi:10.3325/cmj.2009.50.69

Zgheib, N. K., Simaan, J. A., & Sabra, R. (2010). Using team-based learning to teach pharmacology to second year medical students improves student performance. *Medical Teacher*, *32*, 130–135. doi:10.3109/01421590903548521

# Appendix

Figure 17: AC Generator



AC Generator Team Based Learning Package

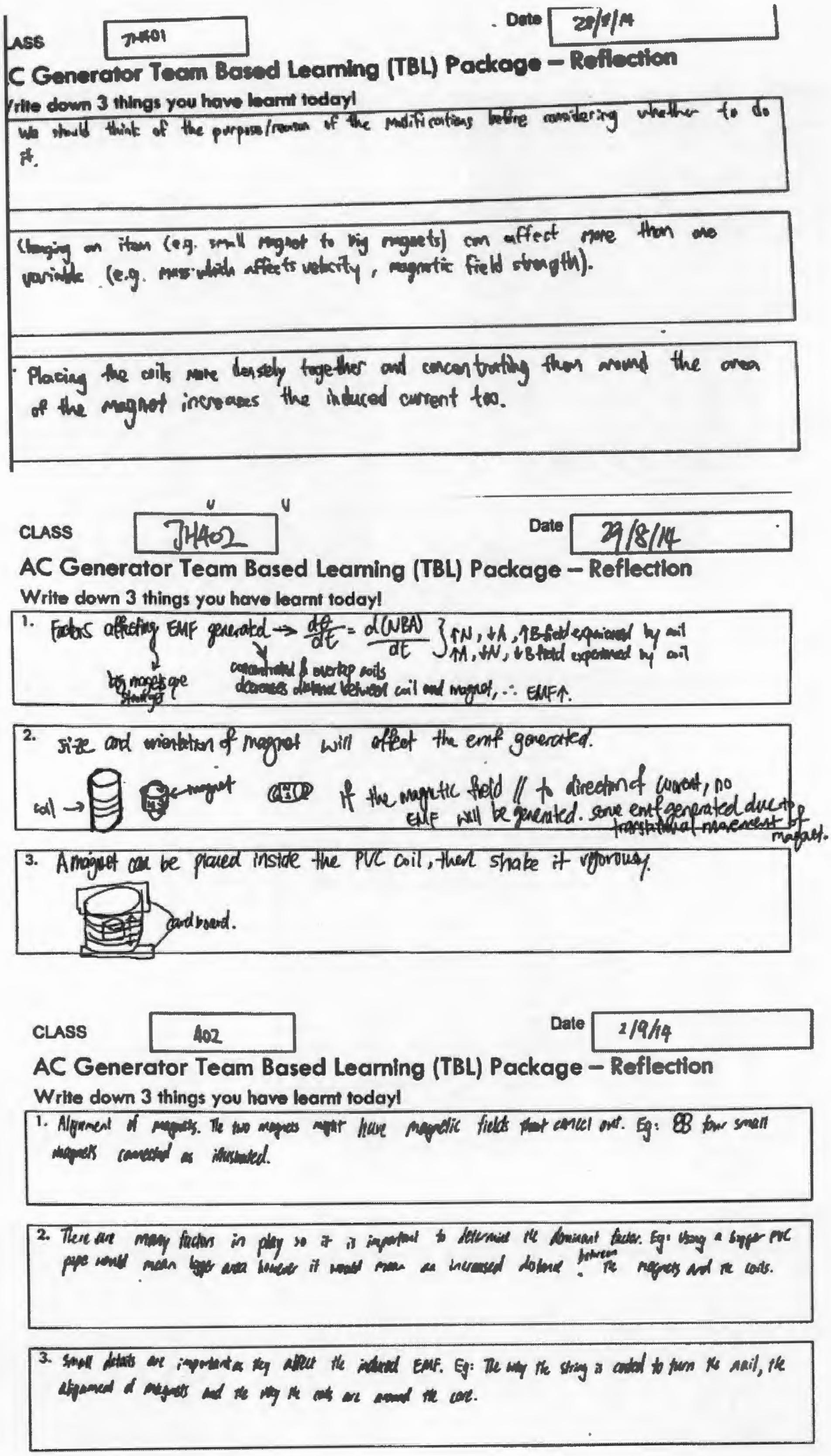
Team Readiness Assessment Test (tRAT)

Total Points: ___________

Scratch off covering to expose answer.
4 points for getting the correct answer on the first try.
2 points are awarded for getting the correct answer on the second try.
No points are awarded otherwise.
Correct answer is represented by an *

| | A | B | C | D | Score |
|---|---|---|---|---|---|
| 1 | | | | | |
| 2 | | | | | |
| 3 | | | | | |
| 4 | | | | | |
| 5 | | | | | |
| 6 | | | | | |
| 7 | | | | | |
| 8 | | | | | |
| 9 | | | | | |
| 10 | | | | | |

Figure 18: Self-made Scratch Card for use in Team Readiness Assurance Test (tRAT)


LASS 7JH401 Date 29/8/14

C Generator Team Based Learning (TBL) Package – Reflection

rite down 3 things you have learnt today!

We should think of the purpose/reason of the modifications before considering whether to do it.

Changing an item (e.g. small magnet to big magnets) can affect more than one variable (e.g. mass which affects velocity, magnetic field strength).

Placing the coils more densely together and concentrating them around the area of the magnet increases the induced current too.

CLASS JH402 Date 29/8/14

AC Generator Team Based Learning (TBL) Package – Reflection

Write down 3 things you have learnt today!

1. Factors affecting EMF generated → $\frac{d\phi}{dt} = \frac{d(NBA)}{dt}$ } ↑N, ↓A, ↑B-field experienced by coil; ↑A, ↓N, ↓B field experienced by coil
big magnets are stronger
concentrated & overlap coils decreases distance between coil and magnet, ∴ EMF↑.

2. Size and orientation of magnet will affect the emf generated.
coil → ← magnet
If the magnetic field // to direction of current, no EMF will be generated. some emf generated due to translational movement of magnet.

3. A magnet can be placed inside the PVC coil, then shake it vigorously.
cardboard.

CLASS 402 Date 2/9/14

AC Generator Team Based Learning (TBL) Package – Reflection

Write down 3 things you have learnt today!

1. Alignment of magnets. The two magnets might have magnetic fields that cancel out. Eg: four small magnets connected as illustrated.

2. There are many factors in play so it is important to determine the dominant factor. Eg: Using a bigger PVC pipe would mean bigger area however it would mean an increased distance between the magnets and the coils.

3. Small details are important as they affect the induced EMF. Eg: The way the string is coiled to turn the nail, the alignment of magnets and the way the coils are around the core.

Figure 19: Samples of Student Reflection