Does Peer-Assisted Instruction for Physics Help Improve Student Learning?

P. Chapagain, N. Malakar, S. Neupane, D. Rimal, and L. J. Kindle

Journal of Nepal Physical Society
Volume 8, No 2, 2022
(Special Issue: ANPA Conference 2022)
ISSN: 2392-473X (Print), 2738-9537 (Online)

JNPS, **8** (2), 48-52 (2022)
DOI: http://doi.org/10.3126/jnphyssoc.v8i2.50149

Published by: Nepal Physical Society
P.O. Box: 2934
Tri-Chandra Campus
Kathmandu, Nepal
Email: nps.editor@gmail.com

ANPA Conference 2022
ISSN : 2392-473X(Print), 2738-9537 (Online)

Research Article ©Nepal Physical Society
DOI:http://doi.org/10.3126/jnphyssoc.v8i2.50149

Does Peer-Assisted Instruction for Physics Help Improve Student Learning?

P. Chapagain,[1, a)] N. Malakar,[2] S. Neupane,[3] D. Rimal,[4] and L. J. Kindle[5]

[1)] *Southern Arkansas University, Magnolia, AR 71753*
[2)] *Worcester State University, Worcester, MA 01602*
[3)] *Middle Tennessee State University, Murfreesboro, TN 37132*
[4)] *The Bee Corp, IN 46225*
[5)] *Southern Arkansas University, Magnolia, AR 71753*

[a)] *Corresponding author: prchapagain@saumag.edu*

Abstract. Supplemental Instruction (SI) is a teaching method adopted by academic institutions to strengthen and extend learning opportunities beyond regular classroom lectures. The supplemental instructor is a junior or senior-level student with a track record of a sound knowledge of the material and works closely with the students seeking help. The SI leader is free to provide different teaching/learning strategies to foster problem-solving skills and critical thinking behavior. While the supplemental instructors are independent in conducting the learning sessions, they work closely with the course instructor. In this work, we investigate the efficacy of the SI model in college physics compare to university physics at Southern Arkansas University using data from ten years. Furthermore, we discuss how this additional teaching pedagogy elucidates to successful completion of a physics class, retention in the department/university, and overall academic success through the peers' support.

Received: 9 August 2022; **Revised**: 4 October 2022; **Published**: 31 December 2022

Keywords: Supplemental Instruction; peer instructions.

INTRODUCTION

A firm understanding of fundamental physics is very important for all areas of natural science. Therefore, physics is an essential course for STEM students and a prerequisite for non-science areas as well. However, the student success rate in these courses is not very satisfactory impeding students from moving forward in the STEM field. For example, inadequate preparation with core concepts and principles of introductory physics is primary cause of academic failure and potential retention of students in engineering programs [1].

To improve the student success rate by enhancing students' academic understanding and developing learning habits, a near-peer learning strategy, known as supplemental instruction (SI), has been introduced. In this approach students from higher levels, often referred to as the SI subject leader, help lower-level undergrads. The subject leader schedules several study sessions during a semester for a group of students under the guidance of a course instructor. Furthermore, these qualified leaders must attend the lecture along with students to familiarize themselves with the course content. The students work independently or in a group in an informal and a sort of relaxed environment while discussing the matter and solving the problems with their peers under the leader's supervision. The program is intended for any students seeking help; not limited to weak or underachieving students [2]. Several prior publications [3, 4, 5, 6, 7] have shown that such programs not only help increase students' confidence level and better prepare for the assessments/exams but also improve academic outcomes and continuing academic pursuit [8]. Moreover, it has been established that SI intervention in challenging classes such as biology [9], physics and chemistry [10], and overall STEM subjects [11] increases the potentiality of succeeding underrepresented minority students in the course work and earning a degree in their respective fields. Research on calculus from first-year engineering students revealed that not only the weak but average and strong students also benefited from SI, thus emphasizing the role of SI participation. The students attending SI could achieve high scores despite low prior mathematical achievement compared to those with high prior achievers [12]. Also, the study conducted on the influence of SI on final grades in university physics among Hispanic students delivered a significant difference in mean final grade among non-SI/low-SI attending compared high SI participants [10].

The consequence of SI has significantly improved the active learning strategy. It is probably because students get a chance to diagnose their learning inability early and get an opportunity for rapid and timely administration of an effective learning environment. Active learning strategies in physics, as in other areas of science [13], primarily focus on (a) developing problem-solving skills, (b) cultivating a group-learning environment, (c) utilizing free resources such as video-based learning, and (d) assessing the learning outcomes through tests and exams.

Typically college physics has the prerequisite of algebra and basic trigonometry whereas university physics requires pre/co-requisite of calculus. The college physics is an algebra-based course, whereas the university physics is calculus-based. The college physics is primarily attended by students who wish to pursue careers in medical field, or engineering technical education. The University physics is expected to prepare students for a variety of career paths including (but not limited to) physics and engineering graduate study, teaching, and direct entry into industry. The impacts of SI on problem-solving strategies have been discussed in the literature [14, 15]. Studies on group-based approaches have shown the effectiveness not only on the problem-solving skills but also usefulness in building fundamental concepts of calculus-based physics [16, 17]. Video-based SI could also be used as an interactive information processing and delivery mechanism that can significantly increase students' understanding of concepts. This approach can help master the course content and develop and refine learning skills [18]. Almost all of the work has shown a positive impact on the overall final grades. Comparisons between students attending SI sessions versus non-attending over six years at San Francisco State University in physics I and II revealed positive impacts on student performance and progression to the subsequent courses in a sequence [19]. Furthermore, it also revealed that the students who achieve grades lower than C– cannot progress in the STEM field. Evidence has shown that students in engineering physics with SI classes are well-prepared for subsequent important gateway courses [16]. Moreover, the number of students dropping out during the first year almost halved with the SI support system at the School of Engineering at Lund University Sweden [20].

In general, SI in physics can improve the learning quality and learning outcomes of physics students. It is obvious that implementation of SI support not only helps students run their laboratory work smoothly but also helps them succeed in the subsequent upper-level courses. This could be a cost-effective way to improve the quality of physics education and retain the students. Our study provides another evidence-based method to support the broader implication of this modality. In particular, the impacts of SI on calculus/algebra-based physics and introductory level physics have been done separately. However, a systematic comparative work has been missing to uplift the active learning strategies in physics. In this paper, we aim to compare the students' success based on the SI survey conducted in college physics compared to university physics.

METHODS

The data for the present study ware collected during the Fall and Spring semesters over a period of ten years. The students were surveyed after completion of the semester and the data were compiled after the final grades were posted. During this period, the SI coordinator visited all sections to which SI leaders were assigned. The purpose of the data collection was explained to the students for their approval during participation. Students were instructed to take the survey on electronic devices. For those who did not have device access the day of the survey or who were experiencing technical difficulty, a hard copy of the survey was provided. The SI Coordinators, who did not mentor the students, collected and maintained the data. In total, 2000 students (SI attendees and non-attendees) were surveyed. Typically, on average five physics students were supervised by a student SI leader. Since our study was focused on the efficacy of SI method, student demographic data were not analyzed.

We calculated the course Grade Point Average (GPA) as one of the primary indicators to check the efficacy of the SI program. The students survey was classified into two groups: SI-attendees and non-SI-attendees. The course GPA (referred to as from GPA here on) for each group was calculated by using the weighted mean method for the overall student grades for the class. The research also investigated the DFW rates for each groups. However, we will focus our study into the impact on GPA for the SI versus non-SI groups. The results are presented in the next section.

RESULTS AND DISCUSSION

To assess the significance of a program, it is common in academia to monitor student outcomes before and after the implementation of the program. We picked Grade Point Average (GPA) as one of the primary indicators to check the efficacy of the SI program. Figure 1 shows the GPA distribution among the SI-takers and non-SI attendees for college and university physics, in which the GPA

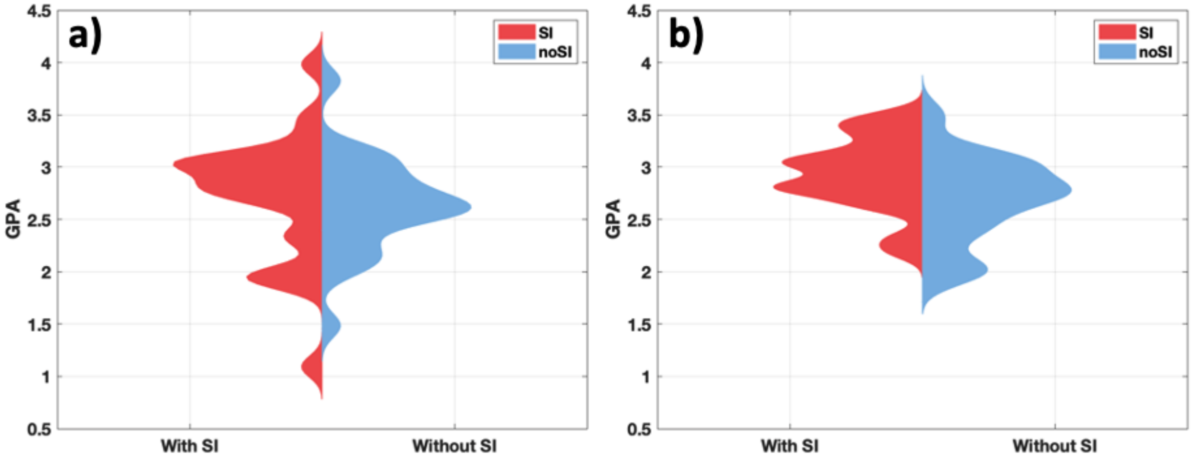

FIGURE 1. GPA distribution of SI vs. non-SI students through violin plots (a) college physics (b) university physics.

for SI attendees for both physics classes corroborate the higher side. However, the probability density function for the non-SI attending group represents the normal distribution and SI attending is skewed towards the right (college physics). It appears that both SI attendees and non-attendees for university physics are right-skewed. This means that the average of the skewed distribution is higher than the median of the same group. It could be possible that some people did exceptionally well or achieved more than expected. Due to the limited data set, we can not confirm this statement at this time. It requires further investigation.

To reinforce the above results, we presented the GPA in a box-notch plot as shown in Figure 2. One can easily see the difference in the median grades for SI users and non-users. The difference is more pronounced in university physics than in college physics. The interquartile range for SI attendees is more or less the same for both courses, whereas the interquartile range for non-SI in university physics is more pronounced than that of college physics. This means that GPA for non-SI takers is very dispersed. The average and standard deviation in GPA for college physics is (2.72 ± 0.61) SI takers whereas for no-SI student group is (2.65 ± 0.47). Similarly, the average and standard deviation in GPA for university physics is (2.94 ± 0.35) SI takers whereas for no-SI student group is (2.7 ± 0.41). Our results suggest a significant improvement in student learning outcomes in physics through the support of the SI program.

In order to achieve success in any coursework, students need to work continuously. This consistency, in this current work, is studied by the change in GPA in terms of the mean number of SI sessions attended as shown in Figure 3. The results show that the change in GPA is slightly correlated with the number of sessions attended. It appears to earn 0.05-grade points above the average class for college physics and 0.03 in the case of university physics, it is necessary for students to attend at least two SI sessions. However, one can not necessarily expect positive results after attending only a couple of sessions. We believe students need to attend three-four sessions to see the influence of the SI on their course grades. It was also found that those who attended only a few sessions (one to three) had a (66.92 ± 0.07)% likelihood of passing the class. Students with regular session attendance (four or more sessions) had a substantially increased likelihood of passing the course, (77.41 ± 0.09)% [21]. There does seem to be outliers among the attendees who could not improve their grades even after attending several sessions. They may need some special attention or personalized tutoring. The attendance to SI sessions could be a very effective tool to boost the self-esteem, collaborative behavior, and learning habits of the students. Since SI is purely voluntary, it is difficult to predict the student's motive behind attending the sessions. Perhaps making SI sessions compulsory as a controlled trial would be beneficial in the study.

CONCLUSIONS AND DISCUSSIONS

The current work shows that SI played a very significant role to support students in challenging courses such as a gateway physics course for students to survive and thrive as entering engineering, medicine, veterinary, chemistry, or nursing school at Southern Arkansas University. Our results show that student's learning outcomes have been improved through the SI support system. However, finding the correct number of sessions that need to be attended to improve a certain fraction of grades needs further investigation. Besides, uplifting the student's learn-

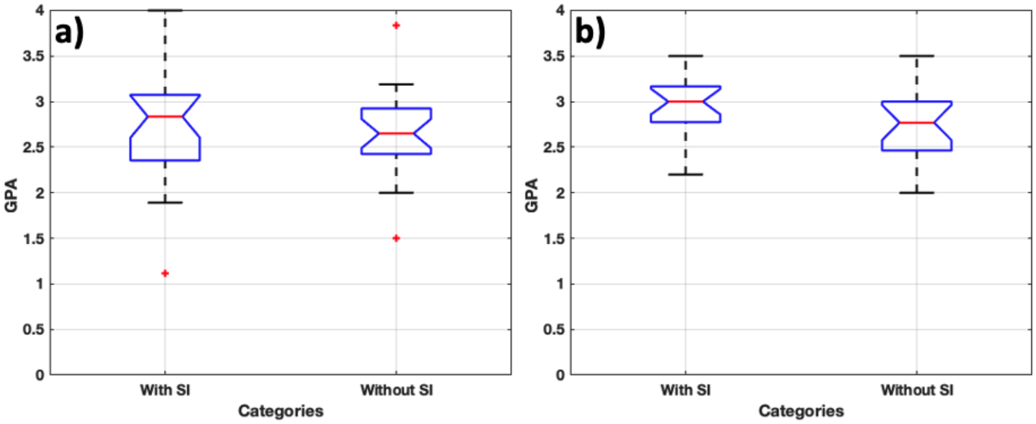

FIGURE 2. Boxplots for comparing the GPA (a) college physics and (b) university physics. Interquartile ranges for SI-takers are almost the same whereas non-SI users seem to be shifted towards the right for both the physics classes.

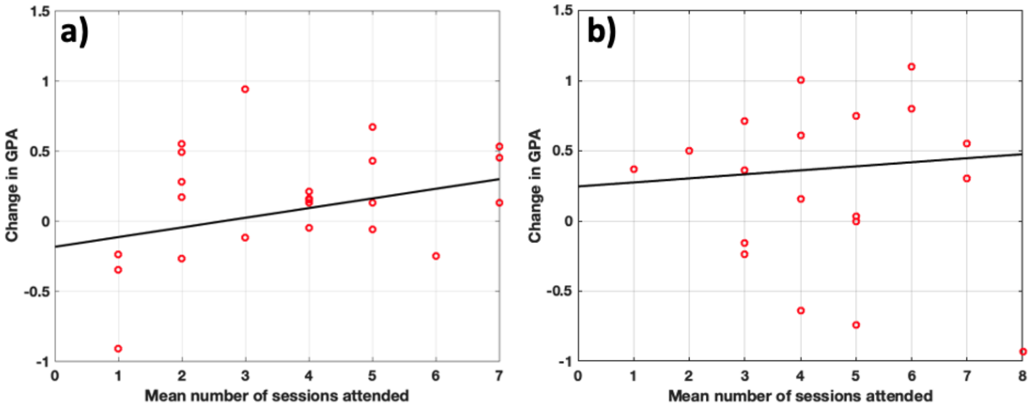

FIGURE 3. Change in GPA versus mean number of sessions attended (a) college physics and (b) university physics. (The straight lines are drawn as guide tools to show the positive correlation).

ing outcomes, we believe this program supports students needing help. Furthermore, students' skills developed by the SI system can be further employed in the upper-level classes to be successful in the program and to graduate on time. In addition to the students, the SI-leaders also benefit from the personal development in teaching, learning and leadership skills. In the long run, we believe that the program helps retain the students in their programs. This needs to be supported by further studies.

Study limitations

There has been a limited study on the efficacy of the SI program in physics. Little or no review articles have been published in the area. Our results are based on data for the ten years of the post-survey quiz. We discussed qualitatively the difference between the SI attendees and non-attendees, and we are not including students' success in terms of letter grades. Lacking pre-survey quizzes on students' ACT/SAT scores, mathematical background, and exposure to physics in high school has constrained our results. Despite a limited data set, we believe that the results presented in this paper may be a valuable resource for any department or institute to initiate peer-assisted learning programs to support student need.

Future suggestions

SI is a very supportive program for students' academic enrichment. We have done some research to find the effectiveness of the program in entry-level physics. However, additional research needs to be done to determine the long-term effect on upper division classes in order to make a concrete conclusion about retention. Regular participation of students in SI sessions is another challenge. Students tend to participate more when they have a quiz or an exam approaching. A revelation of student success semester-wise through audio-visual medium at the beginning of the semester might help address this issue. Still what governs student motivation has been a big question in academia for some time. Furthermore, the SI program will be more beneficial in terms of addressing diversity, inclusion, and equity if we can study its efficacy in a diverse student population.

ACKNOWLEDGMENTS

A peer-assisted learning approach is a useful tool to achieve student academic success and to timely graduation. Further, this is a key component to preserving students within the department as well as at the university level. The SI program was supported by funding from a federal grant by the U.S. Department of Education.

EDITORS' NOTE

This manuscript was submitted to the Association of Nepali Physicists in America (ANPA) Conference 2022 for publication in the special issue of Journal of Nepal Physical Society.

REFERENCES

1. L. E. Bernold, J. E. Spurlin, and C. M. Anson, en“Understanding Our Students: A Longitudinal-Study of Success and Failure in Engineering With Implications for Increased Retention,” Journal of Engineering Education **96**, 263–274 (2007), _eprint: https://onlinelibrary.wiley.com/doi/pdf/10.1002/j.2168-9830.2007.tb00935.x.
2. “Peer Assisted Learning - Department of Physics - University of Liverpool,”.
3. T. Altintas, A. Gunes, and H. Sayan, “A peer-assisted learning experience in computer programming language learning and developing computer programming skills,” Innovations in Education and Teaching International **53**, 329–337 (2016), publisher: Routledge.
4. C. A. Rohrbeck, M. D. Ginsburg-Block, J. W. Fantuzzo, and T. R. Miller, “Peer-assisted learning interventions with elementary school students: A meta-analytic review,” Journal of Educational Psychology **95**, 240–257 (2003), place: US Publisher: American Psychological Association.
5. W. Elshami, M. Abuzaid, and M. E. Abdalla, en“Radiography students’ perceptions of Peer assisted learning,” Radiography **26**, e109–e113 (2020).
6. B. Williams and P. Reddy, en“Does peer-assisted learning improve academic performance? A scoping review,” Nurse Education Today **42**, 23–29 (2016).
7. A. E. Mahdi, en“Introducing Peer-Supported Learning Approach to Tutoring in Engineering and Technology Courses,” The International Journal of Electrical Engineering & Education **43**, 277–287 (2006), publisher: SAGE Publications Ltd STM.
8. K. Skoglund, T. J. Wall, and D. Kiene, en“Impact of Supplemental Instruction Participation on College Freshman Retention,” Learning Assistance Review **23**, 115–135 (2018), publisher: National College Learning Center Association.
9. K. A. Rath, A. R. Peterfreund, S. P. Xenos, F. Bayliss, and N. Carnal, “Supplemental Instruction in Introductory Biology I: Enhancing the Performance and Retention of Underrepresented Minority Students,” CBE—Life Sciences Education **6**, 203–216 (2007), publisher: American Society for Cell Biology (lse).
10. V. B. Meling, M.-A. Mundy, L. Kupczynski, and M. E. Green, en“Supplemental Instruction and Academic Success and Retention in Science Courses at a Hispanic-Serving Institution,” World Journal of Education **3**, 11–23 (2013), publisher: Sciedu Press.
11. C. Achat-Mendes, C. Anfuso, C. Johnson, and B. Shepler, en“Learning, Leaders, and STEM skills: Adaptation of the supplemental instruction model to improve STEM education and build transferable skills in undergraduate courses and beyond: STEM Supplemental Instruction,” Journal of STEM Education: Innovations and Research **20** (2020).
12. J. Malm, L. Bryngfors, and L.-L. Morner, en“Supplemental Instruction: Whom Does It Serve?” International Journal of Teaching and Learning in Higher Education **23**, 282–291 (2011), publisher: International Society for Exploring Teaching and Learning.
13. J. Gardner and B. R. Belland, en“Problem-Centered Supplemental Instruction in Biology: Influence on Content Recall, Content Understanding, and Problem Solving Ability,” Journal of Science Education and Technology **26**, 383–393 (2017).
14. S. Sutarno, D. H. Putri, E. Risdianto, M. Satriawan, and A. Malik, en“The students’ Physics Problem Solving Skills in basic physics course,” Journal of Physics: Conference Series **1731**, 012078 (2021), publisher: IOP Publishing.
15. T. Gok, en“The Impact of Peer Instruction on College Students’ Beliefs About Physics and Conceptual Understanding of Electricity and Magnetism,” International Journal of Science and Mathematics Education **10**, 417–436 (2012).
16. C. Gordon and H. Sevim, “A Supplemental Instruction Model for Engineering Physics Instruction,” (2015) pp. 26.117.1–26.117.7, iSSN: 2153-5965.
17. P. W. Laws, en“Calculus-Based Physics Without Lectures,” Physics Today **44**, 24–31 (1991).
18. R. R. Hake, “Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses,” American Journal of Physics **66**, 64–74 (1998), publisher: American Association of Physics Teachers.
19. A. R. Peterfreund, K. A. Rath, S. P. Xenos, and F. Bayliss, “The impact of supplemental instruction on students in stem courses: Results from san francisco state university,” Journal of College Student Retention: Research, Theory & Practice **9**, 487–503 (2008), https://doi.org/10.2190/CS.9.4.e.
20. J. Malm, L. Bryngfors, and L.-L. Mörner, “Supplemental instruction for improving first year results in engineering studies,” Studies in Higher Education **37**, 655–666 (2012), publisher: Routledge _eprint: https://doi.org/10.1080/03075079.2010.535610.
21. C. A. Wilson, A. Steele, W. N. Waggenspack, W.-H. Wang, and L. L. Ramsey, “Engineering Supplemental Instruction: Impact on Sophomore Level Engineering Courses,” (2015) pp. 26.645.1–26.645.13, iSSN: 2153-5965.