

## STUDENT CONTRIBUTION INDEX (SCI) IN SCIENCE: A MEASURE OF CONTRIBUTION TO MITIGATING SOCIAL LOAFING AND FREE-RIDING IN TEAM PROJECTS

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### Abstract

In this study, we introduce the Student Contribution Index (SCI) to measure these contributions. The purpose of this quantitative study is to test the validity of SCI as a measure of task identifiability and to determine the student satisfaction with SCI-based assessments. To collect the data, 52 students were split into high and low identifiability conditions. Both groups worked on a project and completed SCI once (LI group) and twice (HI group). We measured the SCI variability using an F-test at the significance level of 0.05. Furthermore, a group project of 113 students was assessed using SCI. Students completed an evaluation form to measure procedural fairness, distributive fairness, and satisfaction. We then analyzed the correlations between these variables using Pearson's Correlation. The results show that the variability in SCI of the HI group was negligible ( $SD = 0$ ), indicating that all students contributed equally to the project. Meanwhile, a variability was observed in the LI condition ( $SD = 0.08$ ), suggesting that SCI was a valid measurement. Additionally, students were generally satisfied with the assessment ( $M = 4.40$ ), and a significant correlation was observed between the variables. This study presents a novel method for assigning grades to group members in group projects, taking into account each member's individual contribution. As a result, fairness in grading can be achieved, and educators can discourage social loafing and free-reading behavior.

**Keywords** Collaborative Learning, Free-riding, Group work, Social Loafing, Student Contribution Index (SCI), Teamwork



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## INTRODUCTION

Team-based learning, such as problem-based learning, cooperative learning, and collaborative learning, has been popular because of its benefits for student learning outcomes (Liu & Beaujean, 2017;

Ji-Young, 2021; Sayegh & Rigopoulos, 2023; Sarnoko et al., 2024). This benefit of team-based learning is due to better student engagement (Swanson et al., 2019) and self-directed learning (Kang & Kim, 2021) when students are learning in groups. First, learning engagement has become a research focus because evidence shows that it strongly links to learning outcomes (Darby et al., 2023). Therefore, many studies investigate how instruction can be adjusted to promote learning engagement, where technology is central to this field of research (Katona & Gyonyoru, 2025). Second, self-directed learning contributes to the increase in students' learning outcomes in group work (Gao et al., 2024). In working in groups, students plan their learning and distribute work to ensure the completion of the work, which is a feature of self-directed learning (Mentz & Zyl, 2018). According to recent research, self-directed learning is strongly associated with learning achievement (Zhoc et al., 2018; Doo et al., 2023).

Despite the benefits of team-based learning, some studies also warn us of some drawbacks of this learning type. The disadvantages of this learning type include time inefficiency, students' dissatisfaction, students' lack of collaborative skills, ineffective group formation, "unpromising" research results, social loafing, and free-riding (Le et al., 2018; Tatterton & Fisher, 2022; Hughes, 2023; Endra & Villaflor, 2024; Julianti et al., 2025). Among those shortcomings, the present study focuses on social loafing and free riding, which are related to bias and unfairness in assessment (Bui & Nguyen, 2024), in which educators tend to assign the same grade to all team members regardless of their contributions (Bingjie et al., 2022). In a team project, social loafing refers to giving less effort than expected, and free riding is an act of neglecting responsibilities altogether in group work (Kidwell Jr., 2003). Berhanu (2023) found these behaviours among students when completing group work. When students were asked about the details of the work, many could not provide satisfactory answers. As a result, many "diligent" group members complain about this unethical behavior. In addition, highly motivated students feel unfairly treated when they receive the same grades as their non-contributing peers (Dzulfikar et al., 2025). This feeling of injustice can lead to the sucker's effect or a decrease in motivation among highly motivated students in responding to social loafing and free-riding (Sherif, 2022).

Most educators are aware of social loafing and free-riding in team-based learning. Taggart and Wheeler (2025) suggest grading individual students in a group based on their contributions to completing the group work. However, educators found it hard to measure students' contributions in a group (Hall & Buzwell, 2013; Gedamu & Shewangezaw, 2022). Therefore, it is necessary to use a method to identify individual contributions in a team project to be used in assigning grades to team members. Gunning et al. (2022) attempted to develop an assessment procedure which considers self and team member reported contributions in assigning grades. The procedure is known as Group Skill Factor (GSF). This procedure is a breakthrough in achieving fairness in grading teamwork. However, it has some limitations. First, students who contribute less than 55% are graded zero, which is unfair for these students. Second, students who work extra to compensate for work neglected by social loafers or free riders do not receive extra grades, which is also unfair. Third, the quantitative data do not provide evidence that this method of assessment reduces social loafing and free-riding behaviors. In addition, Gunning et al. (2022) did not extend their study to statistically determine whether GSF is a valid measurement for individual team members in team projects. For this reason, we offer an approach to calculate the Student Contribution Index (SCI), which refers to the aggregate perception of group members on the contribution made by each member in completing their project.

The SCI-based assessment weights team members' effort in percentage, multiplied by the quality of completed work, which enables assigning higher grades to compensators and lower grades to social loafers and free riders. This index goes back to a proposal offered by Nepal (2012) and Spatar et al. (2015), also related to the procedure followed by Gunning et al. (2022). This index provides two functions: (1) as a measure of individual contribution to the team, which can help reduce social loafing and free-riding, and (2) as a basis for educators to grade students based on their efforts. Therefore, in this study, we first experimented with students in low identifiability (not informed of SCI-based assessment) and high identifiability (aware of SCI-based assessment) conditions to find out whether they tended to contribute more to the group project when they were informed that they would be graded based on their contributions. We also extended our study to determine whether students perceive SCI-based assessment as a fair measurement of team member efforts in completing team projects and whether it contributes to student satisfaction. For systematicity, we formulate three research questions to guide this inquiry: (1) Do students who are informed of SCI-based assessment contribute more to complete group work than those who are not informed of SCI-based assessment? (2) How do students perceive SCI-based assessment used

to grade individual group members in team projects?, and (3) Is there any correlation between perceived fairness in SCI-based assessment and students' satisfaction?

## LITERATURE REVIEW

This section introduces key concepts addressed in this article. It discusses social loafing and free riding behaviors and how they are identified and discouraged based on the literature. The section concludes with explanations of how SCI is calculated, with an example and illustrations.

### *Social Loafing and Free-Riding*

Social loafing refers to reduced effort when individuals work in a group relative than working alone (Šerić & Praničević, 2018; Gabelica et al., 2021). In education, not all students have the motivation to excel. Some students just want to get the minimum passing grades, so they contribute as little as possible to their team (Nwoji et al., 2025; Sigar et al., 2025). Such behavior can be harmful to motivated students because it encourages them to reduce their efforts to be comparable to that of social loafers, known as the sucker's effect (Sherif, 2022). This practice has been a concern in education (Valentine, 2018), workplaces (Bokhari & Aftab, 2022), and sports (Gorgulu et al., 2021).

There are several documented determinants of social loafing. These include contribution identifiability, task dispensability, and reward and punishment. Contribution identifiability is the extent to which individual contributions in a group can be measured and identified (Hall & Buzwell, 2013). Task dispensability is the extent to which group members feel their contribution will not affect the group's outcomes (Torka et al., 2021). Reward and punishment are the extent to which high or low contributions are rewarded with extra grades or punished with reduced grades (Maqbool & Shaji, 2024). Of these three factors, contribution identifiability is the focus of the present research because there has been no easy way to measure it (Gedamu & Shewangezaw, 2022). This factor can also be the basis for problems related to the two other determinants. For instance, the absence of a mechanism for identifying individual contributions encourages social loafing among group members who feel that they have an insignificant role in their group. Contribution identifiability is also the basis for rewarding those who work hard or punishing those who work minimally. Thus, a mechanism for measuring individual contribution becomes imperative when implementing team-based learning.

Free riding is more extreme than social loafing, in which certain members deliberately withhold their contributions but benefit from the team's endeavor. As with social loafing, free-riding causes negative perceptions of teamwork among students (de Saint Léger & Mullan, 2014). Morgan-Knapp (2022) strongly claimed that this practice disrespects individuals who contribute to completing the teamwork. However, free riding does not always happen based on bad intentions to take advantage of the group. For example, some students feel they cannot contribute and that their presence can interfere with group performance (Nwune et al., 2023; Beltran, 2025). They consequently rely on other, more competent members to take over their responsibilities. In such a case, a team may encourage incompetent members to free-ride (Dommeyer, 2007). Although such dynamics among team members are inconsistent with the principles of meritocracy (Hing et al., 2011), team members often believe they are acting for mutual benefit in such a case. Finally, free-riding can also occur in the following illustration (Levin, 2003). Team members usually decide together who does what and when, which is recommended to reduce free reading practice (Šerić & Praničević, 2018). More often than not, however, students who speak up get jobs they prefer (e.g., easy tasks), whereas quiet students get the undesirable ones. As a result, the quiet students became reluctant to work and withdrew from teamwork sessions, which could be perceived as free riding by the rest of the team members.

### *Reducing Social Loafing and Free-Riding*

Many studies have offered solutions to social loafing and free riding. Educators can assign students to prepare a group work diary containing the date, members who took part, completed work, and the problems that arose in each teamwork session (Dommeyer, 2007). They can also assign students to plan a schedule of team activities, report to their teacher about changes in the schedule, and rate the performance of each member in each meeting (Levin, 2003). Moreover, it has been suggested that educators should place students according to their level of motivation, which will force unmotivated students to contribute because they cannot rely on other students (Harding, 2018). In addition, Benning (2024) suggested that teachers avoid random group assignments, make small groups, and use peer process evaluation to prevent. Finally, a common suggestion to reduce social loafing and free-riding is through

peer assessment (El Massah, 2018; Wilson et al., 2018). Although these approaches are all plausible ways to minimize social loafing and free riding, they require a rigorous process. In the present study, we propose a more practical approach, which involves calculating the Student Contribution Index (SCI). As we will further elaborate, we built this approach by making improvements to approaches that others had proposed in previous works.

**Identifying Individual Contributions in a Team**

Researchers have tried to build several systems to assess individual contributions when working in a team. For instance, Guzmán (2018) used an Individual Weighting Factor in grading students based on their contributions to their team. Cheng and Warren (2000) first asked team members to evaluate each other’s contributions in a 6-item questionnaire with a 6-point response format (0 = did not contribute to 5 = excellent). Meanwhile, Spatar et al. (2015) used a 5-point response (0 = no contribution to 5 = excellent contribution). They then calculated the Individual Effort Rating (IER) by summing the group members’ ratings on a particular student. Afterward, they calculated the Average Effort Rating (AER) of the group by adding all Individual Effort Ratings divided by the number of students in the group. They subsequently divided the IER by the AER to get the Individual Weighting Factor (IWF). Finally, they graded each student by multiplying the group’s obtained grade with the IWF of the respective student. The strength of this approach lies in the fact that students can rate their fellow team members in private, inducing a sense of anonymity. However, this approach requires a cumbersome effort for teachers and students. For instance, in a team of seven members, each student has to complete six sets of questionnaires, one for each teammate. As for the teachers, the calculations to obtain IWF and the final grade can be tedious. The SCI offers a more straightforward solution, as described in the proceedings.

**Student Contribution Index (SCI)**

The SCI approach involved team members distributing 100 points to themselves and their teammates based on their contributions to the team project. It requires all team members to allocate the points individually and privately. A group of four individuals, for instance, would produce four distributions of points (see Table 1). Using the example in Table 1, we can calculate the SCI of each student by following these steps:

Table 1. SCI matrix

Rater (column) / Ratee (row)	Student A	Student B	Student C	Student D	Total
Student A	30	30	25	15	100
Student B	25	30	25	20	100
Student C	25	25	28	22	100
Student D	25	25	22	28	100
SCI	1.05	1.1	1	0.85	

The interpretation of SCI is straightforward. Assuming that all group members must contribute equally to complete a team project, a member with SCI = 1 had contributed one part, which is supposed to be completed by each member in a team of N people. A member with SCI = 2 had contributed two parts of the project that were supposed to be done by two members in a team of N members. In other words, a member with SCI = 2 had done the work that was supposed to be done by two people. For the example presented in Table 1, Student C contributed his share of the project (SCI = 1). In this case, he had completed 1 out of 4 parts of the project shared among the four team members. Student D had contributed 0.15 less than he should have (SCI = 0.85). Student A contributed his share of the project and the 0.05 parts that Student D had left undone (SCI = 1.05). Student B also did his share and the 0.10 that Student D had left undone (SCI = 1.10). In this example, Student C was a performer who completed his share of the project, Student D was a social loafer / free-rider, and Student A and Student B were both social compensators.

There are two ways to calculate students’ individual grades based on SCI. The first is by using the Standard Score as an anchor, as proposed by Spatar et al. (2015). The standard score is the maximum score that each member could contribute if they received a grade of 100 for the project, and if they all had contributed equally. With this approach, we can calculate each student’s individual grade using the following equation:

$$\text{Individual Grade} = \text{Standard Score} \times (\text{SCI}-1) + \text{Project Grade}$$

Using the aforementioned example, suppose the team had a grade of 75 for the project, Student A would get 76.25 for his final individual grade ( $25 \times (1.05 - 1) + 75$ ) and Student D would get 71.25 ( $25 \times (0.85 - 1) + 75$ ). Student B and Student C would thus get 77.50 and 75, respectively. An alternative to using the standard score is using the project grade as an anchor. Using the previous example, if the team received a grade of 75, assuming that all members had contributed equally, each member could have only contributed 18.75 (75 Project Grade / 4 members) to the project grade. We can calculate each student's individual grade using the following alternate equation, as also found in Nepal (2012):

$$\text{Individual Grade}_{\text{Alternate}} = (\text{Project Grade} / N \text{ members}) \times (\text{SCI} - 1) + \text{Project grade}$$

With the alternate equation, Student A would get an individual score of 75.94, Student B 76.88, Student C 75, and Student D 72.19. This alternate approach reduced the penalty for Student D (the social loafer) and the extra reward for Student A and Student B (the social compensators) compared to the Standard Score approach.

## RESEARCH METHOD

This paper reports two studies. We tested whether clear task identification (as measured using SCI) would reduce social loafing/free riding in Study 1. We expected that implementing SCI would provide a sense of task identifiability, which would theoretically reduce social loafing/free riding. We next examined how students evaluate the use of SCI in Study 2. Specifically, we asked students who had undergone an SCI-based evaluation about their perceptions of distributive and procedural fairness in the adoption of SCI-based assessments.

### Study 1

We conducted Study 1 to test the validity of SCI as a measure of task identifiability. We consider it valid if it can distinguish team members who completed their part of a team project from those who withheld their effort (e.g., social loafing / free-riding) and those who compensated. We also test the idea that task identifiability utilizing SCI would reduce social loafing / free-riding in a team project.

The participants in this study were 52 students from the Faculty of Education (especially in science) in one of the well-established public universities in Aceh, Indonesia. They were selected through a convenience sampling technique, as also utilized by Yadewani et al. (2024) and Hidayat et al. (2024). They were enrolled in a class tutored by the authors of this paper. The standard class sizes of a study group in this university range from 15 to 20 students. The participants of this study came from three different study groups enrolled in the same course. We randomly selected a study group for the high identifiability condition ( $N = 17$ ). We treated the students in the remaining two study groups as the control group (low identifiability condition,  $N = 35$ ).

To determine the contribution of each team member, we used a form as illustrated in Table 1 (see Appendix for further details) delivered through an online survey platform. The students were required to distribute 100 points to themselves and their group members. The total points cannot be lower or higher than 100 because 100 is considered the total efforts that all group members dedicated to completing the team project. Before completing the form, the students were told that if all group members contributed equally, the grade for each member would be 100 divided by the number of members, such as 25 for a four-member group. If a group member decided to assign more than 25 points for one of the group members, he or she would need to assign less than 25 points for one of the other members. Otherwise, the total grade would be higher than 100. Furthermore, we applied the calculation described in the literature review section to calculate each student's SCI.

$$\text{Individual Grade} = \text{Standard Score} \times (\text{SCI}-1) + \text{Project Grade}$$

We allocated students in the low and high identifiability conditions to small groups of 3-5 students. We asked them to work on a group project, which they had two weeks to complete. We told students in the high identifiability conditions that they would be graded based on their contributions to the project. To convince them of the grading system, we asked students in the high identifiability condition to practice completing the SCI form at the end of the first week. Students in the low identifiability condition did not receive such instruction. Students in the low and high identifiability conditions filled out the SCI form as they submitted their projects. With this approach, we expected the students in the high identifiability condition to be more convinced that their contributions to the team project matter.

Standard deviations (SD) of SCI in LI and HI groups were calculated to determine whether each group had social loafers/free riders. SD higher than 0.00 indicates the presence of social loafers/free

riders, and higher SD means more social loafers/free riders (Berhanu, 2023). Afterward, to answer the first research question, an F-test was used to determine whether there is a difference in the variability, represented by SD, between high and low identifiability groups at the significance level of 0.05. This test is a common inferential statistical analysis to assess whether the variances of two populations are equal (Agresti, 2019).

### *Study 2*

The aim of Study 2 was to evaluate student satisfaction with the use of SCI-based assessments. We also examined how students perceived SCI-based assessment in terms of distributive and procedural fairness. Evaluating SCI-based judgments regarding these two types of fairness is important because social loafing and free-riding behaviors violate the sense of distributive and procedural fairness (Lin & Huang, 2009). Distributive justice concerns whether people receive rewards commensurate with their efforts (Jasso et al., 2016). In this case, students who have contributed extra expect higher grades than their less contributing peers. Meanwhile, procedural justice concerns the procedure for allocating rewards (Vermunt & Steensma, 2016). Collective grading does not consider individual contributions, eliminating the opportunity for highly contributing students to receive extra grades. Since SCI-based grading addresses these distributive and procedural fairness issues, we expected students to view SCI-based grading as fairer than collective grading.

Participants, who were also selected using a convenience sampling technique as in Study 1, were undergraduate students who attended the classes tutored by the authors of the present paper. This sample consists of 113 students from the Department of Science Education in one of the well-established public universities in Aceh, Indonesia ( $N = 53$ ), and the Department of Psychology at another well-established public university in North Sumatra, Indonesia ( $N = 60$ ). These students had completed the SCI-based assessment for their team project.

The second study collects students' perceptions of distributive and procedural fairness, along with students' perceived satisfaction. Therefore, a questionnaire was used to measure these three types of information. The questionnaire was initially developed by Colquitt (2001), consisting of four items measuring distributive fairness and four items related to procedural fairness. In addition, the students' satisfaction was measured using two items. All items were presented in a five-point Likert scale (1 = not at all to 5 = very much). In the original study by Colquitt (2001), the factor loadings of each item from the distributive fairness questionnaire range from 0.82 to 0.90, 0.68 to 0.87 for procedural fairness, and 0.90 to 0.95 for students' satisfaction. These factor loadings are much higher than the threshold proposed by Hair et al. (2014). The internal consistencies of each factor were also high, i.e., 0.93 (distributive fairness), 0.93 (procedural fairness), and 0.91 (satisfaction). Due to limited sample size, we did not perform a factor analysis to calculate item loadings in the present study. After releasing their final grade, which was assessed using the SCI assessment procedure outlined in this paper, we asked participants to voluntarily complete an evaluation form of the SCI-based grading. We instructed them to reflect and compare the current SCI-based grading with the usual collective grading (same grade to all members regardless of contributions). We instructed them to answer the questionnaire of the study based on the reflection.

The students' satisfaction was extracted from the descriptive statistics using the mean score. The mean score can be used to determine the sentiment in a perception questionnaire, i.e., the mean score higher than 3.0 for positive sentiment and the score lower than 3.0 for negative sentiment, as also interpreted by Mustafa et al. (2022). Meanwhile, the correlation between the two variable pairs (satisfaction vs distributive fairness and satisfaction vs procedural fairness) was analysed using Spearman Correlation Coefficient. This non-parametric correlation analysis was used because the data belong to ordinal data (Privitera, 2018). The correlations are considered significant at  $p$ -value  $< 0.05$ .

## **RESULTS AND DISCUSSION**

### *Results of Study 1*

The result of Study 1 was intended to answer the first research question, i.e., to determine whether the students who are informed of SCI-based assessment (high identifiability) contribute better to complete group work than those who are not informed of this assessment (low identifiability). For this purpose, we analyze the variability of SCI in high identifiability (HI) and low identifiability (LI) groups. We expected students in the high identifiability condition to perform more evenly, such that members in all teams would have an SCI close to 1. The variability of SCI in the high identifiability condition should vary to a lesser extent than in the low identifiability condition. The results of statistical analysis using an F-test in

Table 2 show that the variability of the two conditions was different,  $F(16, 34) = 0, p = 0.00$ . The variability of SCI in the high identifiability condition was practically non-existent ( $SD = 0$ ). More variability was observed in the low identifiability condition ( $SD = 0.08$ ).

Table 2. Data summary and variability analysis result

Group	n	SD	F	df	p-value
High identifiability	17	0	0	16	0.000
Low identifiability	35	0.08		34	

To put this result into a better perspective, we expected that SCI would be able to distinguish between the performer (students who completed their part of the project), social loafer / free rider (those who ceased or withhold effort), and compensator (those who make up for their peers’ lack of contribution). As shown in Figure 1, there was an apparent variability of SCI among students in the low identifiability condition. In Study group 3, for instance, four students in team number 1 (black fill, blue border) had SCI lower than 1, indicating they had engaged in social loafing or free riding. Two students in this team had SCI above 1, suggesting that they had to compensate for their peers’ lack of effort to complete the project. Team number 3 of Study group 2 (blue fill, green border) was more extreme, in which three out of four members were slacking, leaving a student to compensate for them. As expected, SCI could distinguish the performer, social loafer / free rider, and compensator.

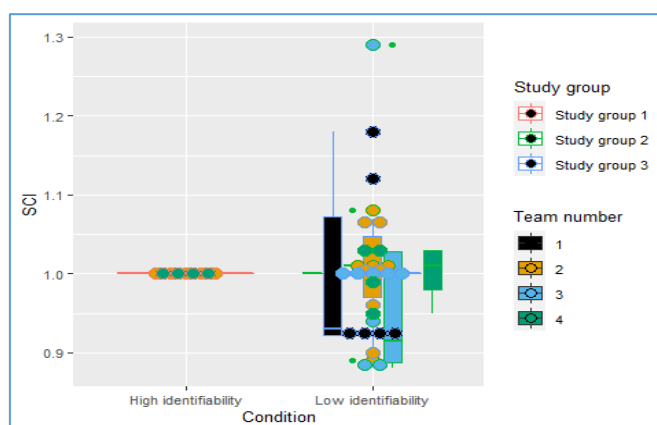


Figure 1. Variability of SCI in the high and low identifiability conditions

**Results of Study 2**

To answer the second research question, we summarized the students’ evaluation of the SCI-based grading in Table 3. As shown in Table 3, on a scale of 1 to 5, on average, the students evaluated SCI-based grading as satisfying. They also viewed it as procedurally and distributively fair. Their ratings on all measures were almost at the maximum, showing their highly benign opinions of SCI-based grading.

Table 3. Descriptive statistics and correlation in Study 2

No.	Variables	Mean	SD	1	2
1	Procedural fairness	4.36	0.47		
2	Distributive fairness	4.50	0.62	0.64***	
3	Satisfaction	4.40	0.65	0.60***	0.71***

Note: \* =  $p < .05$ , \*\* =  $p < .01$ , \*\*\* =  $p < .001$

To answer the third research question, Table 3 presents the results of the correlation analysis of the variables. The results show that higher perceived procedural fairness concerning SCI-based grading was associated with higher perceived distributive fairness and satisfaction with SCI-based grading. Higher perceived distributive fairness was also associated with higher satisfaction with SCI-based grading. Overall, the implementation of SCI has garnered a positive evaluation from the students.

The first objective of this study was to determine whether the high invisibility group contributed better to a team project than the low invisibility group when individual team members were assessed using SCI. In other words, the study was expected to determine whether the use of SCI in grading group

work can prevent social loafing and free-riding practices. The result shows that SCI was able to distinguish between the performer (students who completed their portion of the team project:  $SCI = 1$ ), social loafer / free rider (students who withhold their contributions:  $SCI < 1$ ), and compensator (students who compensate for their peers' lack of effort:  $SCI > 1$ ). Teachers could use SCI to grade their students by penalizing students who lacked contributions and rewarding those who exhibited extra work. For instance, students with  $SCI = 0.85$  contributed 15 percent less than they should. The teacher could reduce these students' grades by 15 percent from the overall team's grade. The teacher could also reward those who had compensated based on their SCI. Previous research has shown that students tended to give lower grades to free-riders (Bayazitova, 2019), making this SCI-based assessment reliable.

Based on previous studies, group-based learning is prominent in higher education (DeVries et al., 2020; Liebech-Lien & Sjølie, 2021; Matsunaga et al., 2021). However, this learning approach is prone to the problems of social loafing and free riding, which threaten its effectiveness. Researchers have long identified contribution visibility as a determinant of social loafing and free riding. In addition, previous studies show that task identifiability negatively correlates with social loafing (Sun et al., 2024), meanwhile; task invisibility increases social loafing behavior (Maqbool & Shaji, 2024). Therefore, educators are recommended to grade students based on their contributions and inform them so. However, measuring contributions was a complex process, so many educators did not consider it (Gunning et al., 2022). Many educators, in turn, often opt to grade students working on a group project collectively (that is, all group members receive the same grade, regardless of their contributions). Although practical, the collective grading approach often makes students who put in the effort feel that they are being treated unfairly.

Study 2 aims to determine whether the students consider the SCI-based assessment fair and how satisfied they were with this assessment procedure. We thus evaluated the implementation of SCI-based grading. The result shows students' positive evaluation of the implementation of SCI-based grading on team projects. The study shows that the students were highly satisfied with their final grades and perceived SCI-based grading as a procedurally and distributively fair grading system. SCI is thus a tool proven to be helpful in the implementation of team-based learning. In addition, the correlation analyses show that students' perceived contributive and procedural fairness correlate with students' satisfaction. This correlation analysis result suggests that students expect that they will receive grades which reflect their contribution rather than receiving the same grades for all group members regardless of their contributions. This result is expected because students who work extra to complete the work withheld by their teammates do not want to receive the same grade as their teammates (Gunning et al., 2022).

In this research, we designed SCI as a novel monitoring approach. As shown in Study 1, SCI is most useful when the students know they are being monitored. In the low-identifiability condition, we only measured SCI at the end of the study. In this case, the measurement of SCI was proper only as a means of identifying contributions. SCI is more useful in high-identifiability conditions. The repeated SCI measurements in this condition acted as a reminder that: (1) Each member's contribution can be identified (task visibility), (2) that members will be evaluated based on their respective contributions (distributive fairness), and (3) members need to communicate and distribute the workload (task-interdependence). Thus, previous research has also shown that assessment based on reported contribution can prevent social loafing and free-riding practices (Sridharan et al., 2018; Samarakoon & Imbulpitiya, 2020; Samarakoon et al., 2022).

This project offers SCI as a tool to identify the role of each group member in completing a group task. As we demonstrated in Study 1, SCI was able to distinguish between those who contribute fully (the performers), those who contribute more than they should (the compensators), and those who contribute less than they should (the social loafers / free riders). Moreover, Study 2 shows the utility of SCI in dealing with the issue of fairness when grading individual performance in group assignments. Therefore, we recommend that educators use SCI-based assessment to assign grades to individual team members after completing a group project. This type of assessment will motivate students to contribute more to completing their share of the work. Thus, the effectiveness of team-based learning, such as cooperative learning, cannot be guaranteed.

Despite the advantages of SCI, we note some weaknesses in the current project. First, grading requires grading the group work and calculating SCI, which requires distributing the SCI form and analyzing the responses. These multiple works add to educators' responsibilities, which is not time-efficient, given the time constraints reported by many teachers in secondary schools (Wang, 2025) and educators in higher education institutions (Suwarsi et al., 2024). However, the development of computer

technology has opened up the possibility of applying SCI seamlessly. For example, educators can prepare an online survey form for students to complete. The data can then be analyzed using statistical software with a pre-prepared analysis code. In our research, we used a free online survey platform and R (using R-Studio IDE) to implement SCI. In addition, educational technology web developers have developed commercial online tools, one of which is the FeedbackFruit peer evaluation tool, accessible with a subscription at <https://feedbackfruits.com/solutions/team-based-learning/>. We recommend that educational technology website developers collaborate to design an open-source online application to facilitate this type of assessment. Second, SCI-based assessment relies heavily on students' opinions, which may be expressed with numerous possible biases. Finally, SCI-based assessment has not offered a solution for social loafers/free riders who were endorsed by the rest of the group members because they consider that these social loafers/free riders will jeopardise the group work.

Furthermore, the result of this study is generalizable to contexts outside the context of this study because, first, this is a quantitative study, which is by nature generalizable. Second, the literature backs up the results of this study. However, the generalizability of the results of this study is subject to some limitations. First, the number of students we could recruit for this study was limited, which threatened the statistical power of this study. Statistical power is the probability of rejecting the null hypothesis when it is actually true (Crespi, 2025). Since we used an F test, statistical power is primarily determined by sample size. Therefore, further studies need more participants to achieve more accurate results. Another limitation is related to the participants' background. Our study only involved undergraduate students majoring in psychology and English language teaching. Therefore, the results of the study might not be generalizable to a group work which is different in nature from the group work in these two social sciences majors. Finally, teachers teaching in high schools need to use SCI to build teamwork skills among their students, but the present study did not focus on this context. While the results of the present study can be used as a basis for contribution-based group work assessment, a separate study needs to focus exclusively on this context.

## CONCLUSION

The results of this study have shown that SCI can be used to identify social loafers / free-riders in group work. Therefore, they can be penalized by reducing their grade, and thus social compensators can be rewarded by increasing their grades. The study has shown that students who were informed that they would be assessed through anonymous peer-assessment based on their contribution tended to contribute better than those unaware of such assessment. In terms of student perception, they evaluated the SCI-based assessment positively. They were highly satisfied with this SCI-based assessment because they consider that this assessment offers distributive and procedural fairness, which correlates to satisfaction, i.e., 0.60 and 0.71, respectively. The results of the study suggest that social loafers and free riders are a threat to group learning effectiveness, but these behaviors can be discouraged by using SCI-based assessment. Based on these promising results, it is strongly recommended that teachers use SCI-based assessment to grade group work to discourage social loafing and free riding practices. Future research needs to determine whether there is a correlation between SCI-based grade and material mastery by giving students individual tests after completing their group work.

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## AUTHOR CONTRIBUTIONS

Burhanuddin Yasin: conceptualization, funding acquisition, and supervision; Omar K. Burhan: data curation and formal analysis; Faisal Mustafa: methodology, project administration, and writing – original draft preparation; Ika Apriani Fata: review and editing; Endang Komariah: Review and editing.

## CONFLICTS OF INTEREST

The author(s) declare no conflict of interest.

## USE OF ARTIFICIAL INTELLIGENCE (AI)-ASSISTED TECHNOLOGY

The authors declare that no artificial intelligence (AI) tools were used in the generation, analysis, or writing of this manuscript. All aspects of the research, including data collection, interpretation, and manuscript preparation, were carried out entirely by the authors without the assistance of AI-based technologies.

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