Feedback-induced Improvement in the Learning of Anatomy and Physiology-specific Terminology among Tenth Grade High School Students

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Abstract

Feedback is perceived as one of the influential educational factors and drivers of students learning. Hence, the present study examined the effect of administering feedback on improving the acquisition of anatomy and physiology-specific terminologies among tenth grade high school students. Participants were randomly divided into three groups: a control group (*n* = 29), instructive feedback (IF) group (*n* = 29) and written feedback (WF) group (*n* = 29). A post-test was administered to determine if feedback had significant effect on the two treatment groups. A Kruskal-Wallis test showed significant differences among all the groups. Therefore, to compare the mean difference between the groups, a post hoc analysis, Dunn's test, was performed. The result indicated significant difference between control versus (vs) IF, control vs WF and IF vs WF, respectively. Similarly, the results of feedback administration on specific anatomy and physiology-specific chapters showed that groups subjected to feedback intervention was statistically significant compared to control group. While there was no significant effect of feedback on gender in IF group, we found that written feedback had significant effect on gender in WF group. Taken together, the present results suggest that administering feedback significantly enhanced learning of anatomy and physiology-specific terminologies. Accordingly, we recommend teachers to provide written feedback as it allows learners ample time for review and maximize its impact.

Keywords: Feedback, teaching and learning, anatomy and physiology-specific terminologies, instructive feedback, written feedback.

Introduction

Understanding the complex systems of organisms in the field of biological science requires a solid foundation in anatomy and physiology. As a result, proficiency in the associated terminology is crucial for grasping the fundamental definitions and concepts within these disciplines. Moreover, this proficiency holds particular importance for students aspiring to pursue careers in healthcare, medicine, or other relevant fields (Miller et al., 2002). However, due to the complexity and technical nature of the subject (Cimer, 2012), high school students are often confronted with challenges in learning and retaining the vast array of intricate anatomical and

physiological terms. To cope with these challenges, students often resort to memorization of the terms through repetitive learning. While this approach may help them remember the terminology, the tradeoff is that it dampens their interest towards learning biology, limiting opportunities for rich instructional discussions as opposed to engaging and intellectually stimulating learning experiences.

To address such challenge, teachers are recommended to incorporate innovative pedagogical strategies (Okolie et al., 2022) to cater to students with diverse learning needs. One highly effective strategy that is supported by research is the feedback-based learning, which is widely acknowledged as an effective strategy for improving students` learning (Hattie & Timperley, 2007). Specifically, feedback can assist students in identifying and resolving errors and misconceptions (Van der Kleij et al., 2015). Examined through the lens of the constructivist theory of learning, feedback is perceived as a component of scaffolding provided by the tutor to facilitate the student's learning process (Orsmond et al., 2005). It entails providing information to a learner after a task or activity, with the purpose of informing them about their present state of learning or performance (Vollmeyer & Rheinberg, 2005) by actively engaging in the learning process.

In Bhutanese science education, particularly biology, students are confounded by the plethora of scientific terminologies laden in the curricula, which are actually intended for laying robust foundation in learning science. It cannot be generalized but previous studies agree well with our perception that students find the terminologies difficult owing to its long, polysyllabic word of Greek or Latin origin (Wandersee, 1998), huge numbers of scientific terminology (Song & Carheden, 2014), complexity of scientific terminology (Krajcik & Sutherland, 2010) and great numbers of new vocabulary (Marintcheva, 2012). Indeed, given the transition from integrated science in junior high school to learning biology as independent subject in high school, it is obvious that beginning students will be overwhelmed by the large numbers of scientific terminologies. Not surprisingly, drawing everyday experiences from our interactions with students in the classroom, it has been observed that students often struggle with the learning of biological terminologies.

The present study, therefore, examined the effect of administering feedback on improving the acquisition of anatomy and physiology-specific terminologies among tenth grade high school students. The hypothesis that feedback administration will positively impact students' learning of anatomy and physiology-specific terminologies was tested by administering two distinct feedback interventions, namely instructive feedback (IF) and written feedback (WF). We attempted to answer these two questions:

1. What is the effect of different types of feedback intervention on the learning of anatomy and physiologic-specific terminologies?
2. What is the effect of different types of feedback intervention on gender?

Literature Review

The use of feedback dates back to 1940s and since then has been extended to many fields (Ende, 1983) such as psychology, education and management literature

(Schartel, 2012). Over the years, there have been huge numbers of articles about feedback in education as it has been found to be efficacious for fostering students learning (Johnson, 2012) and form an integral part of learning process.

In educational context, feedback is defined as a response to student's reflection provided either in written form or administered orally about the learning that occurs in classroom (Baliram & Ellis, 2018). It constitutes a vital part of every school day and plays crucial role in both teaching and learning process (Konold et al., 2004) because of its great potential in heightening students' knowledge, comprehension, performance and skill development (Kluger & DeNisi, 1996). According to van Duijvenvoorde et al. (2008), feedback-based learning is one of the hallmark features of successful learning since it points out the gap between current comprehension and what is aimed to be comprehended in the future (Hattie & Timperley, 2007). Likewise, feedback-intervened learners showed higher achievement than those without feedback (Maier et al., 2016) and learning was found to be usually effective when feedback was administered in the learning course (Bangert-Drowns et al., 1991; Kulhavy & Stock, 1989; Meyer, 1986). Interestingly, Bandiera et al. (2015) showed that even the average students performed better after receiving feedback about their past academic performance.

As a key constituent of learning, feedback enables students to be on track in realizing a purpose (Ende, 1983) and serve as an imperative condition for their goal setting (Erez, 1977). This is because feedback is thought to empower and have substantial impact on students as independent learners, bolstering their motivation and self-confidence that inform how to proceed with the task seamlessly (Irons, 2008). Further, when the feedback is timed properly and viewed as an opportunity for learning, it is reported to augment effectiveness and personal development of students (Altmiller, 2016).

Dehaene (2020) stated that error always wane so long as we receive feedback that informs us how to improve. Subsequently, receiving feedback has been shown to have positive impact when wrong response is preceded by it. On this light, it is believed that feedback's most instructional significance would be to correct the wrong responses (Kulhavy, 1977). Pashler et al. (2005) identified that when feedback is applied promptly after incorrect response, it results in improved final recall. From behaviorist theory of reinforcement, it concurs with the idea that feedback should be applied instantly to remove errors while supporting correct responses (Skinner, 1954). Hence, it allows learners to keep abreast of their learning errors that play a pivotal role in learning.

According to Miller (2002), the purposes of feedback are to induce appropriate learner behavior, convey information on learner's performance and extend their learning opportunities. Consequently, learners can use this information to surpass their pre-established goals (Schartel, 2012) and reinforce learning with much greater specificity (Kulhavy, 1977) and even increase their intrinsic motivation (Badami et al., 2011). For instance, Karelaia and Hogarth (2008) observed that providing feedback on correct outcomes and task information results in improvement of performance and knowledge along with the perceived mastery of the task (Gardner & Wood, 2009).

Concurrently, the quality of teacher feedback and its relevance in learning cannot be taken for granted because quality and relevance play an integral role in learning process (Du Toit, 2012). Research in higher education also indicate that quality feedback is necessary for students to make them independent learners (Brown, 2007). For example, well-orchestrated unambiguous feedback is highly likely to have stronger impact on students' performance than random unplanned vague feedback (Herschell et al., 2002). By contrast, if the feedback provided is perfunctory and vague, chances are that it might leave learners confused and culminate in ineffective learning. Hence, for a feedback to be effective, information contained in feedback should be task oriented with strong focus on quality of students' performance (Shute, 2008), rational and encourage thinking (Black & Wiliam 1998; Perrenoud, 1998).

Methods

Research Design

This study employed a quantitative method known as a post-test only design, as outlined by Creswell (2018). A post-test only design is a between-group design, where treatment is applied only to the experimental groups and not to the control group, and all the groups are assessed through a posttest.

Setting and Participant

The present study was carried out in a nine to twelve level high school during the course of regular academic year 2021. A total of 87 (female = 42, male = 45) tenth grade students from three sections participated in the study.

Experimental Design and Intervention

Participants were randomly divided into control (*n* = 29), IF (*n* = 29) and WF (*n* = 29) groups. The control group was taught using conventional lecture-based method without administering feedback intervention, while specific feedback interventions were applied to both the treatment groups. Therefore, the independent variables were the type of interventions received by the students and the dependent variable was students test scores on post-test.

Briefly, instructive feedback occurred as follows: after gaining students attention, the teacher questions, 'what is the meaning of *tonsil*? 'After student's correct response, the teacher then reinforces the students and attaches a suffix '*itis'* to `*tonsil*` and impart `*tonsilitis*` as the new terminology learning. In this example, meaning of the word `*tonsil*` which students have to learn is the target stimulus and the terminology `*tonsilitis*` is an extra information that serves as instructive feedback stimulus.

Similarly, for the written feedback, the teacher use root words to describe the biological terms. For example, leucocyte, in which the root word *leukos* mean white and the root word *cyte* means cell; therefore, a leucocyte is a white blood cell (Kessler, 1999). Thereafter, to measure the effect of intervention, post-test was administered to each of the three groups. All the three groups were taught the same lessons with the same instructional objectives for 45 minutes each by the three authors for a week.

Instrument Development, Validity and Reliability Analysis

All the items of test instrument were selected from three chapters of grade ten biology textbook (Tshering, 2018), namely digestive system, circulatory system and respiratory system to provide diverse anatomy and physiology-specific terminologies. The instrument comprised of 30 items and were self-created. The test items were vetted for content accuracy within the authors. After drawing a common consensus, the questions were then subjected to experts, including a curriculum developer, possessing substantial knowledge and experiences in teaching high school biology, for vigorous content validation. Experts were asked to rate individual item of the test instrument using a 4-point scale (Davis, 1992): 1 = not relevant, 2 = somewhat relevant, 3 = quite relevant and 4 = highly relevant. Test items that scored 1 or 2 on clarity index were revised rigorously in accordance with experts 'comments until a rating of 3 was scored. Thereafter, the content validity of the instrument was estimated by content validity index (CVI), in which both item (I-CVI) and scale level (S-CVI) were computed (Polit et al., 2007, as cited in Dorji & Nima, 2021). For I-CVI, the number of experts scoring a rating of 3 or 4 was divided by total number of experts and items which scored I-CVI of $\geq$ 0.78 were accepted. For S-CVI, both S-CVI/Universal Agreement (S-CVI/UA) and S-CVI/Average (S-CVI/Ave) were computed to confirm the content validity of overall scale. Subsequently, items that had S-CVI of $\geq$ 0.90 were accepted for overall scale.

Since CVI fails to account for inflated values that might ensue due to chance agreement, modified Kappa coefficient was calculated since it eliminates any random chance agreement (Polit et al., 2007). To interpret the obtained Kappa coefficient, the values of 0.40 to 0.59 was considered as fair, 0.60 to 0.70 as good and > 0.70 as excellent (Fleiss, 1981; Cicchetti & Sparrow, 1981). Subsequently, Kappa coefficient obtained in the present study was 1.0 indicating that consensus index of interrater agreement among experts is beyond chance.

A test instrument consisting of 30 items with dichotomous choices (Yes/No) was then pilot tested with 30 tenth grade students (female = 15, male = 15) from one of the middle secondary schools located in the same district, Thimphu, Bhutan. The main purpose of this pilot study was to test internal reliability of the instrument that was later implemented to the research participants. The reliability of the test items was computed using Kuder and Richardson formula 20 (KR-20) (Kuder & Richardson, 1937) and was adjusted to 0.6 after eliminating four items, as retention of these four items resulted in a decreased alpha value, denoting that the item reliability is moderate. Criteria outlined by Salvucci et al. (1997) was used to interpret the obtained alpha coefficient, where less than 0.5 is considered low, between 0.5 and 0.8 as moderate and greater than 0.8 as high. Further, an alpha value of 0.6 to 0.7 was reported to be at an acceptable level (Hulin et al., 2001).

Item Difficulty and Overall Discrimination Index

Item difficulty and overall discrimination index were also determined to evaluate the quality of the test items. The cut off values maintained to assess the item difficulty

index were: > 0.7 (too easy), 0.3 to 0.7 (average) and < 0.3 (too difficult) (Hingorjo & Jaleel, 2012). Similarly, the cut off values for discrimination index was evaluated following Ebel and Frisbie (1972), where values of ≥ 0.40 is deemed as very good items, 0.30 to 0.39 as moderately good, 0.20 to 0.29 as marginal items (need improvement), and ≤ 0.19 as poor items (to be improved by revision or rejected). Accordingly, the obtained value of 0.35 for item difficulty and 0.31 for overall discrimination index imply that the items were moderate and reasonably good for implementation.

Data Analysis

The data was analyzed for normality using Shapiro-Wilk test and found that data distributions were non-normal. Thus, nonparametric statistics was employed to analyze the data. Statistical differences between treatment groups and control group as well as for specific chapters namely circulatory, respiratory and digestive systems in three different groups were analyzed using Kruskal-Wallis test, followed by post hoc analysis, Dunn's test, with Benjamin Hochberg adjustment. To examine if feedback exerted any significant effect on gender in IF and WF groups, a Man-Whitney test was performed. $p < .05$ was considered statistically significant for all analyses. All analyses were performed by using R Statistical Computing Software, version 4.0.2 (http://www.R-project.org).

Ethics

Approvals were sought from school administration before the onset of the study. Additionally, participants were well informed of the purpose of the study and fully informed consent were also verbally obtained from individual participants.

Results

Table 1

Demographic information of the participants (N = 87)

Gender	Age range	Number	Percentage
Male	13 - 14	1	2.2
	15 - 16	21	46.7
	17 - 18	19	42.2
	19 - 20	4	8.9
Female	13 - 14	0	0
	15 - 16	16	35.6
	17 - 18	24	53.3
	19 - 20	5	11.1
	Total	87	100.0

Figure 1 depicts the mean score of Control, IF and WF groups that were administered with different types of feedback to examine its efficacy on the learning of anatomy and physiology-specific terminology. A non-parametric Kruskal-Wallis test

was carried out and found a statistically significant difference between the groups (χ^2 = 24.2, df = 2, p < .001). Therefore, Dunn's test (p value adjusted with Benjamin Hochberg) was applied as a post hoc analysis to check which specific means significantly differed from each other. Result revealed a statistically significant difference between control and IF (p = .004) as well as control and WF (p < .001), respectively. Interestingly, a statistically significant difference was also found between IF and WF (p = .015).

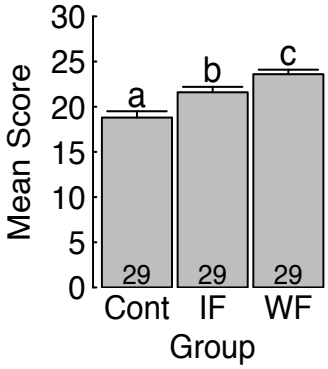

Figure 1. Effect of different types of feedback on mean score of Control and Treatment groups (IF and WF). Values are mean ± SEM. Numbers in (or on) each column indicate number of participants in each group. Different letters show that mean values were statistically different from each other based on Kruskal-Wallis test followed by Dunn's post hoc test (p value adjusted with Benjamin Hochberg). Cont = Control, IF = Instructive Feedback and WF = Written Feedback.

Figure 2 depicts the mean score of three different groups that were administered with different types of feedback to examine its efficacy on the learning of anatomy and physiology-specific terminologies in circulatory, respiratory and digestive system. A non-parametric Kruskal- Wallis test was carried out and found a statistically significant difference between the groups (χ^2 = 7.92, df = 2, p = .019).

Therefore, Dunn's test (p value adjusted with Benjamin Hochberg) was applied to check which specific means significantly differed from each other in circulatory system (A). Result showed that there was a statistically significant difference between control and WF (p = .007). In contrast, a statistically significant difference was not observed between control and IF (p = 0.115) as well as IF and WF (p = .081), respectively.

For respiratory system (B), a statistically significant difference was found between the groups (χ^2 = 22.16, df = 2, p < .001). Subsequently, Dunn's test (p value adjusted with Benjamin Hochberg) found a statistically significant differences between control and IF (p = .011), control and WF (p < 0.001), and IF and WF (p = .011) groups (B). Similarly, a statistically significant (χ^2 = 17.12, df = 2, p < .001) difference was also found between the groups in digestive system (C). Dunn's test (p value adjusted with Benjamin Hochberg) revealed significant difference between control and IF (p = .003)

as well as control and WF (p < .001) groups, respectively. However, a statistically significant difference was not found between IF and WF (p = .110) group (C).

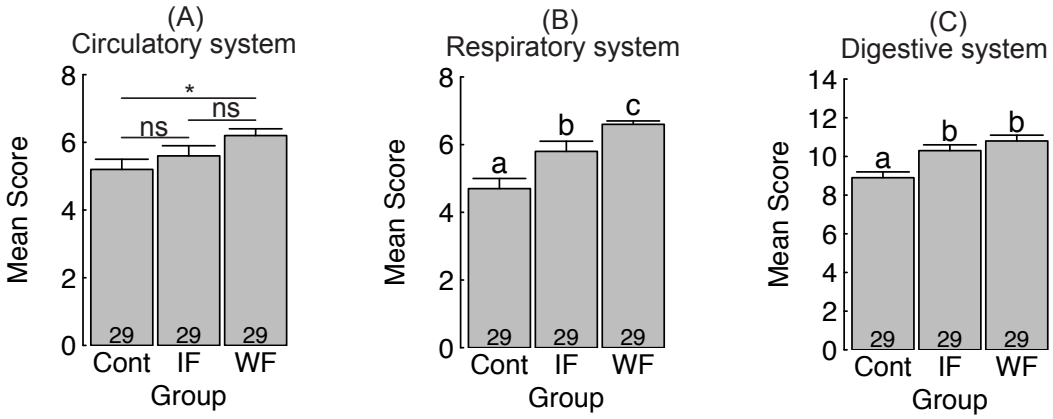

Figure 2. Effect of different types of feedback on (A) Circulatory system, (B) Respiratory system and (C) Digestive system. Values are mean ± SEM. Numbers in (or on) each column indicate number of participants in each group. Different letters show that mean values were statistically different from each other based on Kruskal-Wallis test followed by Dunn's post hoc test (p value adjusted with Benjamin Hochberg). Asterisk denote that there is statistically significant difference between control and WF. ns = not statistically significant, Cont = Control, IF = Instructive Feedback and WF = Written Feedback.

Figure 3 depicts the effect of administering feedback on gender in IF and WF groups. A non-parametric Man-Whitney test was computed to check for statistical difference between the gender. Results showed that there was no statistically significant difference between female and male in the IF (U = 116.5, p = .595) group (A). However, a statistically significant difference (U = 53, p = .049) was observed between female and male in the WF group (B).

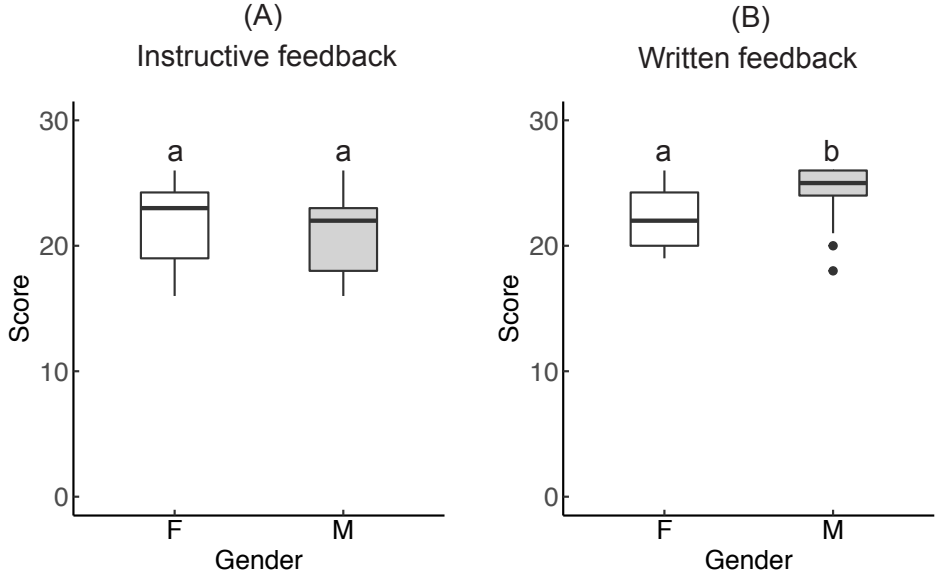

Figure 3. Effects of administering feedback on gender in the IF group (A) and WF group (B). Values are expressed as medians which is indicated by the horizontal line

in the box. The top and the bottom edges of each box represents 75th and 25th percentiles, respectively. The whiskers of the boxplot encompass the data within a range of 1.5 times the interquartile range, spanning the upper and lower quartiles. Different letters show that values were statistically significant based on Man-Whitney test. The two solid circles in the written feedback group shows outliers. IF = Instructive Feedback, WF = Written Feedback.

Discussion

It has been long recognized that feedback constitute an important aspect of learning. Hence, we examined the effect of administering feedback on improving the acquisition of anatomy and physiology-specific terminologies among tenth grade high school students. The findings indicate that feedback enhanced learning of anatomy and physiology-specific terminologies. The groups that were subjected to IF and WF performed significantly better than the conventional lecture-based control group as shown in figure 1. Subsequently, the mean score was also statistically significant in treatment groups compared to control in all the three chapters as shown in figure 2 A, B and C, respectively. There was also a significant effect of feedback on gender in the WF group (Figure 3B). However, there was no effect of feedback on gender in the IF group (Figure 3A).

The findings of our study are consistent with the notion that administration of feedback improves performance of the learners and heighten their learning (Hattie & Gann, 2011). Although no previous literatures are found that specifically studied the effect of feedback on enhancing learning of anatomy and physiology-specific terminologies, few similar studies that involved control and treatment groups that examined the effect of feedback on a broad theme of learning are available. So, we selectively discuss the relevance of our findings with some of these published reports.

A study conducted by Vollmeyer and Rheinberg (2005) to evaluate the efficacy of feedback on learning, divided their study participants into two groups: first group of participants received feedback from the experimenter after the first and second round in the learning phase and a second group didn't receive feedback which served as control group. Their result indicated that the feedback in fact improves performance of the learners as evidenced by the learner's (feedback group) ability to systematically manipulate the system, an indicator they employed to measure the learning outcome in the study. Lim et al. (2021) further reported that group subjected to feedback intervention scored higher in course grades than the control group.

Our finding is further reinforced by meta-analysis (Wisniewski et al., 2020; Forsythe & Johnson, 2016; O'Donovan et al., 2016; Wiliam, 2012; Omer & Abdularhim, 2017) that showed the impact of teacher's feedback on improving learner's performance and accelerating students learning achievement. Similarly, in a study that evaluated the efficacy of targeting only two functional error categories ('a' and 'the') by providing written corrective feedback for ESL writers, they observed that the treatment group performed better than the control group on post-tests (Bitchener & Knoch,

2008). Interestingly, even feedback from peers have been reported to help students perform better in writing tasks (Trang & Anh, 2022).

Based on meta-analysis, Schneider and Preckel (2017) found out positive effect of feedback that surpassed learning outcomes triggered by testing in higher education, which was linked to recalling and achievement. A parallel report of feedback providing additional and effective learning gains was also reported by Enders and colleagues (2020). Likewise, a study by Guo and colleagues (2014) found that providing feedback significantly affected learners' cognitive involvement in groups intervened with feedback.

Interestingly, our study also found statistically significant difference between IF and WF groups. Since administration of written feedback involved description of terminologies in the form of writing as well as verbal explanation, it is highly plausible that this could have ensued in students performing significantly better in WF group compared to IF group. This finding is in congruence with Biber et al. (2011). Additionally, description in the form of writing would have allowed for repeated revisions of the lesson taught and assisted in remembering various anatomy and physiology-specific terminologies. Because written feedback can be reviewed at leisure (Buckley, 2012), learners would have certainly leveraged on this flexibility that culminated in significant difference in WF group.

Previous studies have also shown that simply introducing extra stimuli through instructive feedback after students correct response to direct instructional questions resulted in students acquiring those extra stimuli at the same time the target information is being learned. These have been found effective for all students - primary-aged students (Gast et al., 1991), elementary-aged children (Ross & Stevens, 2003; Stinson et al., 1991), teenagers in middle school (Doyle et al., 1990), individuals with hearing and language problems (Wolery et al., 1993), and adolescents with behavioral disorders (Wolery et al., 1991). For example, it was found effective in teaching spelling of sight words (instructive feedback stimuli) during sight word reading instruction (target stimuli) (Gast et al., 1991; Shelton et al., 1991), and definition of words (instructive feedback stimuli) that are taught to read (target stimuli) (Shelton et al., 1991). These studies were conducted with students having mild cognitive impairments in a small-group instructional arrangement. In each of these studies, administration of instructive feedback helped students gain additional non-target information in about the same amount of instructional time (Werts et al., 1995). Ross and Stevens (2003) also reported that some instructive feedback learning occurred for all students, which involved students with multiple disabilities (MD), Attention Deficit Disorder and Learning Disabilities. Therefore, irrespective of the types of learners, the result of present study and previous research clearly point out that administering feedback has positive impact on students learning.

We further examined if feedback administration had significant effect on gender and found a statistically significant difference between male and female in WF group. On the other hand, a statistically significant difference was not found between male and female in IF group. Therefore, the present findings imply that the effects of instructive and written feedback are varied on genders. However, we remain uncertain

of the plausible reasons about the discrepancies between gender due to scarcity of literatures about feedback intervention on learning with regard to gender.

Conclusion

The present study confirmed the hypothesis that administering feedback positively enhances learning of anatomy and physiology-specific terminologies. Consequently, we suggest teachers to provide different types of feedback to meet the learning needs of diverse type of learners in today's general classroom. In particular, it's recommended that teachers provide written feedback so that it allows learners sufficient time to review at their own convenience and make the most out of it. Such healthy practice is imperative to drive beginner's interest towards learning biological terminologies, so that it eventually instills the love of learning for biological science. Overall, our study further adds to the repository of feedback literature in education, which supports the notion that feedback promotes effective learning.

Limitation of the study

The present study is limited only to anatomy and physiology-specific terminologies and does not account for botanical terminologies. Therefore, it is likely that the results may differ if a similar study is carried out involving botanical terminologies. At a time of administering feedback, the study didn't take into consideration the timing of the feedback which is considered to be an important factor. Another possible limitation is that we didn't collect perception about different types of feedback from the participants which hindered knowing students' preference towards a particular feedback type. We also feel that our study is limited by the small number of sample size.

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