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Student and feedback: Which type of feedback is preferable?

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Abstract

This research: 1) made a comparison of genetic problem-solving ability among participants with different ability levels and different types of feedback and 2) studied the interaction of participant ability level and type of feedback with genetic problem-solving ability. Participants were 786 twelfth-grade students in the first semester of the 2017 academic year (May 2017–September 2017) from 7 schools in the Bangkok educational service area. The results revealed that: 1) the excellent group had the highest ability level ($M = 1.006$, $SD = 0.411$); 2) in the moderate group ($M = 0.497$, $SD = 0.452$) and poor group ($M = -0.595$, $SD = 0.735$) 2), participant ability level and type of feedback interacted with genetic problem-solving ability ($F = 9.200$, $p = .000$); and 3) simplified directive feedback was appropriate for the poor group because of their limited basic knowledge while the moderate and excellent groups who were equipped with better basic knowledge and comprehensive skills did well with worked example feedback.

Introduction

Assessment as learning (AAL) in the educational context is now a popular trend. AAL is advantageous over both assessment of learning (AOL) and assessment for learning (AFL). Both AOL and AFL only provide knowledge of results to students while AAL informs the student's own strength and weakness via feedback for further development (Srichot, 2013).

Based on the AAL definition, students play an important role in self-evaluation to find out their own strengths and weaknesses, so feedback is the way to enhance the students' self-evaluated accuracy. Feedback can be provided by various sources, for example, instructor, classmate, parents, and even the individual. Certainly, feedback can be provided by various methods (oral presentation, and paper-based instruction). Thus, feedback influences students differently, based on the source of feedback (Klaimanee, 2015; Yastibas & Yastibas, 2015; van der Kleij, Eggen, Timmers, & Veldkamp, 2012). Technology has made substantial leaps forward so that a computer-based system with immediate feedback is now one of the most effective ways to provide feedback. A computer-based system has many advantages, for example, it is easier to manage, gains more attention from students, and test result can be informed instantly once the test has been completed (Attali, 2011). Zhang, Zhang, Luo, and Geng (2016) studied the effectiveness of immediate feedback and its relationship to feedback and memory strategies. Their results revealed that the memories of both adults and adolescents were significantly better when equipped with immediate feedback. In contrast, adults were more vulnerable to false memories when there was no immediate feedback and showed less learning effectiveness compared to adolescents. As a result, it can be concluded that immediate feedback is helpful for the learning and memory strategies of everyone.

Iron (2008, as cited in Lumthong, 2010) stated that delayed feedback was definitely ineffective; thus, delayed feedback was equivalent to no feedback. Furthermore, most of the feedback in classrooms was delayed feedback as well

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as providing only knowledge of results to the students. The instructor may need to put in a lot of effort to employ immediate feedback in a classroom environment, so testing a system with immediate feedback seems to be worthwhile for best practice of immediate feedback to determine effectiveness of the type of feedback among students with various ability levels.

Literature Review

Most academic studies related to testing systems with immediate feedback are in the field of student's mathematical ability assessment and only few are available in other fields. However, a testing system with immediate feedback should be applied to other fields of scientific study employing mathematical approaches, such as: rectilinear motion in Physics, solution concentration in Chemistry, and genetic problems in Biology. Based on the literature review, many students were unable to solve genetic problems (Arunpruksakul, 2016). Additionally, Viraphotchananan (2014) found that 44.12 percent of students were unable to calculate the genotype in a genetic problem while 8.82 percent of students were able to do the calculation but did it incorrectly. Genotype calculation is crucial in genetic problems, especially for the Mendelian laws of inheritance and beyond (incomplete dominance, and co-dominance). The current research could not identify any academic study regarding a testing system with immediate feedback for Biology (Genetics) so it would be advantageous to begin with a testing system with immediate feedback for genetic probability problems to determine its effectiveness.

Relevant Theory

Bloom's Taxonomy is a cognitive process dimension representing a hierarchy of cognitive complexity. The cognitive domain of Bloom's taxonomy comprises 6 tiers: 1) remember, 2) understand, 3) apply, 4) analyze, 5) evaluate, and 6) create. Bloom's taxonomy is used as a traditional model in educational assessment. On the other hand, the RISE model of Wray (2013) is a relatively new cognitive model of meaningful feedback that aligns to the cognitive domain of Bloom's taxonomy. The RISE model also has a hierarchical structure with 4 tiers: 1) reflect (R), 2) inquire (I), 3) Suggest (S), and 4) Evaluate (E). Information on each tier of the RISE model can be seen in Table 1.

Type of Feedback and Motivation

Positive feedback is narration or description of positive points of view on personal behavior to encourage students to exhibit a desired behavior. Certainly, positive feedback needs to be consistent, especially in the first phase of behavior modification. Otherwise, the behavior modification may fail.

Negative feedback is the opposite of positive feedback, so negative feedback is attacking criticism without providing any solution or clarification. Occasionally, negative feedback may be considered as humiliation because it leads students to feel ashamed or results in a decline in self-confidence. Undesired behavior will be consistent if there is no information but only criticism provided to students (Musikthong & Lekdamrongkul, 2013).

Table 1
Four hierarchical tiers of RISE model

4	Elevate	Raise to a higher degree or purpose in future iteration
3	Suggest	Introduce ideas for improvement of current iteration
2	Inquire	Seek information and/or provide ideas through questioning
1	Reflect	Recall, ponder, and articulate

Source: Wray (2013)

Type of Feedback Based on Response Time

Delayed feedback is feedback provided after a whole test or a whole set of behaviors has finished (Sinhaa & Glassa, 2015). Iron (2008, as cited in Lumthong, 2010) stated that delayed feedback was definitely ineffective; thus, delayed feedback was considered the equivalent to no feedback.

In contrast, immediate feedback is feedback provided instantly after the desired behavior, for example, testing, oral presentation (Sinhaa & Glassa, 2015). Immediate feedback provides information to students once the desired behavior has finished so they can know their own strengths and weaknesses. As a result, student can make proper progress.

Type of Feedback Based on Sources

Feedback can be divided into 4 sources: 1) instructor, 2) friend, 3) parents, and 4) computer-based system. Yastibas and Yastibas (2015) reported that friend's feedback for a writing session greatly reinforced self-confidence and diminished anxiety. Diab (2015) also reported that student's self-evaluation feedback was noticeably inaccurate compared to the instructor's evaluation feedback. Computer-based feedback was frequently found in the testing system. Most testing systems used the multiple-try feedback/answer-until correct condition (Attali, 2015).

Student Ability Level

Student ability level can be measured by many methods, including scoring-based systems, and the analysis-via-item response theory model. Measurement of student ability using the item response theory model is advantageous over scoring-based systems as student ability does not depend only on the test item attribute (Kanjanawasee, 2014). A 1-parameter model (Rasch model) was employed for this research because it best fitted approximately 200 samples (Chang, 2001; Foley, 2010). The logistic function of a 1-parameter model (Rasch model) can be defined using the following equation:

$$P_i(\theta) = \frac{e^{(\theta_n - b_j)}}{1 + e^{(\theta|n - b_j)}}$$

$P_i(\theta)$ = probability of student with ability (θ) will respond to test item “i” correctly

b_j = difficulty parameter of test item "i" presenting ICC point is at θ point where probability of correct response is at 0.50

$e = 2.718$

b_j = parameter that changes according to each test item attribute

a_i = fixed parameter

$c_i = 0$

Theoretical Model

Based on the literature review, there are many types of feedback and the type of feedback can affect students differently (Klaimanee, 2015; Yastibas & Yastibas, 2015; van der Kleij et al., 2012). Not only the type of feedback, but the student ability level is a crucial factor. Shute (2008) stated that knowledge of result feedback and directive feedback were sufficient for high ability-level students but there was no related study for moderate and low ability-level students. As a result, this research aimed to make a comparative study of student ability level, genetic problem-solving ability, and the type of feedback (see Figure 1).

This research aimed: 1) to compare genetic problem-solving ability among participants with different ability levels and different types of feedback and 2) to study the interaction of participant ability level and type of feedback with genetic problem-solving ability.

Methods

Selection of School and Sample

The population was 35,708 twelfth-grade students in the 2017 academic year, from 119 schools in the Bangkok educational service area.

Initially, samples were acquired from four different types of school categorized by the number of students: 1) small, a school with less than 500 students; 2) medium, a school with 500–1,499 students, 3) large, a school with 1,500–2,499 students, and 4) extra-large, a school with greater than 2,500 students. Then, samples were acquired from mathematics-science programme students. This point was crucial to ensure that students possessed some basic knowledge of Biology so the students could deal with the testing system properly.

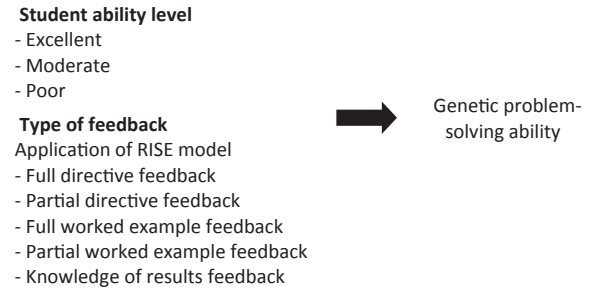

Figure 1 Theoretical model

Groupings and Sample Size

Based on a 1-parameter model, samples were 786 twelfth-grade students from seven schools in the Bangkok educational service area. Subsequently, the 786 students were distributed into 242 students for the excellent group, 309 students for the moderate group, and 235 students for the poor group.

Instruments

1) Pretest of genetic problem-solving ability

The pretest was a mixed-format test (constructed-response item and multiple-choice item). The 16 items were divided into 8 constructed-response items and 8 multiple-choice items. The scoring system was dichotomous (0, 1) with a total score of 16 points. The test comprised two contents (basic knowledge of genetics and Mendelian laws of inheritance). The test reliability was analyzed using the IRT 1-parameter and reliability was 0.757. Finally, the participants were divided into three groups (excellent, moderate, and poor) based on norm-referenced criteria.

2) Testing system with immediate feedback

The testing system was a mixed-format test with 20 test items distributed into 10 multiple-choice items and 10 constructed-response items. The testing system also shared the same contents as the pretest (basic knowledge of genetics and Mendelian laws of inheritance). Participants were allowed to answer until correct under the specific conditions following. Participants were given 4 points if they achieved the correct response at the first attempt then 3 points at the second attempt and 2 points at the third attempt and 1 point at the fourth attempt, with 0 points at the fifth attempt even if they achieved the correct response. A total score of the testing system was 80 points. Testing reliability was analyzed using the Graded Response Model (GRM) and testing reliability was 0.739. Five types of feedback were employed in the testing system, with all of them designed by application of the RISE model of Wray (2013). Information on the types of feedback employed in the testing system can be seen in Table 2.

3) Post-test of genetic problem-solving ability

The post-test was also a mixed-format test and shared the same contents which were Mendelian's laws of inheritance and basic knowledge of genetics. The post-test comprised 8 items distributed into 4 for multiple-choice items (5 choices) and 4 for constructed-response items. The scoring system was dichotomous (0, 1) with a total score of 8 points. The reliability of the post-test was analyzed using the IRT 1-parameter model and resulted in a score of 0.756.

Design

1) Five types of feedback were employed in testing system. All of them were designed by application of the RISE model (Wray, 2013).

Table 2
Type of feedback based on application of RISE model

RISE model	Type of feedback	Condition		Type of feedback employed in testing system
		Correct response	Incorrect response	
Inquire	Worked example feedback	✔	✔	1. Full worked example feedback (FWF)
		✘	✔	2. Partial worked example feedback (PWF)
	Directive feedback	✔	✔	3. Full directive feedback (FDF)
		✘	✔	4. Partial directive feedback (PDF)
Reflect	Knowledge of results feedback	✘	✔	5. Knowledge of results feedback (KORF)

Source: Wray (2013)

2) The testing system was developed using Adobe Flash (Adobe Inc., San Jose, CA, USA). The testing system was online based with an administrator.

3) Participants were distributed into three groups based on their performance in the pretest. The excellent group consisted of 242 participants, the moderate group consisted of 309 participants, and finally, the poor group consisted of 235 participants. Importantly, each participant was provided with only one type of feedback for a whole test. The distribution of each type of feedback for all participants was: 1) FWF for 67 participants, 2) PWF for 105 participants, 3) FDF for 95 participants, 4) PDF for 68 participants, and 5) KORF for 68 participants.

4) Testing was held in a computer room of each school. Each participant was provided with an instruction manual, a registration code, a username and password, and notepaper. Once the instruction session had finished, each participant eventually logged into the testing system. The testing period was 90 min.

Data Analysis

1) Pretest and post-test results of genetic problem-solving ability were analyzed using descriptive statistics (mean and SD).

2) Reliability of the test was conducted by application of the IRL 1-parameter model via MULTILOG (SSI Inc., Skokie, IL, USA). The quality of the test was analyzed using difficulty (b) and a parameter of each participant's ability level (θ).

3) Two-way ANOVA was used to compare the means of genetic problem-solving ability and types of feedback using the SPSS software package (SPSS Inc., Chicago, IL, USA).

Results

1) Genetic problem-solving ability of participants and type of feedback

The poor group's post-test score mean was noticeably low ($M = 2.35$, $SD = 2.033$) and the poor group's ability level (θ) mean was the lowest ($M(\theta) = -0.595$, $SD = 0.735$). The moderate group's post-test score mean was mediocre ($M = 5.43$, $SD = 1.258$) which conformed to their ability level (θ) mean ($M(\theta) = 0.497$, $SD = 0.452$). Finally, the excellent group's post-test score mean was the highest ($M = 6.80$, $SD = 1.054$) and their ability level mean (θ) was also considerably high ($M(\theta) = 1.006$, $SD = 0.411$).

2) Interaction of Ability Level and Type of Feedback with Genetic Problem-Solving Ability

The results of the two-way ANOVA revealed that both the ability level and type of feedback interacted with genetic problem-solving ability ($F = 9.200$, $p = .000$). The summary information can be seen in Table 3.

The result of the simple effect analysis of the mean of genetic problem-solving ability of each group after treatment (immediate feedback) was as follows.

The poor group exhibited higher genetic problem-solving ability at a statistically significant level of 0.05 ($F = 3.456$, $p = .009$) while the mean of the overall poor group ability was relatively low ($M = -0.595$, $SD = 0.730$).

The moderate group also exhibited higher genetic problem-solving ability at a statistically significant level of 0.05 ($F = 26.904$, $p = .000$) while the mean of the overall moderate group ability was mediocre ($M = 0.497$, $SD = 0.450$).

The excellent group exhibited higher genetic problem-solving ability at statistically significant level of 0.05 as well ($F = 14.554$, $p = .000$) while the mean of the overall excellent group ability was impressive ($M = 1.011$, $SD = 0.407$).

Table 3
Interaction of ability level and type of feedback with genetic problem-solving ability

Sources of variance	Type III Sum of squares	df	Mean square	F	*p*
GROUP	319.601	2	159.801	727.607	.000
FEEDBACK	7.396	4	1.849	8.418	.000
GROUP * FEEDBACK	16.164	8	2.020	9.200	.000*
Error	169.111	770	0.220		
Total	614.073	786			
Corrected Total	589.092	785			

Based on Simple effect analysis, the poor group, moderate group, and excellent group exhibited significantly higher genetic problem-solving ability after treatment (immediate feedback), so multiple comparison was used to specify the type of feedback that was actually effective for each group as seen in Table 4.

The poor group exhibited higher genetic problem-solving ability with PDF compared to FWF at a statistically significant level of .05.

The moderate group exhibited higher genetic problem-solving ability with FWF, PWF, PDF, and KORF compared to FDF at a statistically significant level of .05. The moderate group with PWF also exhibited higher genetic problem-solving ability compared to PDF at a statistically significant level of .05.

The excellent group exhibited higher genetic problem-solving ability with FWF, PWF, and KORF compared to FDF, and PDF at a statistically significant level of .05.

Discussion

The results indicated feedback affected students equipped with various level of comprehensive skill and basic knowledge differently. Nonetheless, the feedback was helpful for everyone. Attali (2011, 2015) also found a huge improvement in student's learning effectiveness after feedback was provided.

The poor group exhibited higher genetic problem-solving ability with directive feedback (both FDF and PDF) compared to worked example feedback as the poor group seemed to use less time to comprehend feedback compared to other groups. Consequently, the poor group was likely to neglect complicated feedback so feedback provided to the poor group needed to be concise and simplified.

On the other hand, the moderate and excellent groups exhibited higher genetic problem-solving ability with worked example feedback (both FWF and PWF) compared to directive feedback, as both groups were likely to use a considerable amount of time to comprehend feedback. Worked example feedback was slightly more complicated than directive feedback so it required some comprehensive skill yet provided more detail through its case study approach. The excellent group also tended to use more time to comprehend feedback compared to the poor and moderate groups, which reflected that students with various ability levels used different amounts of time with feedback or testing (Gouli, Gogoulou, & Grigoriadou, 2008; van der Kleij et al., 2012; Yastibas & Yastibas, 2015).

Feedback is helpful for learning and studying but each student requires a different type of feedback. According to the research findings, ability level plays an important role in indicating the best type of feedback for particular students. The poor group did well with simplified directive feedback while the moderate and excellent groups did well with worked example feedback. The instructor should pay attention to student ability level and design a proper teaching plan to maximize the benefit of each type of feedback.

Table 4
Multiple comparison of participant's self-evaluation accuracy based on Tamhane's T2 technique

Group	Feedback		Mean Difference (I-J)	SD	*p*
	(I)	(J)			
Poor	PDF	FWF	0.43	0.140	.027*
Moderate	FWF	FDF	0.50	0.095	.000*
	PWF	FDF	0.54	0.057	.000*
	PDF	FDF	0.28	0.055	.000*
	KORF	FDF	0.40	0.066	.000*
	PWF	PDF	0.27	0.063	.001*
Excellent	FWF	FDF	0.52	0.081	.000*
	FWF	PDF	0.47	0.076	.000*
	PWF	FDF	0.49	0.060	.000*
	PWF	PDF	0.43	0.053	.000*
	KORF	FDF	0.53	0.067	.000*
	KORF	PDF	0.47	0.061	.000*

$p < .05$ was taken to be significant

Conclusion and Recommendation

The results explained the relationship of student ability level and type of feedback with genetic problem-solving ability. The type of feedback noticeably influenced students with different ability levels. Thus, the instructor needs to pay attention to student ability level and provide the proper type of feedback to a specific group of students based on their ability level.

The poor group required special attention because of their limited basic knowledge and comprehensive skills. Instructor should consistently provide feedback to ensure that the poor group knows its own strengths and weaknesses, so the poor group can make further progress properly. Simplified directive feedback did well with the poor group and thus, the instructor should consider using directive feedback that is not too complicated for the poor group.

The moderate and excellent groups also needed consistent feedback as did the poor group. In contrast, both of moderate and excellent groups did well with worked example feedback instead of directive feedback so the instructor should consider using worked example feedback for both groups.

Based on the research findings, the type of feedback makes a big difference for each student group. In a classroom environment, the instructor should pay attention to the majority of students to prepare the proper type of feedback; for example, directive feedback should be employed for classrooms with a majority of low ability-level students. When the proper type of feedback is applied, such feedback may help to improve the learning effectiveness of students.

Conflict of Interest

There is no conflict of interest.

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