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THE SECOND GENERATION OF FEEEDBACK-BASED LEARNING MODEL (FBL-2G) FOR QUANTITATIVE COURSES IN HIGHER EDUCATION

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The aim of the study was to examine the effectiveness of the second generation (2g) of Feedback-Based Learning model (FBL-2g) regarding quantitative courses in higher education. The intention was to examine students' views towards the model and check if there are differences between theoretical quantitative courses such as math or statistics and a computer course. The research was based on three samples of students (n_1=28, n_2=25, n_3=19, n_{total}=72) who studied three quantitative courses based on the new model. All three course sites were prepared and managed by the same lecturer. Students were asked to fill out an online questionnaire to assess various characteristics of FBL-2g and its impact on their motivation and learning process.
The study findings show that according to students' attitudes, FBL-2g is perceived as very effective for learning quantitative courses. All characteristics were highly rated as follows: Diagnosis, prognosis, student

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motivation and sense of belonging and the contribution to learning improvement. Therefore, it is recommended to support and train lecturers who teach quantitative courses in higher education so that they can use this model making a significant contribution to the students' motivation and learning.

1 Introduction

1.1 General Background

Academic studies in general are considered difficult and require students to face the challenge while making significant efforts. Learning quantitative courses in higher education is particularly difficult because students need to understand complex principles and procedures and acquire the ability to solve complicated problems. Moreover, the quantitative courses are based on a hierarchical knowledge structure, that is, new knowledge based on prior knowledge. Therefore, any gap that a student accumulates can make it very difficult to continue to understand and assimilate the course. To address the problem of growing gaps and promoting students, lecturers are required to conduct an ongoing diagnosis of the learners' situation in order to identify the weak points and intervene in real time. In order to achieve an effective diagnosis, comprehensive and appropriate feedback is needed.

Promoting student success in learning has become an issue of concern among educators all over the world (Elton & Johnston, 2002; Knight & Yorke, 2003; Race, 2005). Substantial numbers of students come into a class with all the appropriate prerequisites yet they are incapable of handling the course material (Wilson & Scalise, 2006). The usual explanation for student difficulties is that students do not study enough or they are not interested (Hesse, 1989). In light of the fact that communication between faculty and students is a critical element of higher education, effective feedback may be the missing component in successful outcomes (Felder & Brent, 2004). Higher education will not be significantly improved, Burksaitiene (2011) argues until the feedback system is changed.

Feedback can have different functions depending upon the learning environment, the needs of the learner, the purpose of the task, and the feedback paradigm adopted (Poulos & Mahony, 2008).

There is a substantial body of research reporting both university student and lecturer dissatisfaction with feedback (Ferguson, 2011). Most student complaints focus on: feedback content, organization of assessment activities, untimeliness of criticism, and lack of clarity about requirements or guidance as to how to use feedback to improve subsequent performance (Huxham, 2007). From the lecturers' perspective, complaints revolve around students not making use of or acting upon feedback in subsequent tasks and being concerned only with the mark (Spiller, 2009). Hence, both students and faculty deplore what is known as the feedback gap (Evans, 2013).

In order to be effective, feedback should close the gap between students' actual performance level and the level required by lecturers. Efficient feedback gives specifics regarding shortcomings (Hattie & Timperley, 2007): Does the information imparted in the critique help students close the gap between current knowledge and the program's desired outcomes (Croton, Willis III & Fish, 2014)? Providing such feedback is not an easy task.

Yet international research indicates that students respond very well to feedback delivered in digital form. A meta-analysis of more than 7,000 studies (Hattie & Timperley, 2007) reveals that multimedia feedback is one of the most effective ways to obtain positive results from feedback. While the term "feedback" refers to information provided to students to encourage them to improve their learning, information from students to lecturers may be just as transformative, assisting academic staff in changing their manner of teaching to better fit learners' needs. Often students are the first notice whether teaching is good or not. That said, too many institutions are not geared to accept student insights in an atmosphere that genuinely welcomes such feedback. Although requesting student feedback on their learning experience at the end of a semester has become common practice in many institutes, their views may not have any actual impact. Institutions of higher education need to create environments and mechanisms that allow student views, learning experiences, and performance to be taken into account (McAleese *et al.*, 2013).

The first generation of Feedback-Based Learning model (FBL-1g) confronts the challenge of getting institutions of higher education to appreciate the validity of students' learning experience (Ghilay, 2017; Ghilay & Ghilay, 2015). It provides immediate student responses to lecturers' practice via use of personal smartphones (or tablets/laptops) to online questionnaires concerning the delivery of the educational program. The model significantly improves student feedback to faculty. It informs lecturers how each subtopic has been understood and implemented by all students in the course. This enables instructors to respond in real time to student difficulties either by explaining topics over again or by discussing issues that are surrounded by lack of clarity. Depending upon the prevalence of the difficulty, a lecturer's response may involve a specific student or the whole class.

1.2 The second generation of Feedback-Based Learning model (FBL-2g)

The current research presents a second generation of the Feedback-Based Learning model (FBL-2g) designated mainly for quantitative courses. The new model is designed to overcome the specific difficulties of the quantitative courses mentioned above by two major activities, diagnosis and prognosis. It is quite clear that the diagnosis phase is critical because the prognosis depends on it. Moreover, in conjunction with any diagnostic activity, there must be appropriate prognostic activity that should produce a desired outcome.

While the previous model (Ghilay, 2017; Ghilay & Ghilay, 2015) uses only one diagnostic component (feedback questionnaires), the second generation is based on four main diagnostic modules. The two major phases of the model are the following:

Diagnosis

A lecturer's initiative:

1. *An online feedback questionnaire*: At the end of every main topic, each student answers an online questionnaire covering all subtopics of the main theme. Students are asked to evaluate the extent to which they understood and assimilated the subjects studied on each topic (1-very little, 2-little, 3-medium, 4-much, 5-very much). In addition, they can add verbal comments about the learning process of the subject, especially understanding and assimilation of the material. The questionnaire can be answered by a smartphone, tablet or PC connected to the Internet.
2. *Daily Monitoring of exercises' status*: All the course exercises and examinations are computerized and the instructor is supposed to supervise the progress of the students. It is possible to check who did not submit a certain exercise even though the date of submission was over, what grade was received, what questions the students had difficulty with, etc. The use of Computer Assisted Assessment (CAA) allows complete remote control of student progress, pointing out weaknesses and difficulties.
3. *Constant monitoring of student attendance (for face-to-face courses) or entries to the course website (for distance courses)*: Using the website tools, the lecturer can monitor the absence of students from the class or their entries to the site.

Students' initiative:

4. *Questions and requests forwarded to the lecturer by the students*: Student questions or requests are another important component of the diagnostic information that serves as the basis for the prognosis stage.

***Prognosis*:**

Difficulties can be solved by explaining unclear issues, adapting the rate of progress to students, and treating each student appropriately and individually. Help of any kind may be provided remotely through the various communication channels and in special cases also by connecting the lecturer to the student computer and providing personal guidance. The lecturer can help students solve exercises if necessary, delay the submission time or add response attempts. If students are missing or inactive, the lecturer can contact them and see if they need help. In cases where students ask a question or make a request, the lecturer must be attentive and respond as quickly as possible through one of the available communication channels. The best way is not to dwell on and give answers on the same day that the request was made. All this is done while creating an ongoing dialogue with the student.

1.3 Examining students' views toward FBL-2g

The study examined students' attitudes regarding various characteristics of FBL-2g model for quantitative courses in higher education. These characteristics were examined in various types of quantitative courses in higher education, both in face-to-face and distance learning: Mathematics, statistics and a computer course (PSPP).

Three groups of students who studied the following courses based on FBL-2g were examined:

1. Mathematics for business administration: first year students
2. Introduction to statistics: first year students.
3. Fundamentals of PSPP (statistical software equivalent to SPSS): third year students.

All students participated, studied in the Department of Management and Economics at the NB School of Design and Education, Haifa, Israel. The three courses included the following topics:

- *Mathematics for business administration:* Functions, linear inequalities, quadratic inequalities, exponents and roots, logarithms, arithmetic sequence, geometric sequence, derivative and integral.
- *Introduction to Statistics:* Introduction - basic terms, measurement scales, group data in tables, visualization of the distribution of frequencies, rules of summation (basic use of Sigma and Sigma rules), measures of central tendency (mode, midrange, median and mean), measures of dispersion, relative position of data (standard scores), distribution of standard scores and the standard normal curve.
- *Fundamentals of PSPP:* Introduction to PSPP, data editor, foundations of descriptive statistics, syntax, case selection, descriptive statistics – additional tools (Descriptives and Explore), means, computerized variables, sort files and data control, independent samples T-Test, paired samples T-Test and one sample T-Test, ANOVA (one way analysis of variance), correlations, crosstabs and chi square test, reliability (Cronbach's alpha including item analysis) and factor analysis.

2 Method

The study examined the students' attitudes towards FBL-2g, which are divided into two categories: Theoretical courses and computer courses. The same lecturer prepared all the course sites and conducted the three courses.

2.1 The research question

The research question intended to examine the characteristics and advantages of FBL-2g for quantitative courses in higher education. The following research question was worded:

> *Based on the learners' views, what are the characteristics and advantages of FBL-2g for learning quantitative courses?*

2.2 Population and Samples

Population: The research population addressed through the study included all those who studied quantitative courses, based on FBL-2g.

Samples: Three samples (Academic year: 2017-18) that have been examined are presented in table 1:

Table 1
THE STUDY SAMPLES

No.	Course	Way of learning	Sample size	Rate of response
1	Mathematics for Business Administration	Face-to-face	28	96.6% (28/29)
2	Introduction to Statistics	Face-to-face	25	92.6% (25/27)
3	Fundamentals of PSPP	Distance	19	100% (19/19)
	Overall		72	

2.3 Tools

Respondents were asked to answer an online five-point Likert scale questionnaire consisting of 19 items (1-strongly disagree, 2-mostly disagree, 3-moderately agree, 4-mostly agree, 5-strongly agree). At the end of the questionnaire, the following open ended question was added: Was the FBL-2g helpful for your studying during the course?

2.4 Data Analysis

The following factors divided into two main categories were examined:

Diagnosis and prognosis:
- Diagnosis: Identifying learning difficulties
- Prognosis: Handling problems.

Outcomes:
- Motivation and sense of belonging.
- The contribution of FBL-2g to learning improvement.

Table 2 summarizes the four factors, the items composing them and the reliability. For each factor, a mean score was calculated (including standard deviation). One Way ANOVA was conducted to examine significant differences among the three courses above. Paired Samples T-test was undertaken as well to check significant differences between pairs of factors ($\alpha \leq 0.05$).

3 Results

Table 3 presents the mean scores of the three samples.

Table 2
FACTORS AND RELIABILITY

Factors	Questionnaire's Questions
Diagnosis: Identifying learning difficulties (Alpha = 0.885)	FBL enables me to inform the lecturer as to topics I did not understand. FBL allows the lecturer to know what difficulties I have encountered. FBL allows the lecturer to know what subjects I am familiar with. FBL enables the lecturer to know my weaknesses and strengths.
Prognosis: Handling problems (Alpha = 0.946)	FBL allows the lecturer to explain unclear issues. FBL highlights the difficulties common to most students in the class. FBL allows for treating specific difficulties even if they are not common to most of the class. FBL allows the lecturer to address problematic issues in learning. The lecturer can adjust the pace of the lesson to students' progress. FBL allows the lecturer to treat each student appropriately and individually. FBL enabled me to get responses to difficulties I faced.
Motivation and sense of belonging (Alpha = 0.809)	FBL gives me a feeling that the lecturer is interested in me. When the lecturer is interested in my learning, my motivation to study increases. It is important that the lecturer be interested in my learning. Following the FBL, I feel more comfortable in contacting the lecturer.
The contribution of FBL-2g to learning improvement (Alpha = 0.906)	FBL causes me to learn better. FBL causes me to be better prepared for the final exam. FBL enables me to better understand the material that was taught. FBL causes me to have meaningful learning.

Table 3
SAMPLES' MEAN SCORES

Category	Factor	Course	N	Mean	S.D
Diagnosis and prognosis	Diagnosis: Identifying learning difficulties	Math	28	4.61	.55
		Statistics	25	4.56	.76
		PSPP	19	4.64	.48
	Prognosis: Handling problems	Math	28	4.45	.73
		Statistics	25	4.54	.77
		PSPP	19	4.60	.49
Outcomes	Motivation and sense of belonging	Math	28	4.38	.70
		Statistics	25	4.45	.68
		PSPP	19	4.51	.56
	The contribution of FBL-2g to learning improvement	Math	28	4.35	.82
		Statistics	25	4.42	.60
		PSPP	19	4.55	.58

Below are One Way ANOVA ($\alpha \leq 0.05$)) results intended to find out if there are significant differences between the mean scores of all the samples, relating to the factors mentioned above:

1. Diagnosis: Identifying learning difficulties: $F_{(2,69)} = .104,\ p = .901$
2. Prognosis: Handling problems: $F_{(2,69)} = .273,\ p = .762$
3. Motivation and sense of belonging: $F_{(2,69)} = .222,\ p = .802$
4. The contribution to learning improvement: $F_{(2,69)} = .478,\ p = .622$

The above findings indicate that no significant differences were found between the means of all the samples, for all factors. Therefore, the mean factors for all these samples together are shown in Table 4.

Table 4
MEAN FACTORS: THREE SAMPLES TOGETHER

Category	Factor	N	Mean	S.D
Diagnosis and prognosis	Diagnosis: Identifying learning difficulties	72	4.60	.61
	Prognosis: Handling problems	72	4.52	.68
Outcomes	Motivation and sense of belonging	72	4.44	.65
	The contribution of FBL-2g to learning improvement	72	4.43	.68

The findings of Table 4 can be summarized as follows:

Regarding the diagnosis and prognosis, both factors have been very highly rated by learners for all the different courses or ways of learning: Diagnosis - identifying learning difficulties (4.60) and prognosis - handling problems (4.52). Based on Paired samples T-Tests, there was no significant difference between these two factors ($t_{(71)} = 1.691,\ p = .095$). This means that they are very highly and equally rated. In other words, according to students' perceptions, FBL-2g allows lecturers to make an effective continuous diagnosis for each student and to know regularly what problems learners have and what their weaknesses and strengths are. After mapping the difficulties, the lecturer successfully deals with the problems and resolve them for the entire group as well as for each individual student.

As for the outcomes, both factors have been also very highly rated for various courses and ways of learning: students' motivation and sense of belonging (4.44) and the contribution of FBL-2g to learning improvement (4.43). Findings show that there was no significant difference between these two factors ($t_{(71)} = .259,\ p = .797$), that is, they are highly and equally evaluated. The meaning of these findings is that FBL-2g gives students the sense that the lecturer is interested in them, and in their learning, which increases their motivation to learn and ask questions or requests. Besides, the model provides a significant contribution to improving the learning process. This is accomplished by causing students to better understand the material and have meaningful learning.

The open-ended question strengthens the closed items and gives them more validity as presented in the following quotations of respondents:

Mathematics for business administration:

> "*It is a great idea to know what my situation is in terms of understanding the material being studied. This allows the lecturer to assist me during the learning process".*
> "*The feedback method is interesting and allows me to progress in the material in a consistent and safe manner*".

Introduction to statistics:

> "*The method is very useful and allows to solve problems and difficulties before it gets worse.*"
> "*Thanks to the feedback method, all topics were clear and understandable*".

Fundamentals of PSPP:

> "*The feedback was very helpful for my learning process during the course.*"
> "*The lecturer's continuous follow-up of each student's learning process was excellent and helped to overcome problems quickly and efficiently.*"

The above quotes emphasize the high effectiveness of the FBL-2g model for learning quantitative courses in higher education. Because this type of course is difficult to understand and assimilate, such comprehensive feedback is perceived as very helpful to students' learning.

Conclusion

Studying quantitative courses in higher education is difficult because students need to understand and assimilate complex principles and procedures and face the challenge of dealing with difficult quantitative questions.

As mentioned earlier, a quantitative course is based on a hierarchical knowledge structure. Therefore, the accumulation of gaps that grow over time can be problematic and difficult to deal with as time passes. The FBL-2g model offers an effective solution to address this problem. It enables lecturers to continuously diagnose the situation of learners, identify weaknesses and intervene in real time. At first glance, it appears that it is difficult to conduct a quantitative academic course based on these principles. In fact, this is not the case. If the learning processes of all students are well managed from the beginning without accumulating gaps, the course is well advanced and the lecturer does not have to spend too much work later. On the other hand, in the traditional learning method in which the instructor examines the status of learners only at the end of the semester (if any), students can accumulate ever-increasing knowledge gaps until they lose control.

According to the study, the FBL-2g model may be the first step in improving the learning of quantitative courses in higher education. Thus, researchers are invited to examine the model for other quantitative courses and other samples in order to improve its validity.

The current findings indicate that the method should be used in higher education institutions, which teach courses of this type. Unfortunately, not all faculty members are familiar with the various issues of educational technology needed to implement the model. To do this in practice, training programs are needed so that lecturers will be familiar with the creation and analysis of online questionnaires, use Computer Assisted Assessment (CAA) to effectively handle online exercises and exams, and be proficient in effectively monitoring students' activity on the course site. Such knowledge can be purchased on the basis of the TMOC (Training for the Management of Online Courses) model (Ghilay, 2017; Ghilay & Ghilay, 2014).

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