

**FEEDBACK ON STUDENTS' PERFORMANCE: A POSSIBLE WAY OF  
REDUCING THE NEGATIVE EFFECT OF MATH ANXIETY IN HIGHER  
EDUCATION**

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## **ABSTRACT**

The aim of this study was to investigate the effectiveness of a formative assessment system in improving students' learning. This system involved giving feedback to students regarding the errors they made in a series of assignments performed during a course. Participants were 166 students enrolled in a core course of the degree in psychology offered by the University of Barcelona. Attendance at feedback classes was found to be positively correlated with students' grades, whereas the correlation between math anxiety scores and final exam grades was not significant. Exam grades were only predicted by the 'perceived usefulness of feedback' factor, suggesting that feedback may have helped to reduce the negative impact of math anxiety on students' academic achievement.

**KEY WORDS:** formative assessment; feedback on errors; math anxiety; higher education; academic achievement

## 1. INTRODUCTION

Formative assessment is defined as “a process of appraising, judging or evaluating students’ work or performance and using this to shape and improve their competence” (Tunstall & Gipps, p. 389). Its purpose is to provide direct feedback about the learning and teaching process, and it can have beneficial effects for both students and teachers (Rolfe & McPherson, 1995; Wass, Van der Vlugten, Shatzer, & Jones, 2001). It is generally acknowledged that formative assessment improves students’ learning through the provision of information about their performance (Black & Wiliam, 1998; Hattie & Timperley, 2007).

The core of formative assessment (i.e., assessment for learning) is, therefore, feedback. Feedback has been described as “information with which a learner can confirm, add to, overwrite, tune, or restructure information in memory, whether that information is domain knowledge, meta-cognitive knowledge, beliefs about self and tasks, or cognitive tactics and strategies” (Winne & Butler, 1994, p. 5740). Without feedback from teachers, students’ mistakes go uncorrected and good performance is not reinforced, which may adversely affect not only students’ motivation but also their grades (Bose & Rengel, 2009).

In the present study a formative assessment system was developed and implemented in the context of a *Research Design* course, a second-year core subject in the degree in psychology offered by the University of Barcelona. The specific aim was to investigate the effectiveness of this system in improving students’ learning. The *Research Design* course is high in statistical content and requires numerical reasoning. It is therefore difficult and unpleasant for many students, who either fail to pass the exams or abandon the course because they feel incapable of passing. In a previous study, Núñez-Peña, Suárez-Pellicioni, and Bono (2013b) found that most university students who failed to

pass a *Research Design* course showed a high level of math anxiety and negative attitudes towards this subject. Importantly, math anxiety has been found to be associated not only with negative attitudes towards mathematics but also with poor academic outcomes in the subject and low confidence regarding the ability to learn math (Jasen, Louwese, Straatemeier, Van der Ven, Klinkenberg, & Van der Maas, 2013).

In the formative assessment system described in the present study, students undertook a series of assignments during the course and were provided with feedback about their performance. The syllabus for the *Research Design* course comprised seven topics, each focusing on a type of research design. Each design was worked on in three sessions spread across one week: the first session was a lecture, the second was a practical session, and the third was a feedback session. The practical sessions required students either to solve a problem or to perform a computer analysis, working in small groups in class. At the end of these sessions the students handed in either a set of solutions to the problem they had worked on or the results and their interpretations of their data analysis. These assignments contributed to the final grade for the course (see Materials section). The materials used in these practical sessions were developed with the aim of improving the process through which statistics were taught and learnt, following the recommendations made in several studies related to statistics education (for a review, see Garfield and Ben-Zvi, 2007). Four of these recommendations are as follows: First, practical courses are considered to be more effective than theoretical ones (Becker, 1996); second, the use of statistical software and computing equipment to analyze data enables students both to interact with data and to visualize complex concepts, helping them to solidify their understanding of important concepts (Marasinghe, Meeker, Cook, & Shin, 1996; Weissglass & Cummings, 1991); third, using cooperative groups in class to work on assignments has positive effects on students' grades, because it encourages students to argue convincingly for a particular

approach and helps them become more involved in their own learning (Giraud, 1997; Keeler & Steinhurst, 1995); and fourth, using real data increases students' interest and motivation towards the subject (Garfield, 1995; Sciutto, 1995).

In our formative assessment system, feedback sessions were held the day after the practical session. During the feedback session the practical exercises that had been performed the previous day were corrected by the teacher and the main results and most frequently committed errors (detected by the teacher when correcting students' assignments) were drawn attention to. The ultimate aim of these sessions was that students gained information about their understanding of the course content in order to improve their knowledge and skills and increase their self-confidence in the subject. The correct solutions to the work carried out in the practical classes were also made available to students via the course website.

During the 2012-2013 academic year the formative assessment system was implemented in the *Research Design* course with the general aim of improving students' academic achievement and the specific aim of minimizing the negative impact of math anxiety on their academic performance. The related study goal was to examine whether this system, consisting mainly in giving students feedback on their errors and correcting their misconceptions about statistics, would help them become more confident in relation to learning this subject and, thus, lead to improved grades. We expected that this system would be especially useful for high math-anxious students, who are particularly affected when facing a test situation. It is generally agreed that the lower grades achieved by high math-anxious students on mathematics exams are not merely a reflection of their math knowledge but also of their anxiety (Maloney, Schaeffer, & Beilock, 2013). In research conducted during the 2010-2011 academic year we found that students who did not pass the *Research Designs* course showed a higher level of math anxiety, specifically of math

test and math course anxiety (Núñez-Peña et al., 2013b). In addition, a stepwise multiple regression analysis testing the relationships between math anxiety, math attitudes, and grades yielded an interesting finding, namely that students' final exam grades were best explained by the Math Course Anxiety factor.

In order to assess whether the formative assessment system was able to reduce the negative impact of math anxiety on students' performance (i.e., on their course grades), we first compared the correlations between math anxiety scores and final exam grades that were obtained during the 2012-2013 course with those obtained during the 2010-2011 course (published in Núñez-Peña et al., 2013b). We expected to observe a considerable reduction in the strength of the correlations between math anxiety and students' achievement in the 2012-2013 course. We then used a stepwise multiple regression model to test relationships between math anxiety, math attitudes, the perceived usefulness of feedback sessions, and final grades, and compared these relationships with those observed during the 2010-2011 academic year. We expected to considerably reduce the regression coefficient for the Math Course Anxiety factor in the model for 2012-13, which would suggest that the feedback system implemented during that academic year was useful for minimizing the negative impact of math anxiety on students' grades in the *Research Design* course.

## **2. METHODS**

### **2.1. Participants**

The study sample comprised 166 students who were enrolled during the 2012-2013 academic year in the *Research Design* course that forms part of the degree in psychology offered by the University of Barcelona. One hundred twenty-one were female (72.89%) and 45 were male (27.10%). In terms of age, 42.77% of participants were aged between

18 and 20 years old, 45.18% were between 21 and 25, 7.83% between 26 and 30, and 4.21% were older than 30. All the students gave written informed consent before participating in the study.

## **2.2. Materials**

The *Research Design* course was assessed by means of a final exam, practical classes and *guided practical cases*. We also collected data about students' level of math anxiety, their attitudes towards this discipline, and about their perceptions regarding the usefulness of the different types of classes included in the course. These data were gathered using the following measures:

**2.2.1. Final exam (60% of the final grade):** At the end of the course, students sat an individual exam in which they gave open answers to both theoretical and practical questions.

**2.2.2. Practical classes (10% of the final grade):** There were two types of practical classes:

- 1. Problem-solving classes:** In these classes students worked with practical cases based on real published research in different areas of psychology. Working in small groups they gave open answers to questions regarding methodological aspects of this research, such as the kind of design used, or the choice of dependent and independent variables, etc. Their answers to these questions were given to the teacher at the end of the class.

- 2. Computer-based practical classes:** The main objective of these classes was to familiarize students with one of the software packages most widely used in psychology, SPSS. These sessions began with an explanation of the procedure

for analyzing data with this program, with special emphasis being placed on the interpretation of results. Some of the data used by the teacher corresponded to the cases previously studied in the problem-solving classes, so students knew the basics of their methodological aspects. In the second half of these classes the students were presented with a new practical case and were asked to perform, in small groups, a statistical analysis and to answer some questions about methodological characteristics, the results obtained from the analysis, and the interpretation of these results, with their answers being handed in at the end of the class.

**2.2.3. Guided practical cases (30% of the final grade):** These cases presented real research published in different areas of psychology. Each of the 22 different cases (Núñez-Peña & Bono, 2012; Núñez-Peña, Bono, & Suárez-Pellicioni, 2013a) included a database, which could be either simulated, such that students could reproduce the results of the original study, or real, in the event that the proposed practical case was based on research carried out by one of the course tutors. Students were asked to work in small groups (outside of class time) in order to answer a series of questions about the statistical analysis and methodological aspects of this research, and then to submit their answers at the end of the course. The objective of this extensive practical case work was to familiarize students with the content and structure of scientific papers and to teach them how to obtain information from a real database. Based on previous evidence we expected that working with real articles and with databases would increase students' interest and motivation towards the subject (Garfield, 1995).

**2.2.4. Abbreviated Math Anxiety Rating Scale (sMARS; Alexander & Martray, 1989).** The sMARS is a 25-item version of the Math Anxiety Rating Scale

(MARS; Richardson & Suinn, 1972) and measures the construct by presenting 25 situations which may cause mathematical anxiety. The respondent indicates the level of anxiety that he or she associates with each item, using a five-point Likert scale from 1 (no anxiety) to 5 (high anxiety). The sum of the item scores provides the total score for the instrument (minimum 25 and maximum 125). This scale has been shown to have a three-factor structure: 1) Math Test Anxiety (MTA), which includes 15 items reflecting apprehension about taking a test in mathematics or about receiving the results of mathematics tests (e.g., thinking about an upcoming math test one week before); 2) Numerical Task Anxiety (NTA), which includes five items reflecting anxiety about executing numerical operations (e.g., being given a set of division problems to solve); and 3) Math Course Anxiety (MCA), which includes five items reflecting anxiety about taking a mathematics course (e.g., watching a teacher work on an algebraic equation on the blackboard). The present study used the recently validated and adapted Spanish version of the sMARS (Núñez-Peña, Suárez-Pellicioni, Guilera, & Mercadé-Carranza, 2013c). Scores on this Spanish version have been shown to present strong internal consistency (Cronbach's  $\alpha = .94$ ) and high 7-week test-retest reliability (.72) (Núñez-Peña et al., 2013c).

**2.2.5. Math attitudes questions:** This questionnaire included three questions about enjoyment (*How much do you enjoy mathematics?*), motivation (*How much motivation do you have towards mathematics?*), and self-confidence (*How self-confident are you with regard to mathematics?*) in math. Each question was responded to on a five-point Likert scale ranging from 1 (*not at all / none at all*) to 5 (*very much / very*).

**2.2.6. Questionnaire about class attendance and the perceived usefulness of the different classes:** This questionnaire aimed to assess students' perceptions regarding

the usefulness of the different types of classes included in the course and, especially, of the formative assessment system. The questionnaire began with two demographic questions, asking participants to indicate their age range and gender. This was followed by three questions regarding participants' assistance at the three types of classes: theory, practical, and feedback classes. Answers to these questions were given on a four-point Likert scale: (1) *Never*, (2) *Sometimes*, (3) *Regularly*, and (4) *Always*. Finally, the questionnaire asked about the perceived usefulness of these classes, with ratings being given on a five-point Likert scale: (1) *Not at all useful*, (2) *Not very useful*, (3) *Neutral*, (4) *Somewhat useful*, and (5) *Very useful*.

### **2.3. Procedure**

The formative assessment system was implemented in the 2012-2013 academic year in five of the nine groups that were following the *Research Design* course. The system involved giving feedback about the assignments that students performed during practical classes (problem solving and computer-based practical classes). More specifically, in the feedback classes the teacher provided solutions to the questions that students had been working on in the previous practical class, highlighting and clarifying the most frequent errors. Shortly after the end of the feedback class these solutions were also posted on the course website for further consultation by students, if required.

In the guided practical cases, formative assessment consisted of students having several personalized tutorials with the teacher in order to track their work and to assess, on a periodic basis, the progress they were making in their extensive case work, thereby enabling possible errors or misunderstandings to be detected as early as possible.

At the beginning of the *Research Design* course we collected data about students' level of math anxiety and attitudes towards math, while after implementation of the

formative assessment system we gathered information about students' attendance at the three types of classes and their perceptions regarding the usefulness of the different classes included in the course (theory, practical, and feedback classes). These data were collected in normal classroom settings as part of a voluntary activity devised for the course classes. Trained researchers administered the questionnaires, supervised their completion, and provided appropriate support when required, with special care being taken to avoid coercion or other bias in data collection. Data were double-entered by two research assistants, and discrepancies were resolved by comparison with the original data.

### **3. DATA ANALYSIS**

Data analysis was conducted using SPSS v22 and involved:

- Analysis of the questionnaire in order to document the students' attendance at the three types of classes (theory, practical, and feedback) and their opinions about their usefulness.
- Analysis of the relationship between students' attendance at the three types of classes and the different grades they obtained in the course (i.e., final exam, practical classes, and guided practical cases).
- Analysis of the relationship between students' level of math anxiety, their attitudes toward mathematics, and the different grades they obtained in the course.
- Regression analysis of the relationship between final exam grade, math anxiety, attitudes toward mathematics, and the perceived usefulness of feedback classes.

### **4. RESULTS**

Table 1 shows the students' rates of attendance at the theory, practical, and feedback classes. It can be seen that attendance at practical classes was considerably higher than in

the case of both theory and feedback classes, although around 50% of students always attended the latter two types of class. As regards the perceived usefulness of the three types of class, the students considered that all of them were fairly useful in terms of helping them understand the subject (Table 2). Specifically, for each kind of class over 70% of students stated that attending them was somewhat useful or very useful.

Table 3 shows the correlations between students' course grades and their frequency of attendance at the different classes. Attendance at theory classes and attendance at feedback classes were both positively correlated with all four grades, that is, final exam, practical classes, guided practical cases, and overall final grade ( $p < .01$ ). The pattern of correlations was slightly different for practical classes, the attendance at which was significantly associated with grades for practical classes, guided practical cases, and the overall course grade ( $p < .01$ ), but not with the final exam grade.

The analysis of correlations between course grades, math anxiety (different sMARS subscales), and attitudes towards mathematics revealed that none of them were statistically significant (Table 4). This contrasts with the results obtained for the 2010-2011 academic year (Núñez-Peña et al., 2013b), where a negative correlation was observed between exam grade and math anxiety, as measured by both the sMARS total score and the score on the MCA subscale ( $r = -.237, p < .01$ , and  $r = -.341, p < .01$  for total score and MCA score, respectively); these results indicate that in 2010-11 high scores on math anxiety were associated with lower exam grades. Fisher's Z test (Steiger, 1980) was then used to assess the difference between the correlations obtained in the 2010-2011 academic year and those obtained in the present study. This analysis showed that the former were significantly larger than the latter:  $Z = -2.769, p = .005$  for the correlations between sMARS scores and final exam grades, and  $Z = -2.670, p = .007$  for the correlations between MCA scores and final exam grades.

Finally, we applied stepwise multiple regression analysis to determine which variables explained exam grade (EG). The regression model used was the same as that described in the study by Núñez-Peña et al. (2013b) concerning the 2010-2011 academic year, except that here we added a new variable: perceived usefulness of feedback classes. The results of the previous study by Núñez-Peña et al. (2013b) showed a negative relationship between EG and MCA ( $b_3 = -.803, p < .01$ ), in other words, students with higher levels of MCA had lower exam grades.

Equation (1) analyzes the model that includes math anxiety (MTA, NTA, and MCA), attitudes towards mathematics, enjoyment (ENJOY), self-confidence (SCONF), motivation (MOTIV), and perceived usefulness of feedback (FB):

$$EG = b_0 + b_1MTA + b_2NTA + b_3MCA + b_4ENJOY + b_5SCONF + b_6MOTIV + b_7FB + e \quad (1)$$

where  $e$  is the error term,  $b_0$  is the constant, and  $b_i$  are the unstandardized estimated coefficients in the regression analysis for each of the explanatory variables defined previously. Unstandardized estimated coefficients represent the predicted change in exam grade for a one-unit change in the explanatory variable when all other explanatory variables are held constant.

The estimated coefficients and their associated  $t$ -statistics using equation (1) are shown in Table 5. The results reveal a positive relationship between EG and FB: students who consider feedback classes to be useful have higher exam grades ( $b_7 = 0.644, p < .01$ ).

## 5. DISCUSSION

The aim of this study was to develop, implement, and evaluate a new formative assessment system in the context of a *Research Design* course forming part of the degree

in psychology offered by the University of Barcelona. This system consisted of a series of assignments that students undertook during the course, in relation to which they received feedback about their errors in specific feedback classes. The aim of this process was to improve their learning and increase their self-confidence in the subject. We expected this system to be useful for all students, and especially for those with a high level of math anxiety, who we had previously identified as being those who found it more difficult to pass this course (Núñez-Peña et al., 2013b). These high math-anxious students from the 2010-2011 academic year may have failed to demonstrate their skills because the traditional evaluation system would have generated the inherent tension they experience when faced with an exam or assessment situation. By contrast, we expected that formative assessment would be able to reduce this kind of tension, allowing students to show the real skills they had gained during the course.

As for the relationship between attendance at classes and students' achievement, our results showed that attendance at lectures and at feedback classes was positively correlated with all four grades considered (final exam, practical classes, guided practical cases, and final course grade). This suggests that attendance at these classes increased the acquisition of both practical skills and theoretical knowledge. Interestingly, attendance at practical classes only showed a positive correlation with students' grades in practical classes and guided practical cases (as well as their final course grade). This result suggests that attendance at practical classes has a positive effect on the acquisition of practical skills but no direct impact on theoretical knowledge.

Regarding the relationship between students' achievement on the course and their level of math anxiety and attitudes toward mathematics, the analysis showed that none of these correlations reached statistical significance. This result contrasts with the data we obtained in the 2010-2011 academic year (Núñez-Peña et al., 2013b), prior to

implementation of the formative assessment system, when high levels of math anxiety and negative attitudes towards mathematics were found to be related to low marks in the final exam. That result suggested that high math-anxious students in the 2010-2011 academic year may have experienced intrusive thoughts during their final exam, and that this prevented them from demonstrating the real knowledge they had gained over the course. This explanation is consistent with the proposal of Ashcraft and colleagues (e.g., Ashcraft & Kirk, 2001; Ashcraft, Kirk, & Hopko, 1998; Ashcraft & Krause, 2007) regarding why math anxiety affects math performance. According to these authors, math anxiety consumes working memory resources because it produces intrusive negative thoughts and, as a consequence, reduces the resources necessary to solve complex math problems (see also the theory of Eysenck, 1997, and Eysenck & Calvo, 1992). In addition, Faust, Ashcraft, and Fleck (1996) demonstrated that the performance of low math-anxious and high math-anxious individuals did not differ at all when they performed an untimed math test, which suggests that freeing high math-anxious students from the tension of doing a math test against the clock was enough to suppress the effect of math anxiety on performance.

The present study also applied stepwise multiple regression to test the relationships between math anxiety, attitudes to mathematics, the perceived usefulness of feedback classes, and the final exam grade. This analysis showed that the final exam grade was only predicted by the perceived usefulness of feedback classes, suggesting that this was the most important factor among those studied here when it came to predicting students' achievement. It is worth noting that in our previous study, involving students from the 2010-2011 academic year (Núñez-Peña et al., 2013b), the Math Course Anxiety factor was the only variable associated with the final exam grade, suggesting that math course anxiety had a clear impact on students' achievement. The results of the present study

suggest that giving students feedback on their performance during the course could have reduced the impact of math course anxiety on final exam grades.

The fact that in the 2012-2013 course none of the correlations between students' grades and math anxiety and attitudes towards mathematics were significant, and that in the regression model only the perceived usefulness of feedback was associated with the final exam grade, suggests that the new formative assessment system may have helped students with high math anxiety to gain confidence in their ability to learn the subject, thereby reducing the negative impact of math anxiety on their performance. Math anxiety is usually related to lower expected grades, greater pre-exam anxiety, and lower ratings of preparedness in math courses (Hunsley, 1987), so gaining self-confidence in the subject of *Research Design* could have helped students to free their working memory from intrusive thinking and worries about their performance during the final exam. It should be noted, however, that our results do not enable causal relationships to be identified, and nor can we confirm definitively that formative assessment was responsible for reducing the effect of math anxiety on students' achievement. Only an experimental design with random groups (i.e., an experimental group receiving formative assessment and a control group) would have allowed us to establish such a causal relationship, although this is obviously difficult to put into practice in educational settings.

Although the present study suggests that formative assessment could be a useful educational practice for improving students' learning in general and for helping high math-anxious students to show their real knowledge in a course with high mathematical content, much research remains to be done. It would be of interest to explore whether students low and high in math anxiety differ in their expectancies about receiving a negative feedback on math-related courses, as well as the kind of worrying and negative thinking behind them. Moreover, in the present study, feedback was given to students in

whole-group sessions and solutions to practices were also available to student on the web, but other types of formative assessment strategies are often used by educators. For example, teacher's feedback can be personal by returning to students their marked work and, also, by commenting it face-to-face. The main advantage of this type of feedback is that it is individual and directly related to the particular piece of work. However, it has as a clear disadvantage that it is time-consuming and difficult to carry out when class sizes are large. Other type of formative assessment feedback is the use of rubrics (Andrade, Du, & Wang, 2008; Cohen, Lotan, Abram, Scarloos & Schultz, 2002). Although rubrics are usually used for evaluation, handing out rubrics to students prior to the submission of an assignment is associated with improvements in students' learning and achievement. More research comparing the usefulness of different formative assessment strategies as a way of suppressing the negative effects of math anxiety on students' performance in higher education is needed.

## **6. SUMMARY**

In conclusion, the results of this study show that the formative assessment system based on giving students feedback about their errors in whole-group sessions, a system that was implemented during the 2012-2013 academic year in the context of a *Research Design* course, not only favored our students' learning in general but may, more specifically, have reduced the impact of math anxiety on the performance of high math-anxious students.

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Table 1. Rates (%) of attendance at the three types of classes.

	Never	Sometimes	Regularly	Always
Theory classes	.61	12.05	34.34	53.00
Practical classes	.60	1.20	16.27	81.93
Feedback classes	6.63	17.47	30.72	45.18

Table 2. Ratings (%) for perceived usefulness of the three types of classes.

	Not at all	Not very useful	Neutral	Somewhat useful	Very useful
Theory classes	3	6	19	35	37
Practical classes	0	0	14	34	52
Feedback classes	0	8	15	41	36

Table 3. Correlations between course grades and frequency of attendance at the different types of classes.

	Theory Attendance	Practical Attendance	Feedback Attendance
Exam grade	.381**	.149	.365**
Practical classes grade	.356**	.589**	.343**
Guided practical cases grade	.358**	.306**	.243**
Final grade	.477**	.313**	.404**

\*\*  $p < .01$

Table 4. Correlations between the different grades and math anxiety, the three math anxiety factors, and attitudes towards mathematics.

Grade	sMARS	MTA	NTA	MCA	Enjoy ment	Self- Confidence	Motivation
Exam	.054	.054	.020	-.070	.037	.014	.087
Practice	.185	.205	.096	.015	.010	-.019	-.001
Guided practice	-.064	-.033	-.026	-.195	.178	.122	.194
Final	.044	.059	.020	-.109	.056	.064	.142

*Note.* sMARS: Shortened Math Anxiety Rating Scale; MTA: Math Test Anxiety factor from the sMARS; NTA: Numerical Task Anxiety factor from the sMARS; MCA: Math Course Anxiety factor from the sMARS.

\*  $p < .05$       \*\*  $p < .01$

Table 5. Stepwise multiple regression results using equation 1.

Predictors	Estimated coefficient	<i>t</i> -ratio
Constant	1.316	1.948
MTA	-0.155	-1.303
NTA	-0.094	-0.808
MCA	-0.212	-1.860
ENJOY	0.176	1.548
SCONF	0.118	1.031
MOTIV	0.097	0.846
FB	0.644	3.317**

*Note.* MTA: Math Test Anxiety factor from the sMARS; NTA: Numerical Task Anxiety factor from the sMARS; MCA: Math Course Anxiety factor from the sMARS; ENJOY: Enjoyment; SCONF: Self-confidence; MOTIV: Motivation; FB: Feedback perceived utility.

\*\*  $p < .01$