Рыкова Л.Л. Дидактические условия использования учебных моделей в преподавании естественно-математических дисциплин.

В статье затронута проблема повышения качества естественно-математического образования. Сформулированы и обоснованы дидактические условия использования учебных моделей в процессе преподавания естественных и математических дисциплин.

Ключевые слова: учебная модель, структурные и функциональные модели, эволюционные цепочки моделей, модели-аналоги.

Rykova L. Didactic conditions of use of educational models in the teaching of natural and mathematical sciences.

The article touches upon the problem of improving the quality of science and math education. Formulated and justified the use of didactic conditions of training models in the teaching of natural sciences and mathematical disciplines.

Keywords: training model, structural and functional model, the evolutionary chain models, model-analogues.

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ON THE RELATIVE EFFECTIVENESS
OF HYBRID AND FACE-TO- FACE TEACHING

У статті представлено один з етапів виконання досліджень у рамках спільного україно-американського проекту по вивченню специфіки розвитку інтелектуальних умінь та творчого мислення учнів та студентів. Порівнювалася ефективність традиційного навчання та так званого «гібридного навчання», що передбачало поєднувати традиційне навчання та навчання он-лайн з метою компенсації зменшення так званих «контактних годин». В експерименті брали участь студенти бізнес-колледжу університету. У процесі експерименту оцінювались рівні навченості груп студентів старших курсів, що вивчають один і той самий розділ математичного курсу під керівництвом одного і того ж самого викладача. Студенти, що навчалися за так званою «гібридною формою», мали можливість одержувати он-лайн допомогу. Участь у експерименті взяли студенти, що навчалися у групі традиційного навчання (зустрічалися на заняттях з предмету двічі на тиждень по 75 хвилин), та студенти, з якими відбувалося «гібридне навчання» (зустрічалися на заняттях з предмету один раз на тиждень по 75 хвилин). Потім студенти виконували однакові завдання. У статті детально описано методику проведення експерименту, його результати.

Ключові слова: навчання математики; гібридне навчання; навчання face-to-face.

Introduction. National surveys reflect the increased availability and usage in U.S. higher education over the past two decades of degree-credit courses offered partially or wholly online (Allen and Seaman, 2014; U.S. Department of Education, 2014). For purposes

of this paper, a face-to-face (F2F) course (or a course under F2F delivery) is regarded as a course with the same total time spent in class meetings as a traditional course yielding the same number of credit hours would have; and a hybrid course (or a course under hybrid delivery) is regarded as one with anywhere from one-third to two-thirds the total time spent in class meetings as a traditional course yielding the same number of credit hours would have, and with online work assigned to compensate for the reduced in-class time. This paper highlights several studies assessing the relative levels of student learning under hybrid and F2F delivery of the same undergraduate business college-credit course taught by the same instructor at the same institution and offers a new study to complement that literature.

Review of prior studies. This review focuses on prior studies that compared student learning in an undergraduate business course taught by the same instructor at the same institution under face-to-face (F2F) and hybrid delivery. The studies were identified primarily through searches (using search terms of hybrid or blended, and traditional or face-to-face or F2F) of the ABI/Inform Complete, ERIC, and the Directory of Open Access Journals (DOAJ) databases.

[Studies from 2013 paper: Dana (2013), Dowling et al (2003), Keller et al (2009), Priluck (2004)]

[2013 paper: Verhoeven and Rudchenko (2013)]

Principles of Microeconomics. Joyce et al (2014) conducted a study in which each of two professors taught one hybrid section (with one in-class meeting per week) and one F2F section (with two in-class meetings per week) of Principles of Microeconomics, and in which for each pair of sections originally scheduled for the same two days of the week random assignment of students to either hybrid or F2F delivery was employed. (96% of the originally enrolled students in the four sections agreed to participate; the sample sizes and results below pertain to those students.) In addition to the same textbook, the same pedagogy was employed by both professors for the hybrid and F2F students: in-class lectures were based on PowerPoint slides (both profs used the same totality of slides) that were also available online; weekly pre-lecture and post-lecture online quizzes (comprising 20% of the course grade) were required; questions about quiz or practice exam questions were addressed in class (and the practice exam questions, with solutions, were posted online); and for each chapter a few short videos recorded by one of the profs and providing "annotated answers to 10 multiple choice questions" were posted online. Given half the in-class meeting time for the hybrid than the F2F students, the hybrid students received less thorough discussions of the PowerPoint slides underlying the lectures as well less as less time going over quiz and practice exam questions than did the F2F students.

Professor A taught in a smaller classroom than Professor B and had 97 students in the hybrid section and 98 in the F2F section, whereas Professor B taught in a large lecture hall with 269 students in the hybrid section and 261 in the F2F section. The same midterm and final exam, respectively comprising 30 and 40 multiple-choice questions, and respectively representing 35% and 45% of the course grade, were used in all sections. Attrition rates—the percentage of students who officially withdrew or failed to complete the course—were reported to be 10% across each of the hybrid and F2F students. Based on a regression analysis controlling for several variables including professor (acknowledged to be confounded with classroom size), a GPA measure, age, gender, and ethnicity, the hybrid students, on average, had a significantly and estimated 2% lower total score on the midterm and final than the F2F students, and the *ceteris paribus* effect on the total score of having been "taught by Professor A and in the smaller classroom" was an estimated positive .

Introduction to Information Systems. Burns et al (2013) assessed the impact of course delivery method (online versus hybrid versus F2F) of an Introduction to Information Systems course on the likelihood of receiving an exceptional (A), acceptable (B), or

unacceptable (C, D, or F) course grade. The subjects were the 109 F2F, 155 online, and 129 hybrid students collectively taught by the same instructor over four semesters. The F2F students met in class twice weekly; the hybrid students had 10 in-class meetings and were "responsible for independent work supported by instructor-developed resources available to all students in all sections" (p 456) for weeks without in-class meetings; and the online students had no in-class meetings.

All students were responsible for the same assignments and had access to recorded lectures and exam reviews. The F2F and online students had the option to receive assistance from the instructor during "several independent workdays…before final project due dates); the hybrid students had optional weekly support labs "staffed by the instructor, graduate assistants, and peer tutors" (p. 456). Four exams (all but one multiple-choice) were proctored in class for the F2F and hybrid students, but not proctored for the online students (though with the same time limitation as the F2F and hybrid students). Controlling for student GPA, age, gender, proximity to campus, class standing, and Pell Grant eligibility in an ordered probit model, the authors found that the likelihood of receiving a better grade was higher under F2F than either hybrid and online delivery, and that GPA was the most significant factor impacting (its impact was positive) the course grade regardless of delivery method.

Introduction to Management Information Systems. Larson and Sung (2009) compared each of the grades on three exams and the numerical course grade of students in sections of an Introduction to Management Information Systems course taught by the same instructor under online (one section with 0 in-class meetings, and exams proctored at locations convenient to the students), hybrid (multiple sections, each with 11 weekly in-class meetings, 3 devoted to exams), or F2F (multiple sections, each with 16 weekly in-class meetings, 3 devoted to exams) delivery. For each weekly in-class meeting of the 63 F2F students, Larson delivered a lecture and raised discussion questions for class discussion. For each weekly online session, the 22 online students were expected to read lecture notes from the textbook publisher and were required to submit a detailed answer to one of a few discussion questions as well as respond to one other student's answer to the question. The 83 hybrid students' in-class meetings and online sessions mirrored those of the F2F and online students, respectively, except that whereas the online students were required to purchase the lecture notes, the hybrid and F2F students were not. The students in all three sections were as well assigned the same (unspecified) homework.

Each exam comprised true/false and multiple choice questions identical for all students, and essay questions similar across the online, hybrid, and F2F students. Based on one-way ANOVAs, no significant differences between the online, hybrid, and F2F students as to the grades on the three exams (whether including or excluding the essay questions portion) or the numerical course grade were found.

STUDY

Setting. This study was conducted in the business college of a large public university where the majority of students work and commute to campus. All undergraduate business majors are required to take two quantitative methods courses, a lower-division introductory statistics course and an upper-division part statistics and part management science course (henceforth referred to as QM 3000) having the introductory statistics course as a prerequisite. QM 3000 is designed to convey a working knowledge of one-way ANOVA, simple and multiple linear regression, linear programming, forecasting methods, and decision analysis. Though instructing a fully online course at the university is predicated on the course as designed passing a QM Course Review and the instructor completing training on course design and pedagogy, the review and training are optional for instructors of hybrid courses. The instructor in this study elected to have the review and training. Her course design met every standard.

Subjects. The subjects were the 77 students enrolled in one F2F section and 54 students enrolled in two hybrid sections of QM 3000 taught by the same instructor in the same (spring of 2015) term. The instructor had previously taught one section of QM 3000 under hybrid delivery, and several under face-to-face delivery. As indicated in Table 1, the hybrid and face-to-face (F2F) students were of comparable mean age, and — with GPA representing cumulative GPA at the beginning of the course — the mean GPA of the hybrid students was significantly and an estimated .17 grade points lower than that of the F2F students.

Table 1.

Comparison of ages and GPAs of enrolled F2F and Hybrid students

	Hybrid students	F2F students	t statistic	p-value
Number enrolled	77	54		
Mean age (standard deviation)	23.1 (3.3)	22.6 (2.7)	-.87	.39
Mean GPA (standard deviation)	3.08 (.43)	3.25 (.44)	1.66	.035

Description of F2F and Hybrid Course Designs. For each of fifteen weeks, the F2F students met in class for 75 minutes twice weekly and the hybrid students met in class for 75 minutes once weekly. In a typical (non-testing) week, the first class meeting for the F2F students focused on introducing a new topic (e.g., one-way ANOVA, integer linear programming, decision making under uncertainty), and the second focused on associated real-world applications (and, where applicable, the associated use of Excel). For such a typical week, and consistent with what has been termed the "flipped model" of hybrid course delivery, the hybrid students were afforded the introduction to the new topic online and experienced the same class meeting focusing on real-world applications as did the F2F students. The instructor referenced/used the same expositions in PowerPoint or Word documents for both the F2F and hybrid students when introducing new topics or referencing real-world applications or describing usage of applicable (e.g., Solver, Regression) tools, and additionally assigned for online study by hybrid students viewing narrated videos (whether professor-created or available through YouTube). For each of the three testing weeks, practice test questions were discussed in the F2F class and available online (with solutions) for all students.

The F2F and hybrid students shared the identical learning objectives (listed in the syllabus), assigned textbook readings, five quizzes, three tests (on three respective modules, the first on ANOVA and linear regression, the second on linear programming, the third on forecasting and decision analysis), and an optional (in effect, able to replace the lowest test grade) cumulative final exam. Each quiz and test, and the final exam, comprised 20 multiple-choice questions. The five quizzes (each worth 20 points, with the higher of up to two attempts serving as the recorded grade) were non-proctored, evenly spaced throughout the term, and taken online. Each quiz was preceded by an online practice quiz for which solutions were subsequently provided so students could check their work. The tests and final exam (each worth 100 points) were proctored and taken in class. The numerical course grade (which could range from 0 to 100) was the average of the quiz grade total and the three highest of the test and final exam grades.

For both the F2F and hybrid students, the identical course material (including the aforementioned PowerPoint and Word documents and narrated videos) was posted to Deslire2Learn (D2L), the course management system used by the university for all of its courses. The upper-level organization of that material as posted to D2L (see Table 2) was identical for the F2F and hybrid students. The lower-level organization of the material differed between the F2F and hybrid sections in one key respect: for each topic, the material

placed in an In class folder for the F2F students was subdivided into Online and In class folders for the hybrid students so that the hybrid students could readily locate the material supporting their online self-study on that topic. For both the F2F and hybrid students, optional material for students to explore the topic in more depth was placed in an Additional Materials folder.

Table 2.

Upper-level organization of material posted to course management system for all students

Level One Header	Level Two Header
Start Here	Introduction
	Syllabus
Practice Assessments [for]	Quizzes
	Tests
Excel Tutorials	Module 1
	Module 2
	Module 3
Module 1	ANOVA
	Simple Linear Regression
	Multiple Linear Regression [2 weeks]
Module 2 [on linear programming]	Model Formulation and Graphical Solution
	Computer Solution and Sensitivity Analysis
	Integer Programming
	More Modeling Examples
Module 3	Forecasting
	Decision Analysis [2 weeks]

"Today, more than 850 colleges and universities subscribe to Quality Matters." https://www.qualitymatters.org/higher-education-program   accessed 07/13/2015

Null hypotheses tested. Pursuant to assessing the relative effectiveness of hybrid and F2F and course delivery of QM 3000 as designed and executed by the instructor, and with a student classified as having completed the course if he neither officially withdrew nor disappeared from the course, the following null hypotheses were tested at the .05 significance level:

H1: The percentage of enrolled students completing the course is the same under F2F and hybrid delivery.

For students completing the course, and controlling for GPA:

H2: The mean numerical course grade is the same under F2F and hybrid delivery

H3: The mean Test 1 grade is the same under F2F and hybrid delivery

H4: The mean Test 2 grade is the same under F2F and hybrid delivery

H5: The mean Test 3 grade is the same under F2F and hybrid delivery.

Results and Discussion. With 72 of the 77 enrolled hybrid students completing the course, and 51 of the 54 enrolled F2F students doing so, the respective course completion rates of 93.5% and 94.4% were not significantly different (chi-square = .049, p = .825) thus null hypothesis H1 was not rejected. The high and similar course completion rates are attributable largely to providing all students: in-class examples of applications of the modeling techniques addressed by the course; online access to course material explaining, and illustrating through applications, the modeling techniques addressed by the course; periodic practice and graded quizzes to keep the students engaged in learning; practice tests; and instructor availability outside of class in responding to questions via e-mail or in person.

H2 through H5 were tested by regressing (via an ordinary least squares regression) each of numerical course grade, Test 1 grade, Test 2 grade, and Test 3 grade on Hybrid (= 1 if a hybrid student, 0 if a F2F student) and GPA (cumulative GPA at the beginning of the course). As indicated by the regression results summarized in Tables 3 and 4:

H2 was rejected, with the mean numerical course grade an estimated 3.7% lower under hybrid than F2F delivery.

H3 was not rejected.

H4 was rejected, with the mean Test 2 grade an estimated 4.3% lower under hybrid than F2F delivery.

H5 was not rejected.

The lower numerical course grade under hybrid than F2F delivery can be attributed to the significantly and marginally significantly lower performance of the hybrid relative to F2F students on Tests 2 and 3, respectively, Test 2 was on linear programming, which historically—based on the performance of students in the instructor's immediately preceding five F2F sections taught [check to see if this is true]—has been the most difficult of the three modules for students.

Table 3.
Regression results for testing H2 and H3

Dependent variable = numerical course grade			Dependent variable = Test 1 Grade		
	Coefficient (standard error)	t statistic (p-value)		Coefficient (standard error)	t statistic (p-value)
Intercept	54.04 (5.80)	9.31 (.000)	Intercept	47.72 (7.08)	6.74 (.000)
Hybrid	-3.70 (1.61)	-2.29 (.024)	Hybrid	-.26 (1.98)	-.13 (.897)
GPA	10.95 (1.75)	6.25 (.000)	GPA	13.02 (2.13)	6.12 (.000)
F = 25.15 (p = .000); Adj R^2 = .28, n = 123			F = 19.45 (p = .000); Adj R^2 = .24, n = 117		

Note: Numerical course grade (on a 0 to 100 point scale) = average of total of quiz grades and three highest grades on three tests and (optional) final exam; Test 1 grade is on a 0 to 100 point scale; Hybrid = 1 if a hybrid student, 0 if a F2F student; GPA = cumulative GPA at beginning of term

Table 4.
Regression results for testing H4 and H5

Dependent variable = Test 2 grade			Dependent variable = Test 3 grade		
	Coefficient (standard error)	t statistic (p-value)		Coefficient (standard error)	t statistic (p-value)
Intercept	40.62 (7.88)	5.16 (.000)	Intercept	86.44 (6.94)	12.46 (.000)
Hybrid	-4.32 (2.16)	-2.00 (.048)	Hybrid	-3.64 (1.88)	-1.94 (.055)
GPA	13.41 (2.37)	5.65 (.000)	GPA	2.81 (2.09)	1.35 (.181)
F = 20.72 (p = .000); Adj R^2 = .25, n = 120			F = 3.32 (p = .040); Adj R^2 = .04, n = 120		

Note: Each of Test 2 grade and Test 3 grade is on a 0 to 100 point scale; Hybrid = 1 if a hybrid student, 0 if a F2F student; GPA = cumulative GPA at beginning of term

We recommend further research that focuses on the effect on student learning (in specific courses) of the choices of, and student time spent on, active and passive learning activities.

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Рудченко Т., Чашечникова О. Эффективность гибридного обучения и обучения face-to-face.

В статье представлен один из этапов выполнения исследований в рамках общего украино-американского проекта по изучению специфики развития интеллектуальных умений и творческого мышления учеников и студентов. Сравнивалась эффективность традиционного обучения и так называемого «гибридного обучения», предусматривающего совмещение традиционного обучения и обучения он-лайн с целью компенсации уменьшения так называемых «контактных часов». В эксперименте принимали участие студенты бизнес-колледжа университета. В процессе эксперимента оценивались уровни обученности групп студентов старших курсов, которые изучают один и тот же раздел математического курса под руководством одного и того же преподавателя. Студенты, которые обучались по так называемой «гибридной форме», имели возможность получать он-лайн помощь. Участие в эксперименте приняли студенты, обучающиеся традиционно (встречались на занятиях по предмету дважды в неделю по 75 минут), и студенты, обучающиеся по «гибридной форме» (встречались на занятиях по предмету один раз в неделю по 75 минут). Потом студенты выполняли одинаковые задания. В статье детально описана методика проведения эксперимента, его результаты.

Ключевые слова: обучение математике; гибридное обучение; обучение face-to-face.

Rudchenko T., Chashechnikova O. The effectiveness of hybrid learning face-to-face.

The article presents one of the stages of implementation research in the framework of the joint Ukrainian-American project on study the specifics of the development of intellectual skills and creative thinking of pupils and students. The effectiveness of traditional training and the so-called "hybrid learning", which combines the traditional training and online training to compensate the reduction of the so-called "contact hours", is compared. The students of the College of business of the University took part in the experiment. During the experiment the authors evaluated the levels of proficiency of groups of the students, who have studied the same chapter of a math course under the guidance of the same teacher. Students who have studied according the so-called "hybrid form", had the opportunity to get online help. The participants of the experiment were the students who studied in the traditional training group (they met at the classes twice a week for 75 minutes), and students who studied in the way of "hybrid training" (they met at the classes once a week for 75 minutes). Then the students solved the same tasks. The methodology of the experiment and its results is described in the article in details.

Key words: mathematics education; hybrid learning; teaching face-to-face.