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DISCUSSION PAPER SERIES

IZA DP No. 17946

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Stefani Milovanska-Farrington
University of Tampa and IZA

Olivier LaForge
University of Nebraska at Omaha

Jennifer Burton
University of Tampa

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IZA – Institute of Labor Economics

Schaumburg-Lippe-Straße 5–9
53113 Bonn, Germany

Phone: +49-228-3894-0
Email: publications@iza.org

www.iza.org

ABSTRACT

Seeing It in a New Light: Do Cross-Disciplinary Comparisons Make Learning Economic and Financial Concepts Click?

Analogies can simplify complex new material by relating it to ideas students already know. Making cross-disciplinary connections also makes the material more engaging, accessible and memorable. In this study, we perform a controlled empirical test to examine whether providing cross-discipline analogy examples enhances students' learning. We find strong evidence of an increase in students' self-reported understanding of the material and actual performance after exposure to analogies. Students who are less familiar with the concepts prior to the class benefit from the analogy examples the most. About 40% of the students report that examples that cross-reference their major facilitate learning the most, followed by about 25% of the students who find everyday examples the most useful. The findings have implications for the importance of designing a curriculum that prioritizes a cross-disciplinary, holistic approach that allows students to recognize analogies between various fields of study and helps them apply basic principles in various contexts in the future.

JEL Classification: A20, A22, I21

Keywords: analogy, controlled experiment, empirical test, introductory economics, finance, teaching economics, teaching finance

Corresponding author:
Stefani Milovanska-Farrington
Department of Economics, ICB 205
The University of Tampa
401 W. Kennedy Blvd.
Tampa, FL 33606-1490
USA

E-mail: smilovanska@ut.edu

1. Introduction

Different disciplines often share common underlying principles although the language they use to explain them typically differs. By using analogies from various disciplines and everyday life, educators could help students recognize these connections. When students make cross-disciplinary connections, learning becomes more engaging and memorable, fostering a more comprehensive and integrated approach to education. Analogies could simplify complex ideas by relating them to something familiar. By drawing parallels to everyday life or other disciplines, students can connect the new material to knowledge they already possess, making the new content more accessible, more memorable, and more likely to remain in long-term memory, facilitating future recall. Relatable analogies can also grab students' attention and help them stay motivated and focused, which could further enhance learning. Making connections can also help students think more creatively and can make them more able to apply the basic principles in various contexts in and outside the classroom.

With this motivation in mind, the major research question of this study is whether analogies from various disciplines and everyday life improve students' *perceived understanding* of key concepts taught in introductory economics and finance courses. We also briefly explore whether this cross-disciplinary, analogy-based approach improves the *actual learning* in the forementioned courses. Finally, we examine whether *specific examples*, such as those that relate to a student's major or everyday examples, *help students' perceived understanding of the material the most*.

To answer these questions, we first teach four concepts in the "conventional" way as typically taught in introductory economics and finance courses. Then, for each concept, we ask students how well they think they understand the concept and give them one test question related to the concept to gauge their actual understanding of the concept that was taught. Then, we provide analogous examples extracted from other disciplines and everyday life related to the concept. Finally, students complete a second survey similar to the first one. The goal is to determine whether the analogies have improved students' self-perceived understanding of the material.

We created and administered a survey in three sections of a principles of microeconomics course at the University of Tampa, and three sections of a personal finance course at the University of Nebraska Omaha in the Fall of 2024. For each concept included in the experiment, we gave students a QR code to the first part of the survey immediately after introducing the relevant concept, and then, the second part of the survey after providing the analogous examples from various disciplines. We find that a classroom intervention using analogies from multiple disciplines and everyday examples is associated with a statistically significant improvement in students' self-reported understanding of the material.

The rest of the paper is structured as follows. We present the literature relevant to this study in Section 2. A detailed description of the classroom intervention and summary statistics of the collected data are presented in Section 3. The empirical approach is described in Section 4. Results are located in Section 5. Sections 6 and 7 offer a discussion and conclude the analysis.

2. Literature review

Example-based learning is commonly used in the classroom. It involves presenting a concept followed by examples and encouraging students to explore how each of the examples provided illustrates the relevant concept (Dyer et al. 2015; Renkle 2014). While examples are useful, the theory of generative learning

suggests that learners relate new information to knowledge they already possess. They make connections between new (target) concepts and base ones that they already understand (Wittrock 1974). Ratey (2002) claims that the brain tries to relate ideas to one another by looking for similarities, differences and relationships.

Analogies refer to making such comparisons, typically to clarify a new concept or idea. Analogical reasoning between disciplines is a form of higher-order thinking (Richland et al. 2016), and as such, a curriculum that emphasizes it enhances students' creativity and design thinking processes (Choi et al. 2017). Literature has reached a consensus that education should prioritize this higher-level thinking over memorization of facts. For example, in a literature review in the context of mathematics, science and history, Richland et al. (2015) show that students tend to understand the material better when they view concepts as systems of relationships and draw analogies between these systems (Richland et al. 2015). Glynn et al. (1998) show that learning through analogies improves understanding and retention of the material in biology of middle school students. Similarly, Pabuccu et al. (2012) find a positive association between the use of analogies as a learning tool and understanding of chemistry concepts. Orgill et al. (2004) interviewed biochemistry students whose instructors provided analogies in class to learn about students' perception about the usefulness of analogies. Students claim that analogies are helpful, and they use them to recall and visualize material discussed in class. However, they also admit that not all analogies are effective (Orgill et al. 2004). Structuring analogies effectively is a major challenge for educators although using analogous examples is an effective way to support learning even at an early age under six (Vendetti et al. 2015).

Analogies are effective when they are simple, easy to remember and refer to familiar analogous concepts (Orgill et al. 2004). Students have to be well-aware of them, and the students' and instructor's understanding of the relevant comparisons have to be the same (Harrison et al. 1993). Educators have to provide the differences in addition to the similarities between the analogous examples (Richland et al. 2015), indicating explicitly when an analogy could "break down" (Vendetti et al. 2015). Gray et al. (2021) have summarized five principles to maximize the benefits from using analogies in STEM fields: 1) use a well-known base and explain the analogy thoroughly, 2) use not only verbal but also gestural and visual support of the comparisons, 3) align real-world and abstract knowledge, 4) present the comparison in an easy way that minimizes cognitive load, and 5) encourage students to make inferences when they are supposed to know the material (Gray et al. 2021). Students in groups or with the entire class, in addition to instructors, can create analogies (Hutchison et al. 2007). Vendetti et al. (2015) even claim that involving students in the process of making comparisons between the known and new concepts and ideas could enhance the benefit of using analogical reasoning.

Teaching through analogies has been tried in various disciplines including biology (e.g., Mastrilli 1997; Glynn et al. 1998), mathematics (e.g., Richland et al. 2016), languages (Hulshof et al. 2002), STEM disciplines (e.g., Gray et al. 2021), psychology (e.g., Iding 1993), and other fields of study. Burdina et al. (2015) describe practical strategies for using analogies in an economics principles class. However, they point out that future work needs to explore whether the technique improves student learning outcomes (Burdina et al. 2015). Similarly, Franz (2020) provides practical examples of analogies that could be easily incorporated into an economics classroom, but again, acknowledges that the effectiveness of these learning techniques remains to be tested (Franz 2020).

We fill this gap in the literature by exploring whether students' perceived and actual understanding of economic and financial concepts increases between an initial presentation of a concept using discipline-specific language and a subsequent presentation of that same concept using analogous everyday examples and examples from other disciplines. If we find a positive, statistically significant effect of analogical reasoning, this could highlight the importance of policies that support such thinking, including testing that

evaluates these skills, providing the collected assessment data to teachers to help them improve their curriculum, and offering professional development to teachers to ensure that they have the resources to incorporate these skills in their courses (Richland et al. 2016).

3. Data

3.1. Survey and classroom intervention

To collect data for this study, we administered two surveys for each of four major concepts covered in both introductory economics and personal finance courses: trade-offs, expectations, equilibrium, and diminishing returns:

- **Trade-offs and Opportunity Cost**: Trade-offs represent the idea that more of A means less of B. Opportunity cost is the highest-valued alternative that must be given up to obtain something else.
- **Expectations**: Expectations are important in business because people's predictions about what will happen in the future will impact people's financial and economic assessments and perceptions of what is happening today.
- **Equilibrium**: Equilibrium is a situation in finance or economics in which the quantity supplied of a given good, service of financial asset equals its quantity demanded.
- **Law of Diminishing Returns**: The law of diminishing returns is the idea that the additional output (or benefit) associated with each additional unit of a variable input will start to decline at a certain point given that all other inputs remain constant.

The steps we followed to conduct an experiment for each of the aforementioned concepts were the following. First, we taught the concept in the "conventional" way, using the "language" that pertains to the discipline (economics or finance) in which the concept was taught. Next, students were given a QR code to access the first part of the survey (see Appendix 1 for exact questions).

In this survey, we asked students for their name, institutional email address, and course in which they were asked to complete the survey (economics or finance). They were also asked how clear the concept was to them, how familiar they were with the concept before taking the course, and one test question that demonstrated students' actual understanding of the concept.

To determine the level of self-perceived clarity of the concept, students could choose between extremely unclear (0), somewhat unclear, neither clear nor unclear, somewhat clear, or extremely clear (4). This question indicates students' perception of their understanding of the concept whereas the test question reveals the true/actual knowledge of the students. After we had collected the data, we assigned numerical values from 0 to 4 to the answers to this question, where 0 indicates that the concept is extremely unclear and 4 refers to the highest level of perceived understanding (extremely clear). There are four possible responses that indicate students' pre-class familiarity with the concept, varying from never heard (assigned a numerical value of 0) to well-aware (3). The purpose of this question is to examine whether students with or without prior knowledge of the material benefit more from the additional analogies. The analogous examples from other disciplines and everyday life are included in Appendix 2. The beneficial impact of the additional analogies was explored by comparing students' answers on the first and the second surveys.

After students completed the first survey, the professors who taught the classes participating in the study showed the analogous examples from other classes and real life (see Appendix 2) on slides and also

briefly explained them to the students. Professors then distributed the second part of the survey (see Appendix 3 for exact questions) that students could access by a second QR code.

In this part of the survey, we asked students the same questions that were included in the first part, and additionally, we asked them to provide their major (economics, finance, marketing, other business major, medicine, psychology, other, or undecided) and select the example that helped them the most to understand the concept. The test question used to determine students' actual knowledge was similar but not identical to the one asked in the first part of the survey. Participant email addresses were used to match the first survey with the second survey. Answers were compared to test for changes in both perceptual and actual understanding of the financial or economic concept.

3.2. Data

One of the goals of this study is to compare students' perceptions of their understanding and actual knowledge before and after providing analogical examples. Because one response of a given student would not help us accomplish this goal, we drop students who have submitted only one part of the survey for a given concept. The numbers of students (observations) who have completed both surveys for each of the four concepts are the following: trade-offs – 106; expectations – 97; equilibrium – 90; and diminishing returns – 73. The combined dataset consists of 366 observations (732 completed surveys).

Table 1 presents summary statistics based on this combined dataset. The total numbers of two-part surveys administered in economics and finance classes are 229 (62.57%) and 137 (37.43%), respectively. A little less than one third of the respondents have reported a finance major (31.69%), followed by a business major different from economics, finance or marketing (26.23%). Marketing majors (15.30%), other non-business majors (10.38%), economics majors (9.02%), undecided majors (6.56%) and Psychology majors (0.82%) made up the rest of the sample. A little less than 30% of the students have found the economics examples most helpful, followed by everyday examples (25.74%).

Table 1. Tabulation of courses, majors, and reported most helpful examples

	Freq.	Percent
Course in which survey was administered		
Economics	229	62.57
Finance	137	37.43
Major		
Economics	33	9.02
Finance	116	31.69
Marketing	56	15.30
Other non-business major	38	10.38
Other business major	96	26.23
Psychology	3	0.82
Undecided	24	6.56
Most helpful analogy example		
Economics example	108	29.59
Everyday/Other example	94	25.75
Finance example	74	20.27
Marketing example	43	11.78
Medicine example	24	6.58

Psychology example	22	6.03
Total two-part surveys	366	100.00

Summary statistics for each concept are presented in *Table 2*. *Figure 1* visually illustrates the average level of clarity pre- and post-intervention for each concept. *Figure 2* shows the percentage of students who answered the test question (by concept) correctly before and after the intervention. The statistics in *Table 2* and *Figures 1* and *2* reveal that before learning about the concepts in the respective courses, students were least familiar with the concept of diminishing returns (mean = 1.04 out of 3) compared to the other three terms used in the analysis. For all four concepts, students felt that the concept was clearer after they were provided cross-disciplinary analogies. Moreover, for three of the four concepts (all except expectations), a larger proportion of students answered the test question correctly.

Table 2. Summary statistics by concept

	N	mean	sd	min	max
Concept: Trade-offs					
Familiarity with the concept (before class)	106	1.906	.857	0	3
Clarity (pre)	106	2.83	.99	0	4
Clarity (post)	106	3.123	.789	1	4
Correct test question (pre)	106	.33	.473	0	1
Correct test question (post)	106	.717	.453	0	1
Concept: Expectations					
Familiarity with the concept (before class)	97	1.629	.893	0	3
Clarity (pre)	97	2.907	.947	0	4
Clarity (post)	97	3.216	.857	0	4
Correct test question (pre)	97	.866	.342	0	1
Correct test question (post)	97	.856	.353	0	1
Concept: Equilibrium					
Familiarity with the concept (before class)	90	1.922	.824	0	3
Clarity (pre)	90	2.944	.904	1	4
Clarity (post)	90	3.244	.692	1	4
Correct test question (pre)	90	.756	.432	0	1
Correct test question (post)	90	.833	.375	0	1
Concept: Diminishing returns					
Familiarity with the concept (before class)	73	1.041	.949	0	3
Clarity (pre)	73	2.562	1	0	4
Clarity (post)	73	2.986	.79	1	4
Correct test question (pre)	73	.726	.449	0	1
Correct test question (post)	73	.822	.385	0	1

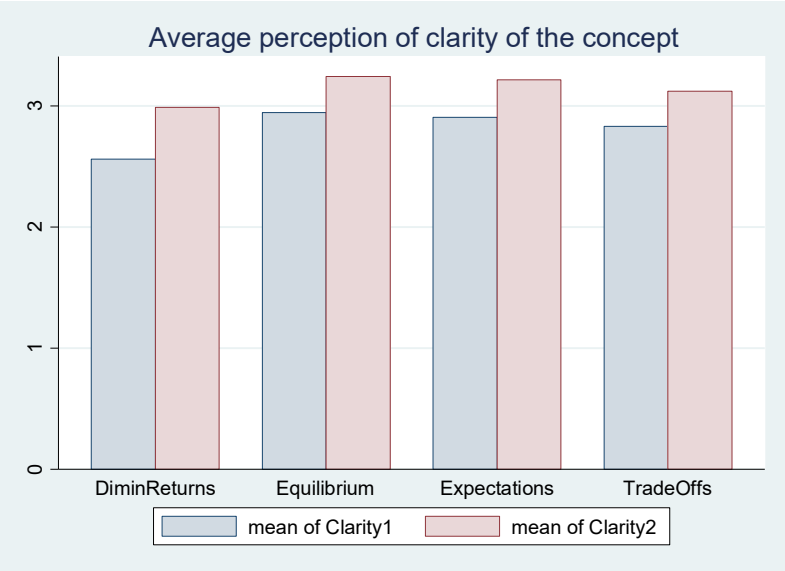

Figure 1. Average perception of clarity of the concepts pre- and post-intervention

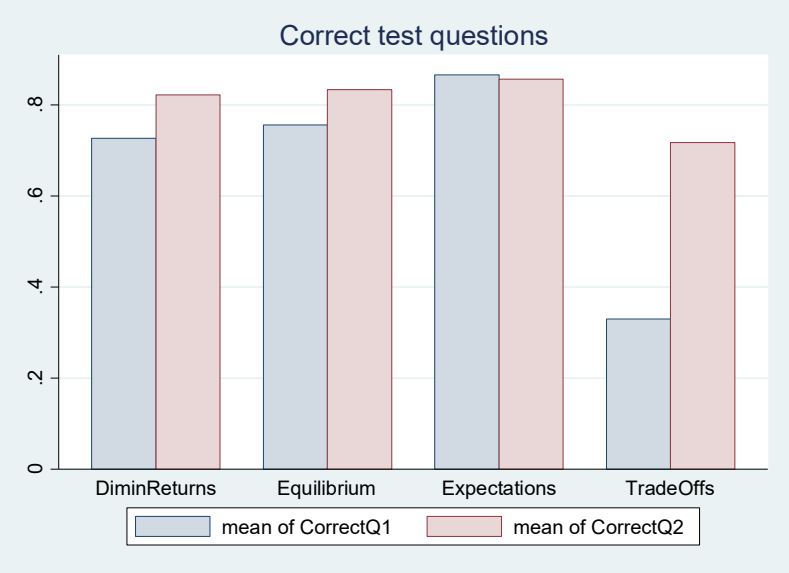

Figure 2. Percent of students who answered the test question correctly pre- and post-intervention, by concept

Then, we distinguish between courses in which the survey was administered. In *Figure 3*, we show the average perception of students' understanding (*Figure 3a*) and the percentages of students who answered the test questions correctly (*Figure 3b*) before and after the intervention. Analogies seem to help students in finance courses more than those in economics classes. Yet, these statistics should be interpreted with caution given that data from economics and finance courses were collected from two different institutions, potentially adding noise to the forementioned findings.

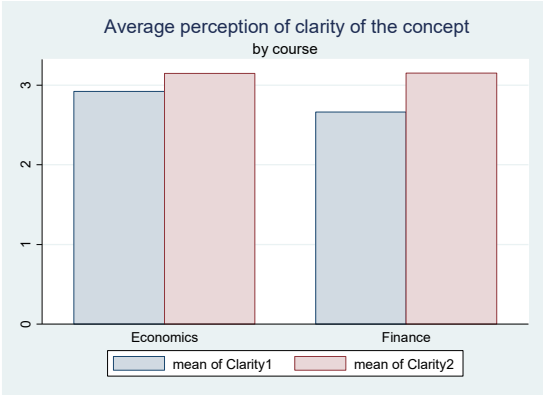

Fig. 3a

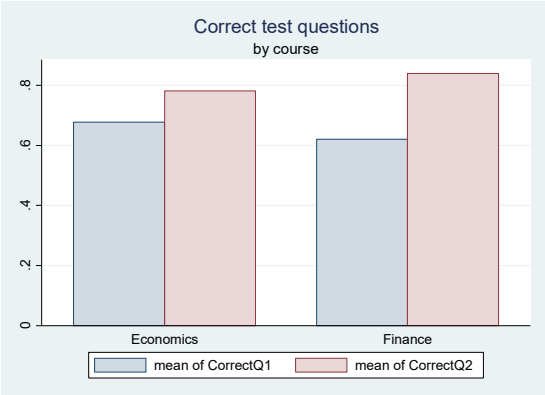

Fig. 3b

Figure 3. Perception of clarity of the concepts (Fig. 3a) and Percent of students who answered the test question correctly (Fig. 3b) pre- and post-intervention, by course in which the survey was administered

4. Method

First, to examine whether students feel that they understand major concepts more after they have been given analogous examples from various disciplines, we perform paired t-tests for dependent samples. Specifically, we run paired t-tests using data collected right after the instructors have taught each concept and data extracted from the responses of the same students after they have been exposed to the additional intervention. This allows us to examine whether the interdisciplinary examples were associated with statistically significant differences in the average perceptions of the students' understanding of the material. The null hypothesis of the test indicates no difference in students' understanding. The t statistic and the p-value for a two-tailed test being used for these tests are calculated through the following formulas:

$$t = \frac{\bar{X} - \bar{Y}}{\sqrt{\frac{\sum D^2 - \frac{\sum D^2}{N}}{N(N-1)}}} \text{ and } p = 2 * \Pr(T > |t|),$$

where $\bar{X}$ and $\bar{Y}$ are the means of the relevant variables (perceived understanding) pre- and post-intervention, D is the difference in the examined variables between each X and Y pair (e.g., pre- and post-intervention result), and N is the number of pairs.

The underlying assumption of the test is that students are independent and their reported perceived understanding of the concepts exhibit a normal distribution. Anderson-Darling Z test formally tests for normality. The null hypothesis is that the differences in the perceived understanding are normally distributed.

If we find a statistically significant difference in students' (perceived) understanding of the concepts, we utilize Cohen's d statistic to measure the effect sizes based on mean comparisons. It shows how many standard deviations higher or lower the average perceived understanding after the intervention is compared to understanding before the intervention.

To examine whether the analogies improve students' actual learning, we compare the percentages of students who have answered the test question for each concept correctly pre- versus post-intervention. Future research could explore actual learning more thoroughly. We provide details in the Results section of this paper.

Then, to examine whether there are groups of students who benefit from the analogous examples the most, we distinguish between students who have reported different prior familiarity with the concepts under investigation. We also perform a subsample analysis by major. Finally, we create an indicator that shows whether each student has found the example from their declared major the most helpful and conduct a subsample analysis to explore whether examples students can relate to help them understand the material the most. We conduct a similar investigation for everyday examples that tend to be relevant to all students regardless of their field of study.

5. Results

Analogies and perceived understanding of concepts

First, we perform a series of paired t-tests to evaluate the effectiveness of multidisciplinary analogies for students' perceived understanding of major concepts. The results, including the average perceived understanding before and after the intervention, and Cohen's d measure of the effect size based on mean comparisons are presented in *Table 3*. They provide evidence of a *statistically significant improvement in the average level of perceived clarity of concepts after compared to before the intervention* ($t = 8.043$, $p < 0.01$). The result is highly statistically significant at any significance level and is consistently confirmed for each of the concepts used in the analysis. Specifically, clarity of concepts improved for trade-offs (difference = 0.292, $p < 0.01$), expectations (difference = 0.309, $p < 0.01$), equilibrium (difference = 0.300, $p < 0.01$) and the law of diminishing returns (difference = 0.425, $p < 0.01$). Furthermore, Cohen's d statistic suggests *"medium" size of the effects*. For all concepts (as well as combined), Cohen's d is above 0.2. The effect is below the threshold of 0.8 needed for "high" impact, but there is strong evidence of medium-sized effect of providing analogies.

Table 3. Average perceived understanding (clarity), paired mean-comparison test results, and effect sizes based on mean comparison

	Mean				
Time period	**All concepts**	**Trade-offs**	**Expectations**	**Equilibrium**	**Diminishing returns**
Pre-intervention	2.825	2.830	2.907	2.944	2.562
Post-intervention	3.150	3.123	3.216	3.244	2.986
Difference	0.325***	0.292***	0.309***	0.300***	0.425***
Cohen's d	0.369	0.327	0.342	0.373	0.471

**** p<.01, ** p<.05, * p<.1*

Analogies and actual learning

As previously noted in the Data section of this article, the percentage of students who answered the assigned test question correctly increased after the analogical examples were offered for three out of the four concepts. The sizes of the improvements varied by concept. More research is needed to obtain more

accurate results. Specifically, we gave students only one test question before and another question after the experiment per concept. This implies that students receive a score of either 0% or 100% on these "mini tests." In future studies, students could be given multiple questions, which would allow for more variation in the test scores. This would enable the researcher to perform a more detailed analysis similar to the one we presented above for perceptions.

Subsample analysis

Next, we examine whether prior exposure to the relevant concepts influences how helpful analogies are to mastering the material. *Figures 4a* and *4b* graphically show the average perceived clarity (*Fig. 4a*) and the percentage of students who answered the test question correctly (*Fig. 4b*) pre- and post-intervention, by pre-course exposure to the concepts. In *Table 4*, we present the pre- and post-intervention mean self-reported clarity of the material, mean comparison test results and effect sizes based on Cohen's d statistic organized by the pre-course familiarity with the concepts students have reported.

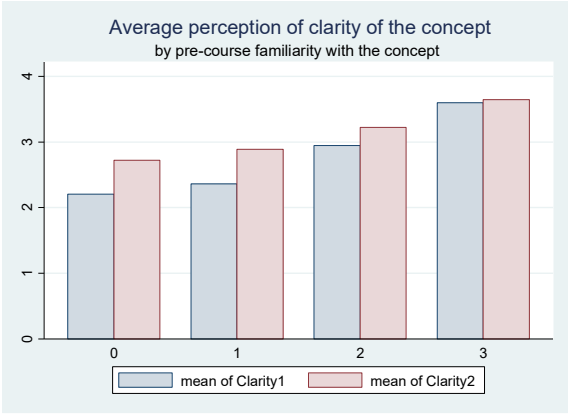

Fig. 4a

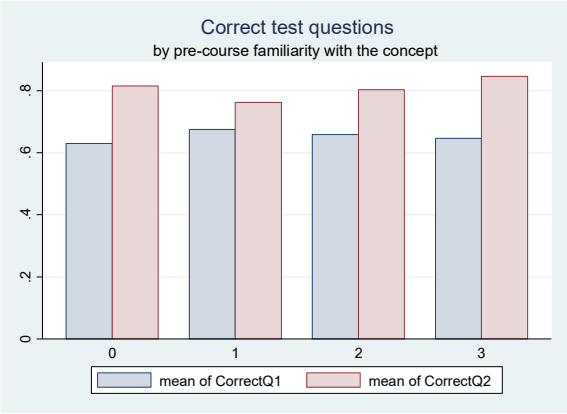

Fig. 4b

Figure 4. Perception of clarity of the concepts (Fig. 4a) and Percent of students who answered the test question correctly (Fig. 4b) pre- and post-intervention, by pre-course familiarity with the concepts

Table 4. Average perceived understanding (clarity), paired mean-comparison test results, and effect sizes based on mean comparison, by pre-course familiarity with the concepts

	Mean (by level of pre-course familiarity)			
Time period	**0 (never heard)**	**1**	**2**	**3 (well-aware)**
Pre-intervention	2.204	2.363	2.946	3.600
Post-intervention	2.722	2.888	3.222	3.646
Difference	0.519***	0.525***	0.275***	0.046
Cohen's d	0.622	0.591	0.375	0.059

**** p<.01, ** p<.05, * p<.1. Note: Level of pre-course familiarity with the concept = 0 corresponds to students' answer "No, I had never heard of it."; 1 refers to "I had heard of it, but did not know what it*

meant."; 2 indicates "I had heard of it, and had some knowledge of what it meant."; and 4 refers to "Yes, I was well-aware of the concept before taking this course."

Figure 4 and *Table 4* indicate that *all students, regardless of their prior exposure to the material benefit from cross-disciplinary examples, that is, analogies improve students' feeling of understanding of the concepts.* The effect is *highly statistically significant for all levels of pre-course familiarity except for students who were well-aware of the concept before class. The effect of providing analogies on students' perceived understanding of the concepts is the largest for students who have only heard the concepts before class but were unaware of the meaning of the concept (Difference = 0.525, p < 0.01). The benefit of analogies to students who have never heard of the concept before class is very similar to that of the aforementioned group (Difference = 0.519, p < 0.01). Figure 4b* also indicates that *there is an increase in the percentage of students who are able to answer test questions correctly after the intervention, regardless of their prior exposure to these concepts.*

In *Figures 5a* and *5b*, we show graphs similar to the ones in *Figures 4a* and *4b*, but distinguish between different majors. The results by major are consistent with the findings we reported previously.

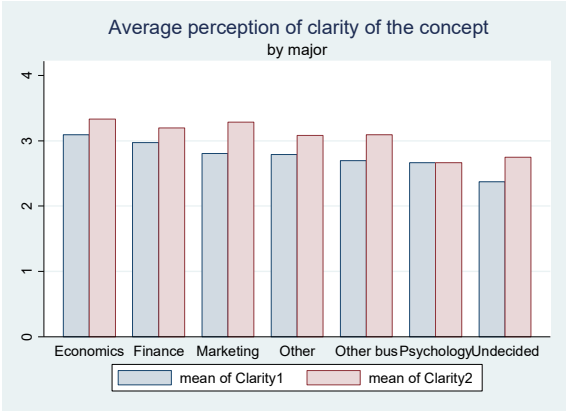

Fig. 5a

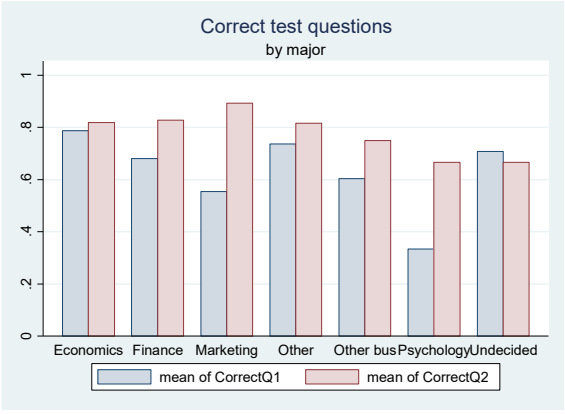

Fig. 5b

Figure 5. Perception of clarity of the concepts (Fig. 5a) and Percent of students who answered the test question correctly (Fig. 5b) pre- and post-intervention, by students' major

Do analogy examples related to students' major help the most?

For this part of the analysis, we generate an indicator (MajorExMostHelpful) which takes a value of 1 if a given student reported that the example that helped them understand the material the most was the one that relates to their major (economics/finance/marketing/psychology). The fore-mentioned indicator equals 0 if the major does not match the most helpful example reported by a given student. We exclude students who have reported an undecided, other business or other major in the survey.

It is worth noting that this is only a preliminary analysis of the effect of different types of analogies on students' understanding of the material. Specifically, we provided students with examples that relate to economics, finance, marketing, psychology, medicine (for some concepts) and everyday examples. A more accurate study could provide analogies from a number of other fields of study. Another

improvement could involve providing different groups of students with different examples rather than giving all students all (and the same) examples. This is an opportunity for future research.

Based on the currently available data, out of the 366 students who have completed both surveys for a given concept, we were able to assign a value to the variable MajorExMostHelpful to 208. From this subsample, 83 observations (39.9%) have found the example related to their area of study the most helpful.

We present the results from this subsample analysis in *Table 5*. These results confirm the findings presented earlier in the paper. *The post- versus pre-intervention difference in perceived understanding is very similar regardless of whether students found the example related to their (Difference = 0.289, p < 0.01) or a different major (Difference = 0.296, p < 0.01) to be the most helpful. The effect sizes for the two subsamples also appear to be very similar.*

Table 5. Average perceived understanding (clarity), paired mean-comparison test results, and effect sizes based on mean comparison: Subsample analysis depending on whether the most helpful example was the major-related one

	Mean		
Time period	**Major example was most helpful**	**MajorExMostHelpful = 0**	**Everyday example was most helpful**
Pre-intervention	2.964	2.928	2.660
Post-intervention	3.253	3.224	3.085
Difference	0.289***	0.296***	0.426***
Cohen's d	0.332	0.353	0.486

**** p<.01, ** p<.05, * p<.1*

How about everyday examples?

A little more than a fourth (25.75%) of the respondents have reported that the everyday examples have helped their understanding the most. *The improvement in the average perceived understanding of the material post- compared to pre-intervention is higher for students who found the everyday example the most beneficial (Difference = 0.426, p < 0.01) compared to the ones who reported that another example was more useful* (see the last column of *Table 5*).

6. Discussion

This study contributes to the literature by showing that analogies are a useful tool to improve students' understanding of economic and financial concepts. Students often find these concepts challenging if they are presented only in a discipline-specific language. The evidence that analogies from other disciplines and everyday life are useful to students supports the need to encourage educators to incorporate analogical reasoning in their classes to help students understand the material better and to facilitate future retrieval of information. The results also justify the implementation of policies that encourage analogous reasoning and evaluation of thinking through analogies. It would also be useful for educators to be enrolled in professional development workshops that train them to construct effective analogies to improve their curriculum and to maximize the benefit to the students.

There are opportunities for future extensions of the current study. First, given that our sample size is small, a larger dataset could improve the accuracy of the findings presented here and could potentially provide additional insights that we are unable to capture with the currently available data. Second, principles of economics courses are typically taken before and are often a prerequisite for personal finance courses. Therefore, students in finance courses are more likely to have had prior exposure to the concepts used in this study. We alleviate this concern by performing a subsample analysis by course in which the survey has been conducted, but further research could be worth it. Finally, another possible extension of this study could involve administering the surveys we used for this study and adding one more survey that could be given to students either a few weeks after covering a given concept, or at the end of the semester. Comparing the results immediately after the intervention to the data collected at a later time period would reveal students' retention of the material.

7. Conclusion

Hutchison et al. (2007) claim that teaching is "effective" if it facilitates future retrieval. This requires incorporating higher-order thinking into the curriculum, rather than simple memorization of facts. Unfortunately, there is a challenge to encourage higher-order thinking, including analogical reasoning, in education (e.g., Richland et al. 2016).

In this research, we provide evidence of the importance of providing analogies. Specifically, we run a controlled empirical test to investigate whether offering students cross-disciplinary and everyday analogous examples of major concepts taught in economics and finance courses could improve students' understanding of the material. We find that providing analogies is associated with a highly statistically significant, medium-sized increase in both students' self-reported and actual understanding of key economic and finance concepts. The result is confirmed for various financial and economic concepts such as trade-offs, expectations, equilibrium and the law of diminishing returns. We also show that all students regardless of their major or prior exposure to the concepts benefit from cross-disciplinary analogous examples. The effect of providing analogies on students' perceived understanding is the largest for students who have heard of the concepts before class but were unaware of their meaning and those who have not heard of the concept before class. The findings also suggest that giving analogical examples is related to a larger proportion of students answering actual test questions related to the concepts taught correctly. About a fourth of the students have reported that everyday analogies are the most helpful, and about 40% of the respondents have indicated that analogies related to their major helped them understand the material the most. These findings provide strong evidence of the power of analogies in helping students grasp complex ideas.

They are a powerful justification for the development of a curriculum that prioritizes connecting disciplines and recognizing the analogies between the material covered in different fields of study. The results also have implications for the importance of educating instructors and encouraging them to invest in professional self-development so that they can be equipped with the knowledge that would allow them to relate ideas in the classes they teach to other disciplines. Our hope is that educators would embrace the power of "speaking the language" of the students and accept the challenge to facilitate students' learning through analogies.

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Appendix 1. Survey questions (Part 1)

Q1: What is your name?

Q2: What is your email address? (Use your University email address & double-check the spelling!)

Q3: Select the course you are enrolled in:

a. Economics
b. Finance
c. Marketing

Q4: How clear is the concept/idea of [insert the concept] to you? [Extremely unclear == 0, Extremely clear == 4]

a. Extremely unclear
b. Somewhat unclear
c. Neither clear nor unclear
d. Somewhat clear
e. Extremely clear

Q5: Were you familiar with this concept/idea before taking this course? [Never heard == 0, Well-aware ==3]

a. No, I had never heard of it.
b. I had heard of it, but did not know what it meant.
c. I had heard of it, and had some knowledge of what it meant.
d. Yes, I was well-aware of the concept before taking this course.

Q6: [One multiple-choice question to check basic understanding of the concept.]

Opportunity cost and trade-offs:

Which of the following statements about a student's opportunity cost of saving for retirement is correct?

a. It would increase if the value of any of the alternative uses of the money for this student increases.
b. It would decrease if the value of any of the alternative uses of the money for this student increases.
c. It would increase if the value of the next best alternative use of the money for this student increases.
d. It would decrease if the value of the worst alternative use of the money for this student increases.

Equilibrium:

If the quantity supplied of celebrities willing to advertise athletic apparel exceeds the quantity demanded for these celebrities, i.e., there are more celebrities than athletic apparel companies are willing to hire, the pay celebrities receive for advertising athletic apparel has to _____ to reach equilibrium.

a. **Decrease.**
b. Increase.
c. Remain the same.
d. It cannot be determined.

Expectations:

Which of the following statements about expectations is correct?

a. What a consumer expects from a brand does not influence how they feel when they consume the product.
b. If a consumer believes that orange juice is better than cranberry juice, then orange juice may still never taste better than cranberry juice for this consumer.
c. Consumers' expectations are not important.
d. **Consumers' expectations about the future price of granola bars could influence their choice whether to buy the product today.**

Diminishing returns:

Which of the following scenarios best exemplifies the concept of diminishing returns?

a. **After a business invests a certain amount of resources in marketing its new product, the additional benefit from further investment begins to decrease.**
b. The opportunity cost of going to college for a student is lower during a recession.
c. A company continues to produce a product that generates losses for the business simply because it has invested a lot of resources in research and development of the good.
d. The average cost of making a pizza decreases the more pizzas a pizzeria makes.

Appendix 2. Analogy examples

- **Trade-offs and opportunity cost**:
    - Economics example: a business (e.g., Apple) has to choose between producing more/less of different goods (e.g., iPhones vs. iPads vs. Mac computers), given fixed amounts of inputs (labor, physical capital, etc.) – e.g., more iPhones would mean fewer iPads; efficiency vs. equity trade-off
    - Finance example: risk vs. return (Historically, it has been shown that investors enjoy higher returns on investments that are riskier (more volatile), while investments that are considered less volatile carry lower returns.); saving vs. spending
    - Marketing example: budgeting (If I am going to increase my social media budget, then I am going to have to lower spending on other forms of marketing such as television or magazine advertising).

    - Medical example: medication/treatment A vs. B; more effective treatment with more potential side effects vs. less effective or no treatment with fewer or no side effects
    - Psychology example: tradeoffs when choosing a house or a spouse; Household budgetary priorities such as vacation versus home improvements
    - Everyday Examples: producing more (quantity) vs. better quality (management); going to a party tonight vs. prepare better for the next exam; go to graduate school vs. look for a job after graduation
- **Expectations matter**:
    - Economics example: if consumers expect that the price of a good will increase in the future, demand increases today; if producers expect that the price of the good they supply will increase in the future, they decrease supply today
    - Finance example: stock prices depend on investors' expectations about companies' earnings in the future
    - Marketing example: customer satisfaction is more of a function of customer's expectations of a product or service rather than their actual utility from using that product or service.
    - Medical example: patients expect that a treatment or prescribed medication would improve their health
    - Psychology example: personal beliefs that may be true or not, psychology of expectations – if you believe that dark chocolate is better than milk chocolate, it will taste better to you, even if a blind test shows the opposite for you
    - Everyday example: expectation from a partner in a relationship
- **Equilibrium**:
    - Economics example: equilibrium in the market for a good or service (e.g., the equilibrium price of cheese is the price at which the quantity that consumers are willing and able to buy equals the quantity that sellers are willing and able to sell); labor market equilibrium (e.g., equilibrium wage of teachers is the wage at which the number of teachers schools are willing and able to hire equals the number of teacher who are willing to work at the equilibrium wage)
    - Finance example: determination of stock prices
    - Marketing example: Supply Chain (the number of products a business should produce for the supply chain equals the number of products consumers are willing to purchase at the selected price point)
    - Medical example: cognitive equilibrium (related to mental health and psychology, the balance between individuals' expectations and the environment); enough medicine if the amount patients need equals the amount supplied by producers at a given price - shortages occur if the amount producers are willing and able to provide is lower than the amount patients are willing and able to buy (price of medicine is too low)
    - Psychology example: balance between new information and existing knowledge (adjust their way of thinking to adapt/fit the environment), e.g., a small child adjusting its understanding of a concept until (s)he learns (a small child may first see an apple on a tree and assume that all fruit grows on a tree; then, when (s)he sees blueberries on a bush, the kids adjusts its understanding, etc. until a balance between understanding and reality is reached)
    - Everyday examples: work – life balance; chemical equilibrium (chemistry)
- **Diminishing returns**:

- Economics example: a restaurant hires cooks – as more cooks are added (to a fixed space, number of ovens, etc.), the additional number of meals each of them makes initially increases (as they specialize and help each other), but after a certain number of cooks are already in the kitchen, adding more results in fewer and fewer extra meals made, e.g., because the kitchen becomes overcrowded, etc. (exemplifies the law of diminishing returns, applied to firms/production); the more scoops of ice-cream you have, the less you enjoy each additional one (diminishing marginal utility, connection to consumers)
- Finance example: diminishing returns of diversification (too much diversification may limit the returns without further reducing risk); after some amount of investment, investing more may result in a decrease in the ROI
- Marketing example: Social media marketing campaigns – after a company invests a certain amount in advertising, the additional gain from investing more decreases, keeping everything else constant (relationship between marketing expenditure and increase in sales)
- Medical example: increasing the amount of medication a patient has may be good to some extent, but then, may hurt the patient
- Psychology example: higher income increases happiness up to some level, but after some income level has been reached, more money adds less and less (or no) additional happiness
- Everyday examples: spending more time working helps us get more done, but after we have worked some amount of time, extra time may not add so extra work completed; some amount of sun is good, but after we have been exposed to some amount of sun, more may lead to burning

Appendix 3. Survey questions (Part 2)

Q1: What is your name?

Q2: What is your University email address? (Use your University email address & double-check the spelling!!)

Q3: Select the course you are enrolled in:

a. Economics
b. Finance
c. Marketing

Q4: How clear is the concept/idea of [insert the concept] to you?

a. Extremely unclear
b. Somewhat unclear
c. Neither clear nor unclear
d. Somewhat clear
e. Extremely clear

Q5: What is your major?

a. Economics
b. Finance
c. Marketing
d. Other business major
e. Medicine
f. Psychology
g. Undecided
h. Other

Q6: If your answer to the previous question was "Other major," please specify your major here. If your answer to the previous question was "Undecided," please write the major you are most likely to choose here. If you selected any of the other answers in the previous question, you can skip this question.

Q7: Which of the examples your professor provided to illustrate the concept/idea specified in Question 4 helped you understand the concept/idea the most?

a. Economics example
b. Finance example
c. Marketing example
d. Medicine example
e. Psychology example
f. Everyday/Other example

Q8: [One multiple-choice question to check basic understanding of the concept.]

Opportunity cost and trade-offs:

Which of the following best identifies a company's opportunity cost of an advertising campaign?

a. The value of the next best alternative use of the company's resources spent on this advertising campaign.
b. The value of the worst alternative use of the company's resources spent on this advertising campaign.
c. The cost of the resources necessary for any alternative advertising campaign.
d. The cost of the time spent on the advertising campaign.

Equilibrium:

If the demand for Starbucks Corp stocks increases, Starbucks Corp's stock price _____ to reach its new equilibrium.

a. Decreases.
b. Increases.
c. Remains the same.
d. It cannot be determined.

Expectations:

Which of the following statements about Nestle's consumers' expectations is correct?

a. Whether investors invest in Nestle does not depend on their expectations about the earnings of the company.
b. If consumers who love Nestle chocolate expect that its price will significantly increase very soon, they will still not change the amount they purchase today.
c. If consumers expect that Nestle always offers high-quality chocolate, they could be disappointed if they do not like a bar of Nestle chocolate.
d. Consumers always have low expectations about the quality of products sold by renowned brands.

Diminishing returns:

Which of the following scenarios best exemplifies the concept of diminishing returns?

a. The price of cheese decreases as more cheese producers enter the market for cheese.
b. A smartphone producer realizes that at the current price of its smartphones, the quantity supplied exceeds the quantity demanded, so it lowers the price to reach equilibrium.
c. A business realizes that after its employees have had a certain amount of training, the additional benefit from more training sessions becomes lower and lower.
d. Investors earn lower returns on less risky investments.