Developments in Economics Education Conference 2023

The effect of a flipped classroom where students work on exercises in groups during class time

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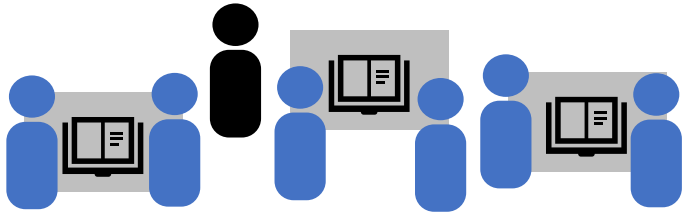
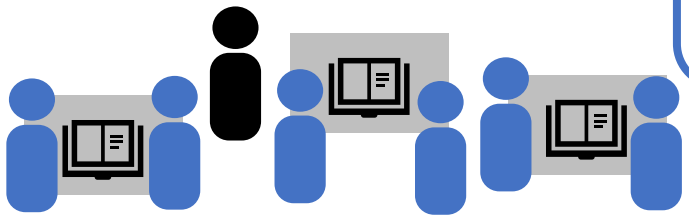
Yasukazu Ichino (email: yasukazuichino@gmail.com),
Toru Kawai and Mai Seki
Ritsumeikan University, Japan

What is a flipped classroom?

	Before class (outside of class time)	During class	After class (outside of class time)
Flipped classroom	Watch video lectures 	Review the lecture, work on exercises, and other activities with classmates 	
Traditional lecture		Have a lecture with classmates 	Review the lecture and work on exercises 

Why is a flipped classroom supposed to be effective?

	Before class (outside of class time)	During class	After class (outside of class time)
Flipped classroom	Watch video lectures **Flexibility** 	Review the lecture, work on exercises, and other activities with classmates 	**Peer teaching** Students can receive real-time feedback from their classmates.
Traditional lecture		Have a lecture with classmates 	Review the lecture and work on exercises 

Students can take **video lectures** at any time they like at their own pace.

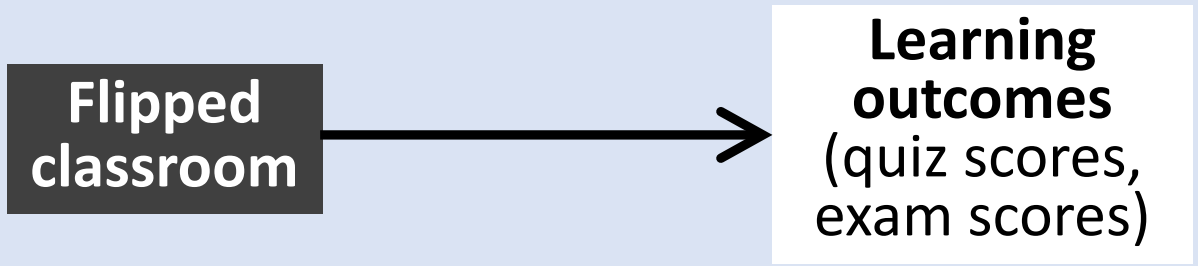
Related Studies

No randomized controlled study for large-sized classes

Study	Course	Treatment # of sections, n = # of obs.	Control # of sections, n = # of obs.	Learning outcomes	Class activities	RCT?	Positive effect?
Calimeris & Sauer (2015)	principles of microeconomics	1, n=31	1, n=35	midterm, final exam	experiments, discussing news articles & video clips	partially yes	mixed
Caviglia-Harris (2016)	principles of microeconomics	2, n=50 (full flip) 2, n=55 (partial flip)	2, n=58	final exam, common questions	in-class exercises & games, clicker questions	no	yes
Balaban *et al.* (2016)	principles of economics	1, n=367	1, n=362	final exam	problem solving	no	yes
Wozny *et al.* (2018)	introduction to econometrics	7 (5 lessons) n=137 in total	7 (5 lessons) n=137 in total	quizzes, midterm, final exam	independent & group work on exercises, mini lectures	partially yes	mixed
Lombardini *et al.* (2018)	principles of microeconomics	1, n=146 (partial flip) 1, n=117 (full flip)	1, n=157	exams, students' evaluation, likelihood of D, F, and withdraw	pair and group activities, exercises and discussions	no	mixed
Ficano (2019)	introductory microeconomics	3, n=58	3, n=72	exams	work on application questions in groups	no	no
Yamarik (2019)	international economics	2, n=63	2, n=59	midterm, final exam, student perceptions	Individual & group exercises, group experiments	no	no
Craft & Linask (2020)	principles of microeconomics	6, n=117	6, n=122	course grade, final exam, TUCE posttest	solving problems, classroom experiments, discussion	partially yes	mixed
Setren *et al.* (2021)	introduction to calculus, principles of economics	26, n=435 (math) 14, n=226 (econ)	25, n=417 (math) 15, n=250 (econ)	quizzes, final exam	problem set	yes	mixed

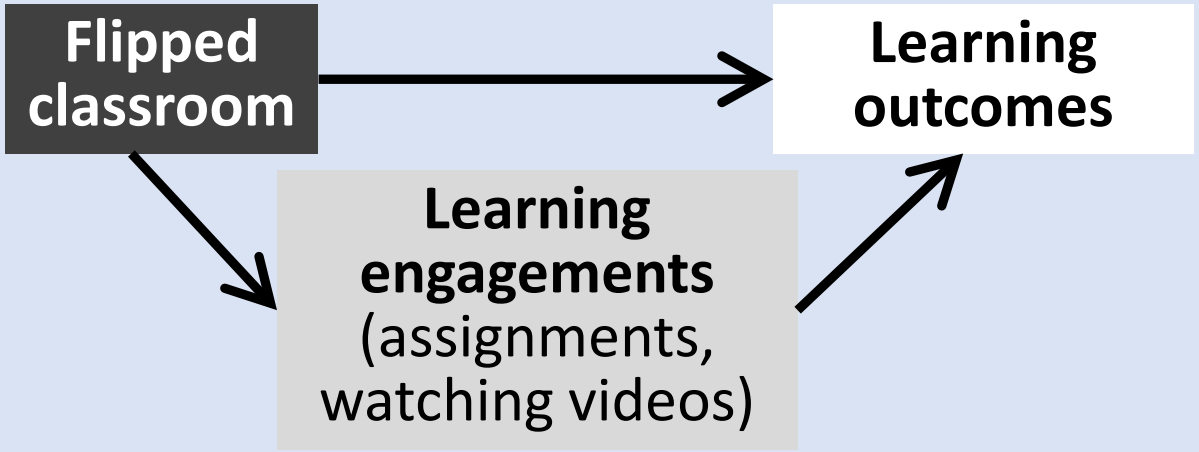
The objectives of our study

1



Examine the effect of flipped classrooms on student learning outcomes under **a randomized controlled design** in **large-sized classes**.

2



Examine the effect of flipped classrooms on learning outcomes **through learning engagements**.

Introduction to Economics course in spring 2022

- First-year undergrad students were assigned randomly to the sections by the admin office.
- The experiment was conducted on the 7 lessons in 2 sections (C and D) of the course.
- The same instructor has taught Section C and D.

Traditional lectures and flipped classrooms applied to the both sections

	Lesson	1	2	3	4	5	6	7
	Date	11 Apr.	18 Apr.	25 Apr.	2 May	16 May	23 May	30 May
Section C 185 students (180 consented)		**Traditional lecture**				**Flipped classroom**		

	Lesson	1	2	3	4	5	6	7
	Date	6 Jun.	13 Jun.	20 Jun.	27 Jun.	4 Jul.	11 Jul.	18 Jul.
Section D 179 students (158 consented)		**Flipped classroom**				**Traditional lecture**		

Class format

Lecture

Exercises

Problems similar to the quiz

Quiz

Five multiple-choice questions

Class format and assignments

Flipped classroom

Before class	During class	At the end of the class
Video **lecture**	**Exercises** in randomly assigned groups	**Quiz**

Submit **a question about the lecture** to the course website

Traditional lecture

During class	After class	At the beginning of the next class
Live **lecture** in the classroom	**Exercises** by each student	**Quiz**

Submit **a question about the lecture** to the course website

Panel data of 338 students × 7 lessons

Student learning outcomes

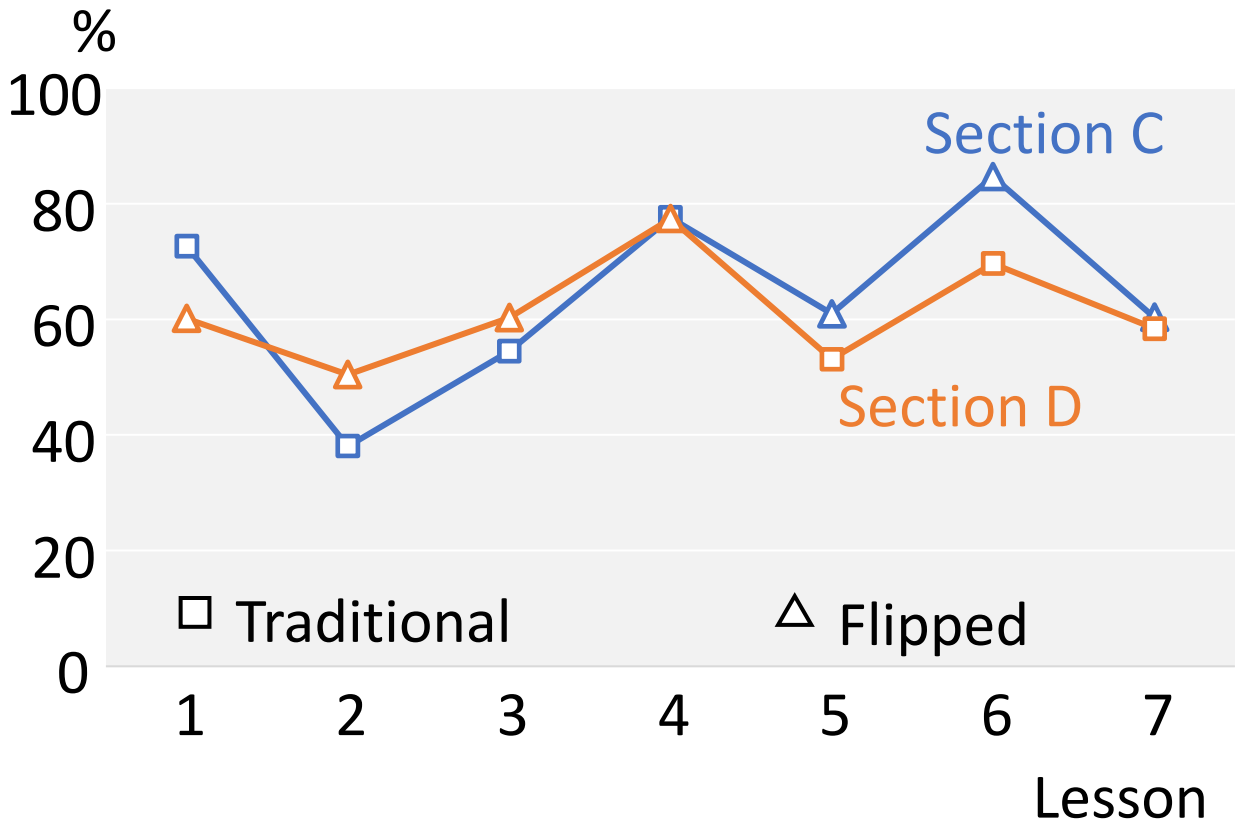
- Quiz scores (short-term learning outcomes)
- Final exam scores (long-term learning outcomes)
  - 18 questions in total, each question related to one of the seven lessons

Student learning engagements

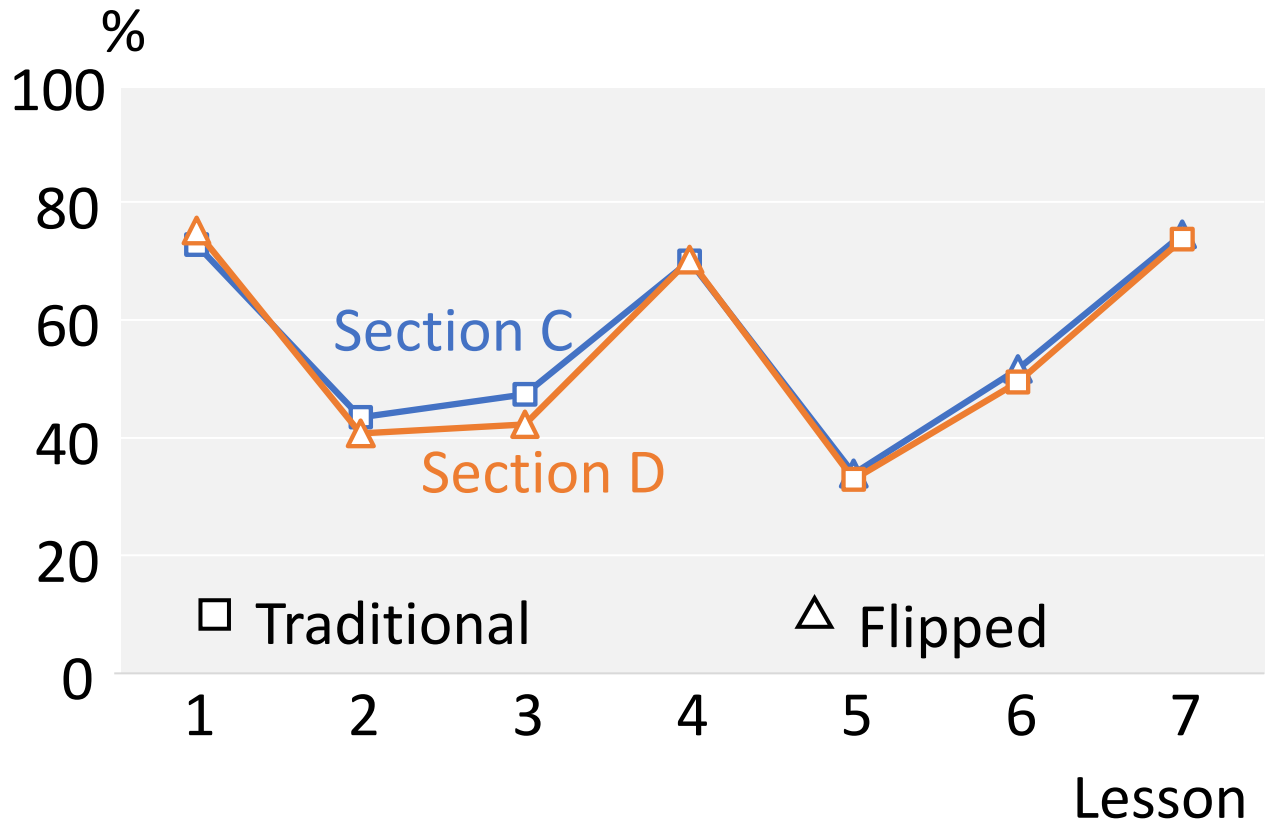
- Questions about the lecture
  - Submitted or not
  - Question length (the number of characters)
- The scores of exercise problems
- Completion rate of watching videos
- attendance

The effect of flipped classrooms on learning outcomes

The averages of % of correct answers in the quizzes



The averages of % of correct answers in the final exam



The effect of flipped classrooms on learning outcomes

Pooled OLS	Quiz scores (Standardized for each lesson)				Final exam scores (Standardized for each lesson)	
	All lessons	All lessons	Except lesson1	Except lesson 1		
Flipped	**0.1802*** (0.0385)**	**-0.4214* (0.2503)**	**0.2862*** (0.0408)**	**-0.4985* (0.2786)**	**0.0193 (0.0342)**	**0.1672 (0.2125)**
Standardized math placement test score	0.1182*** (0.0287)	0.1224*** (0.0286)	0.1325*** (0.0300)	0.1384*** (0.0292)	0.0840** (0.0340)	0.0949*** (0.0318)
Standardized English placement test score	0.1623*** (0.0358)	0.1589*** (0.0362)	0.1475*** (0.0394)	0.1456*** (0.0392)	0.1759*** (0.0402)	0.1760*** (0.0386)
Female	-0.0329 (0.0655)	-0.0148 (0.0665)	-0.0331 (0.0699)	-0.0116 (0.0703)	0.0325 (0.0664)	0.0469 (0.0642)
Attitude toward group learning (Likert scale)		-0.1861*** (0.0576)		-0.2289*** (0.0657)		-0.1096** (0.0464)
Attitude toward group learning * Flipped		0.1618*** (0.0684)		0.2117*** (0.0757)		-0.0387 (0.0569)
Observations	1857	1818	1584	1549	2072	2037
R^2	0.0689	0.0758	0.0771	0.0878	0.0479	0.0561

The eff

Positive effect of the flipped classrooms on the quiz scores

No effect of the flipped classrooms on the final exam scores

Pooled OLS	Quiz scores (Standardized for each lesson)				Final exam scores (Standardized for each lesson)	
	All lessons	All lessons	Except lesson1	Except lesson 1		
Flipped	**0.1802*** (0.0385)**	**-0.4214* (0.2503)**	**0.2862*** (0.0408)**	**-0.4985* (0.2786)**	**0.0193 (0.0342)**	**0.1672 (0.2125)**
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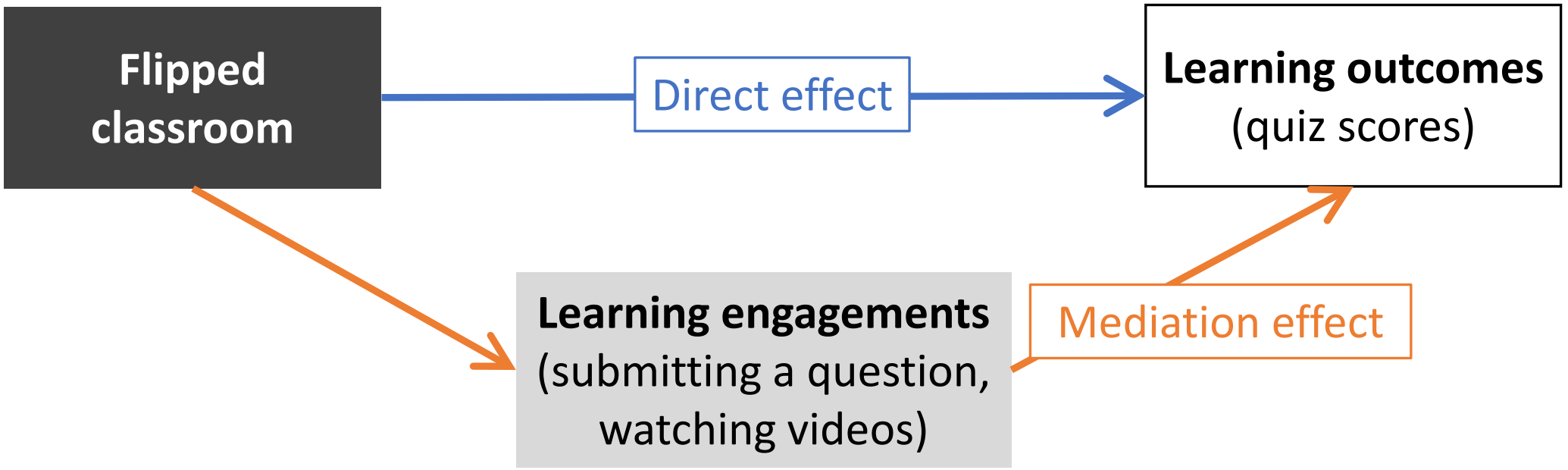
Positive attitude toward group learning decreases the quiz scores but strengthens the effect of the flipped classrooms.

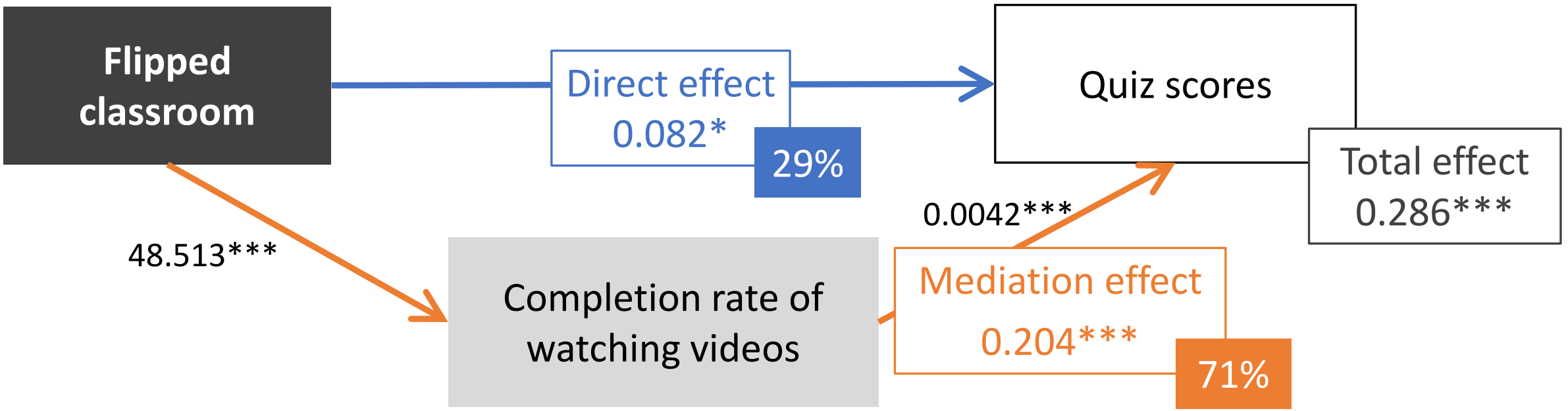
Causal mediation analysis

Examine the effect of the flipped classrooms on learning outcomes through learning engagements

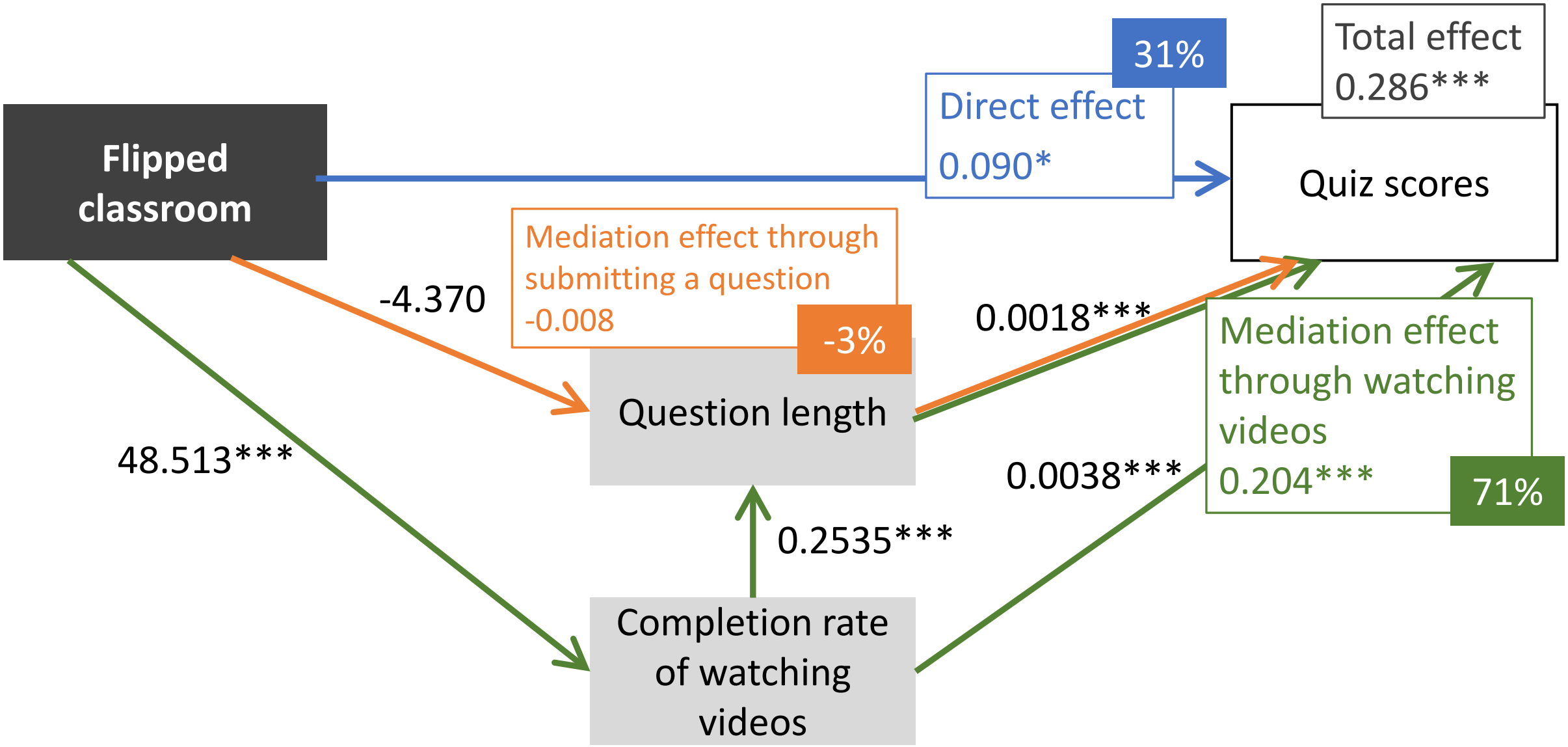


Causal mediation analysis: results

Examine the effect of the flipped classrooms on learning outcomes through learning engagements



Two-mediator mediation analysis

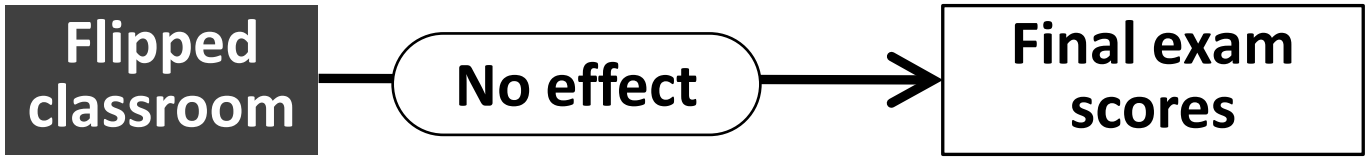


Why is a flipped classroom supposed to be effective?

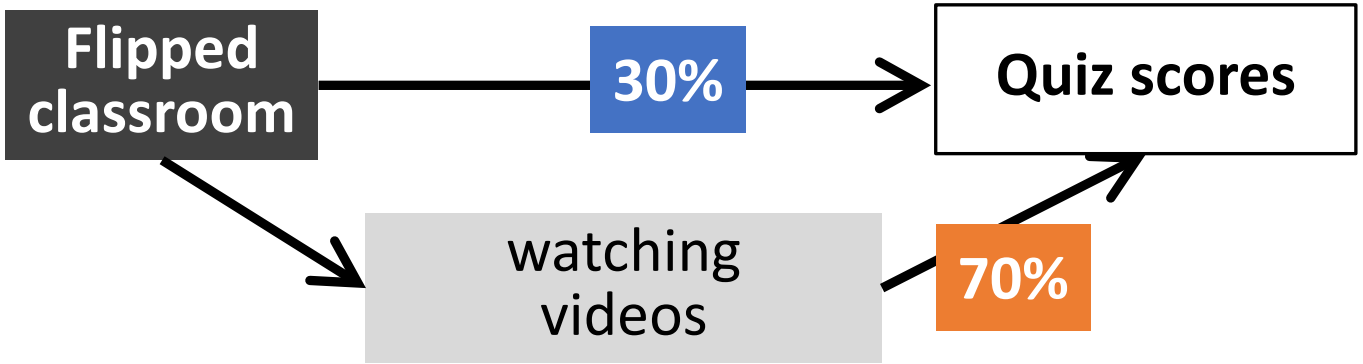
	Before class (outside of class time)	During class	After class (outside of class time)
Flipped classroom	Watch video lectures **Flexibility** Students can take **video lectures** at any time they like at their own pace. **70%** The mediation effect through watching videos	Review the lecture, work on exercises, and other activities with classmates	**Peer teaching** Students can receive real-time feedback from their classmates. **30%** The direct effect
Traditional lecture		Have a lecture with classmates	Review the lecture and work on exercises

Summary of the findings

Positive effect of the flipped classroom on quiz scores (short-term learning outcome) about 0.18 to 0.29 standard deviation



No significant effect of the flipped classroom on exam scores (long-term learning outcome)



Of the total effect of flipped classrooms, 70% is mediated through watching videos, and the remaining 30% is the direct effect, interpreted as the effect of activities during class.

Our experiment in 2021：original design

Lesson	1	2	3	4	5	6	7
Date	12 Apr.	19 Apr.	26 Apr.	10 May	24 May	31 May	5 Jun.
Section C 196 students	**Traditional lecture**				**Flipped classroom**		

Lesson	1	2	3	4	5	6	7
Date	7 Jun.	14 Jun.	21 Jun.	28 Jun.	5 Jul.	12 Jul.	19 Jul.
Section D 191 students	**Flipped classroom**				**Traditional lecture**		

Our experiment in 2021：what was done

Due to the COVID-19, classes were held online from mid-April to mid-June.

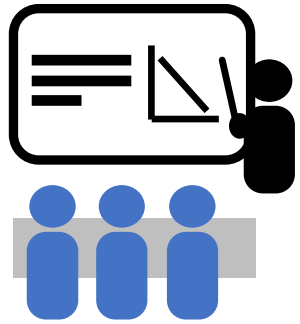
Lesson	1	2	3	4	5	6	7
Date	12 Apr.	19 Apr.	26 Apr.	10 May	24 May	31 May	5 Jun.
Section C 196 students	**Traditional lecture**				**Flipped classroom**		
	In person			**Online**			

Lesson	1	2	3	4	5	6	7
Date	7 Jun.	14 Jun.	21 Jun.	28 Jun.	5 Jul.	12 Jul.	19 Jul.
Section D 191 students	**Flipped classroom**				**Traditional lecture**		
	Online			**In person**			

The effect of in-person and online flipped classroom in 2021 and 2022

In person (2021)

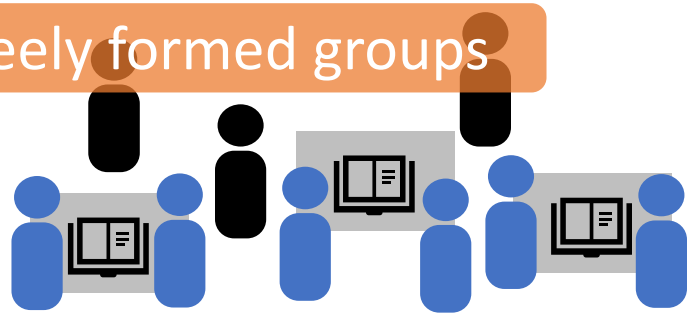
Traditional lecture



-0.347 **Negative effect of in-person flipped classroom**

Flipped classroom

Freely formed groups



Online (2021)

Traditional lecture

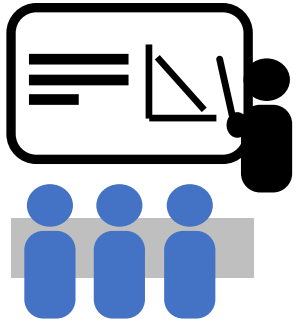
+0.641 **Positive effect of online flipped classroom**

Flipped classroom

Randomly assigned groups

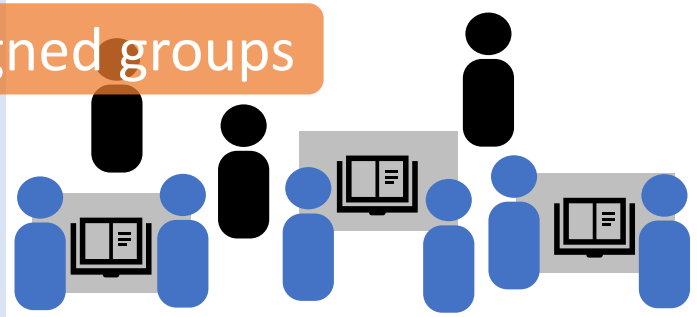
In person (2022)

Traditional lecture



+0.286 **Positive effect of in-person flipped classroom**

Flipped classroom



Summary of the findings

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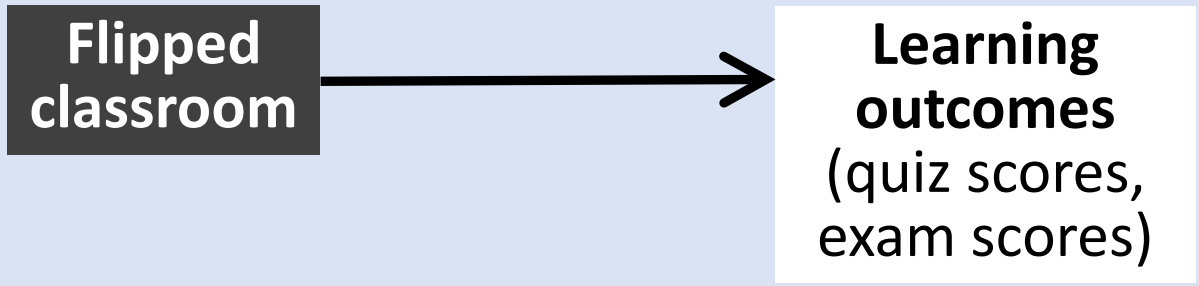
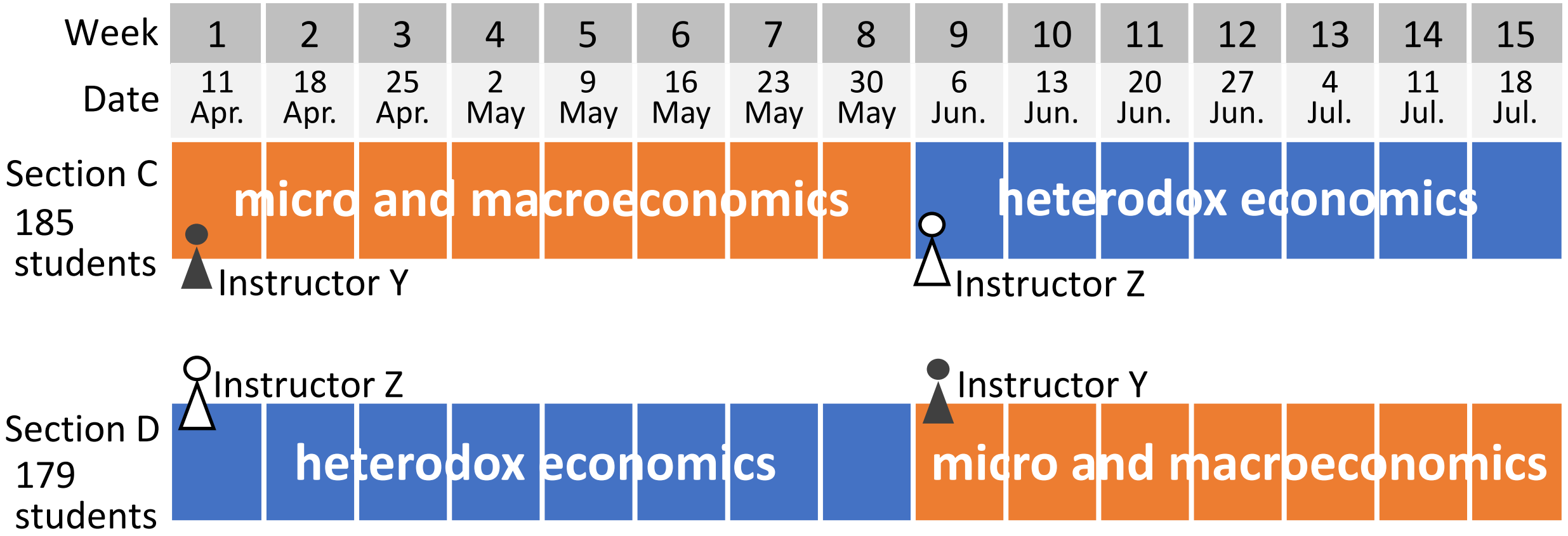


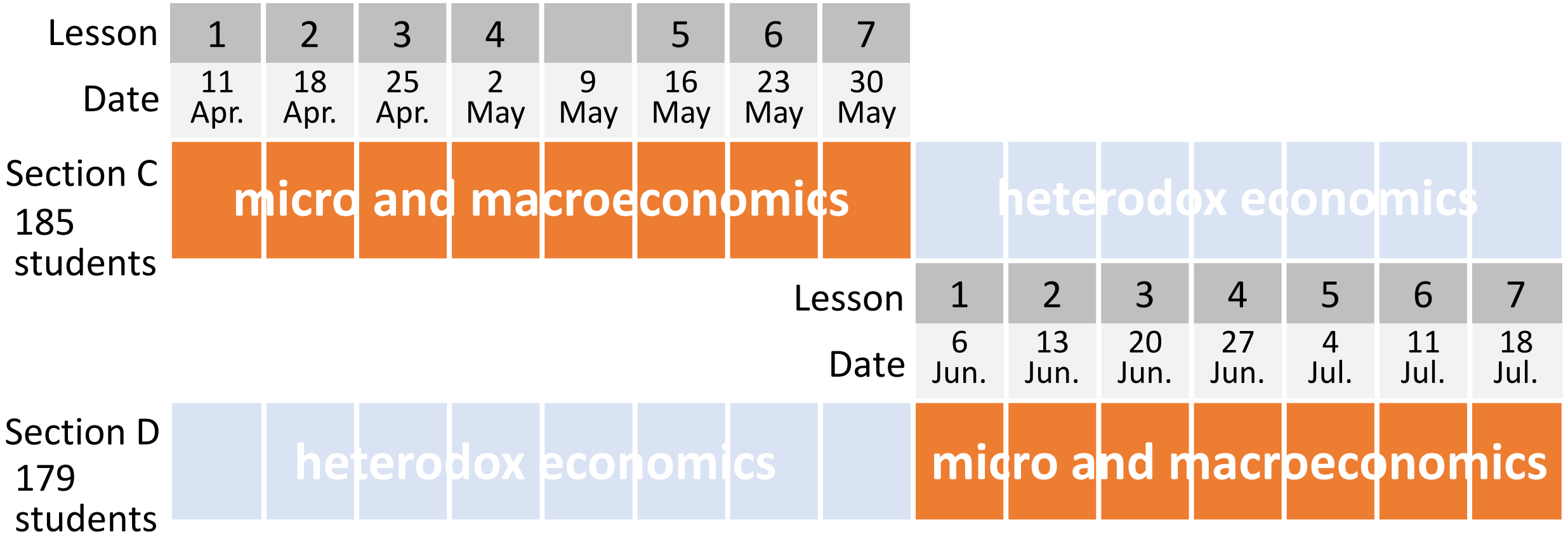
- Positive effect of the flipped classroom on quiz scores (short-term learning outcome) about 0.16 to 0.29 standard deviation
- No significant effect of the flipped classroom on exam scores (long-term learning outcome)
- Randomly assigned groups can be a successful ingredient for flipped classrooms.

Supplementary materials

Introduction to Economics course in spring 2022



Experiment on the 7 lessons of “Introduction to Economics”



Introduction to Economics course in spring 2022

First-year undergrad students were assigned randomly to the sections by the admin office.

Lesson	1	2	3	4		5	6	7
Date	11 Apr.	18 Apr.	25 Apr.	2 May	9 May	16 May	23 May	30 May
Section C 185 students	**Traditional lecture**					**Flipped classroom**		

The experiment was conducted on the **7 lessons** in **2 sections** (section C and D) of the course

Traditional lectures and flipped classrooms applied to the both sections

Lesson	1	2	3	4	5	6	7
Date	6 Jun.	13 Jun.	20 Jun.	27 Jun.	4 Jul.	11 Jul.	18 Jul.
Section D 179 students	**Flipped classroom**				**Traditional lecture**		

Contents of the course

Based on Mankiw's ten principles of economics

Lesson 1	Tradeoffs
Lesson 2	Cost, rational choice, incentives
Lesson 3	Marginal principle, profit maximization
Lesson 4	Gains from trade
Lesson 5	Efficiency of a market economy, market failure
Lesson 6	GDP
Lesson 7	Price levels, inflation and unemployment

Class format and assignments

Flipped classroom

Before class	During class	At the end of the class
Video **lecture**	**Exercises** in randomly assigned groups	**Quiz**
Submit **a question about the lecture** to the course website before class	Submit **answers to the exercises** to the course website after class	

Traditional lecture

During class	After class	At the beginning of the next class
Live **lecture** in the classroom	**Exercises** by each student	**Quiz**
Submit **a question about the lecture** to the course website after class	Submit **answers to the exercises** to the course website after class	

Class format

Lecture | Exercises | Quiz

	Before class	During class	After class	Next class
Flipped classroom	• Readings • Video **lecture** • Submit a question about the lecture	• Work on **exercises** by randomly assigned groups • Take a **quiz** in the last 10 minutes	• Submit the answers to exercises	

90 minutes — A week

	Before class	During class	After class	Next class
Traditional lecture	• Readings	• Live **lecture** in the classroom	• Work on **exercises** by each and submit the answers • Submit a question about the lecture	• Take a **quiz** in the first 10 minutes

Before class | During class | After class | Next class

Grading

Final exam 30%	quizzes 40%	Question about the lecture 20%	Exer-cises 10%

Regression using panel data of 338 students × 7 lessons

$$\text{Leaning outcome}_{ij} = \alpha + \boldsymbol{\beta}\text{Flipped}_{ij}$$

$$+ \sum_{k} \gamma_k \text{Student characteristics}_{ki}$$

$$+ \sum_{j} \theta_j \text{Lesson dummies}_j + \varepsilon_{ij}$$

i for students and j for lessons

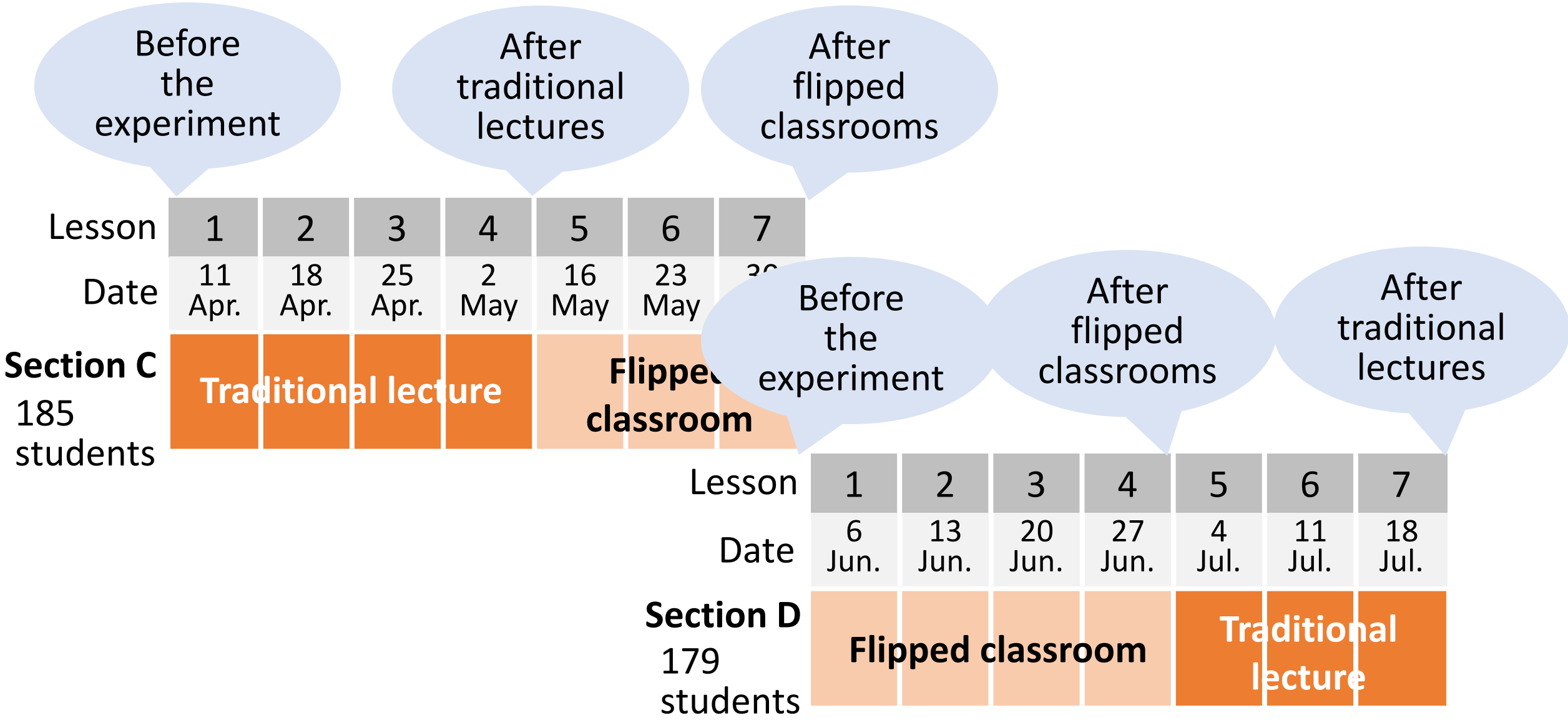
Characteristics of students

- English placement test score
- Math placement test score
- Gender

Survey about learning

- Self-regulated learning strategies
- Attitude toward group learning
- Eagerness to learn

Survey about learning



Survey about learning

Self-regulated learning strategies (24 questions)

Behavioral strategies (6 questions)

- I plan ahead.
- …

Cognitive strategies (8 questions)

- I think about what I needed to understand in class.
- …

Emotional strategies (4 questions)

- I try not to think too much about how bad things could happen.
- …

Motivational strategies (6 questions)

- I am motivated to take classes even if I am not interested.
- …

Attitude toward group learning (8 questions)

- A team makes better decisions than one person.
- It's fun to work with classmates.
- Listen carefully to others.
- …

Summary statistics：Sections and student characteristics

Section	# of students consented/# of students
C	180/185
D	158/179

	Section	mean	Std. dev	min	max	# of obs.
Gender (male=0, female=1)	C	0.21	0.41	0	1	180
	D	0.25	0.43	0	1	158
Math placement test scores (out of 42 points)	C	24.39	6.59	10	39	169
	D	23.50	6.89	5	39	150
English placement test scores (out of 1000 points)	C	542.16	109.33	76	735	179
	D	539.46	100.85	117	762	158

The effect of flipped classrooms on learning outcomes: Quiz scores

Pooled OLS	Dependent variable: standardized quiz score			
	(1) All lessons	(2) All lessons	(3) Except lesson 1	(4) Except lesson 1
Flipped	.180 (.038) ***	-.177 (.278)	.286 (.041) ***	-.297 (.323)
Standardized math placement test score	.118 (.029) ***	.116 (.028) ***	.133 (.030) ***	.134 (.028) ***
Standardized English placement test score	.162 (.036) ***	.151 (.034) ***	.148 (.039) ***	.137 (.037) ***
Female	-.033 (.065)	-.020 (.064)	-.033 (.070)	-.019 (.069)
Attitude toward group learning		-.178 (.063) ***		-.235 (.071) ***
Attitude toward group learning * Flipped		.242 (.080) ***		.279 (.086) ***
Behavioral learning strategies		-.057 (.054)		-.035 (.059)
Behavioral learning strategies * Flipped		-.065 (.057)		-.090 (.062)
Cognitive learning strategies		-.080 (.063)		-.078 (.071)
Cognitive learning strategies * Flipped		.094 (.089)		.087 (.096)
Emotional learning strategies		-.015 (.041)		.001 (.046)
Emotional learning strategies * Flipped		-.058 (.045)		-.044 (.050)
Motivational learning strategies		.124 (.053) **		.116 (.063) *
Motivational learning strategies * Flipped		-.151 (.070) **		-.102 (.082)
Observations / R^2	1857	1813	1584	1544
R^2	0.0689	0.0842	0.0771	0.0927

The effect of flipped classroom
Quiz scores

Positive effect of the flipped classrooms on the quiz scores on average

Pooled OLS	Dependent variable: standardized quiz score			
	(1) All lessons	(2) All lessons	(3) Except lesson 1	(4) Except lesson 1
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Attitude toward group learning		-.178 (.063) ***		-.235 (.071) ***
Attitude toward group learning * Flipped		.242 (.080) ***		.279 (.086) ***
Behavioral learning strategies				
Behavioral learning strategies * Flipped				
Cognitive learning strategies				
C		.094 (.089)		.087 (.096)
E		-.015 (.041)		.001 (.046)
E		-.058 (.045)		-.044 (.050)
Motivational learning strategies		.124 (.053) **		.116 (.063) *
Motivational learning strategies * Flipped		-.151 (.070) **		-.102 (.082)
Observations / R^2	1857	1813	1584	1544
R^2	0.0689	0.0842	0.0771	0.0927

Positive attitude toward group learning lowers the scores but strengthens the effect of the flipped classrooms.

Motivational learning strategies raise the scores but weaken the effect of the flipped classrooms.

The effect of flipped classrooms on learning outcomes: Final exam scores

Pooled OLS	Dependent variable: standardized final exam score	
	(1)	(2)
Flipped	.019 (.034)	.201 (.257)
Standardized math placement test score	.084 (.034) **	.092 (.032) ***
Standardized English placement test score	.176 (.040) ***	.168 (.038) ***
Female	.033 (.066)	.051 (.064)
Attitude toward group learning		-.062 (.060)
Attitude toward group learning * Flipped		-.042 (.061)
Behavioral learning strategies		-.123 (.053) **
Behavioral learning strategies * Flipped		.091 (.057)
Cognitive learning strategies		.014 (.071)
Cognitive learning strategies * Flipped		-.036 (.070)
Emotional learning strategies		-.052 (.034)
Emotional learning strategies * Flipped		-.011 (.038)
Motivational learning strategies		.049 (.055)
Motivational learning strategies * Flipped		-.049 (.051)
Observations	2072	2,030
R^2	0.0479	0.0616

The effect of flipped classrooms on learning outcomes: Final exam scores

Pooled OLS	Dependent variable: standardized final exam score	
	(1)	(2)
Flipped	.019 (.034)	.201 (.257)
Standardized math placement test score	.084 (.034) **	.092 (.032) ***
Standardized English placement test score	.176 (.040) ***	.168 (.038) ***
Female	.033 (.066)	.051 (.064)
Attitude toward group learning		-.062 (.060)
Attitude toward group learning * Flipped		-.042 (.061)
Behavioral learning strategies		-.123 (.053) **
Behavioral learning strategies * Flipped		.091 (.057)
Cognitive learning strategies		.014 (.071)
Cognitive learning strategies * Flipped		-.036 (.070)
Emotional learning strategies		-.052 (.034)
Emotional learning strategies * Flipped		-.011 (.038)
Motivational learning strategies		.049 (.055)
Motivational learning strategies * Flipped		-.049 (.051)
Observations	2072	2,030
R^2	0.0479	0.0616

No significant effect of the flipped classrooms on the final exam scores

The effect of flipped classrooms on learning engagements

Positive effects on learning engagements on average.

	Question submission (submitted=1)	Question length	The scores of exercise problems (0,1, or 2)	Attendance (attended=1)	Completion rate of watching videos(%)
	probit	pooled OLS	ordered probit	probit	pooled OLS
Flipped	**0.0872** **(0.0605)**	**9.6629***** **(2.2452)**	**0.2878***** **(0.0570)**	**0.1585***** **(0.0543)**	**43.402***** **(1.8024)**
Standardized math placement test score	0.1854*** (0.0561)	8.3528*** (2.4601)	0.1380*** (0.0560)	0.0991*** (0.0396)	0.0140 (1.1568)
Standardized English placement test score	-0.1824*** (0.0603)	0.4154 (2.8134)	-0.0951* (0.0521)	-0.0286 (0.0448)	2.6259* (1.3490)
Female	0.4382*** (0.1483)	1.4785 (4.8033)	0.4234*** (0.1475)	0.3093** (0.1218)	8.8676*** (3.1619)
Observations	2233	2233	2233	2233	2233
R^2	0.0502 (pseudo)	0.0747	0.0540 (pseudo)	0.0316 (pseudo)	0.2710

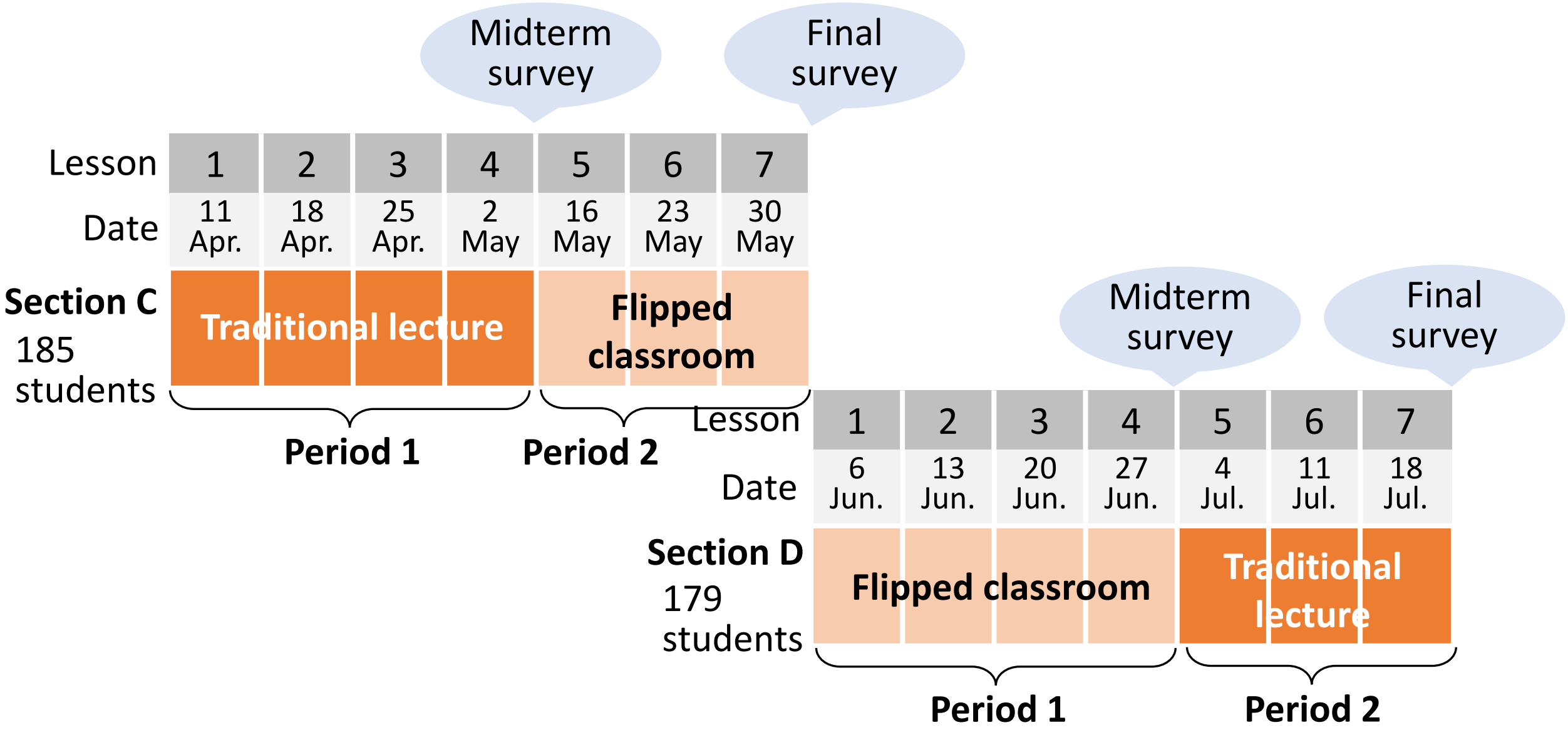
Student satisfaction

	Student satisfaction Pooled OLS	
Flipped	**-0.2973*** (0.0643)**	**-1.7389*** (0.4479)**
Standardized math placement test score	0.0762 (0.0458)	0.0476 (0.0420)
Standardized English placement test score	0.0046 (0.0398)	0.0044 (0.0380)
Female	0.0497 (0.0978)	0.0081 (0.0900)
Attitude toward group learning		0.1861** (0.0731)
Attitude toward group learning * Flipped		0.3899*** (0.1105)
Period-2 dummy	-0.1280* (0.0646)	-.1469** (0.0619)
Observations	609	596
R^2	0.0405	0.1390

Less satisfied with the Flipped classrooms than the traditional lectures

The students with highly positive attitude toward group learning are satisfied with the flipped classrooms
but the other students are not.

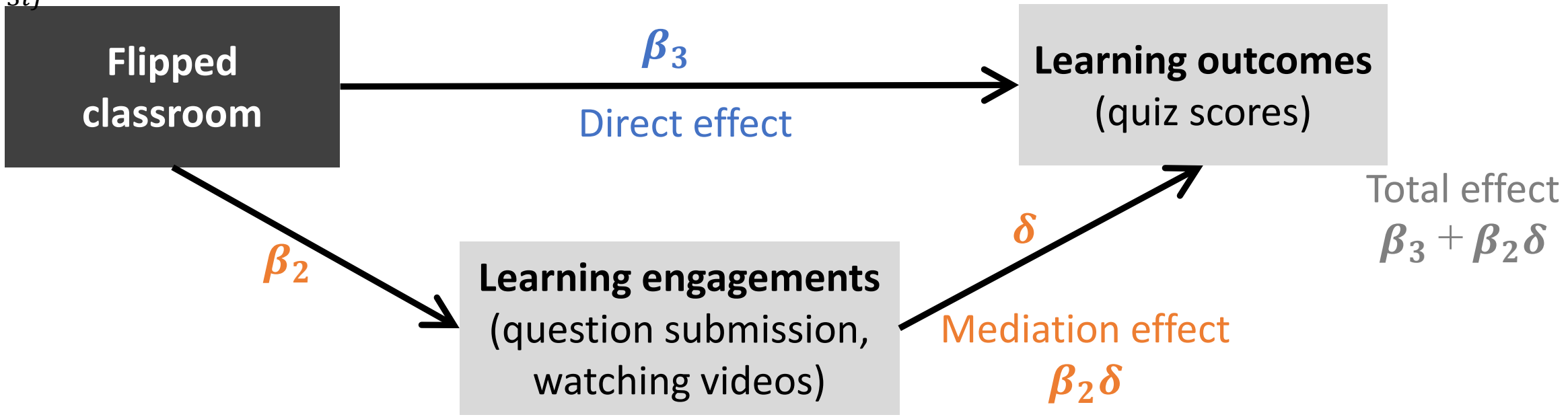
Student satisfaction



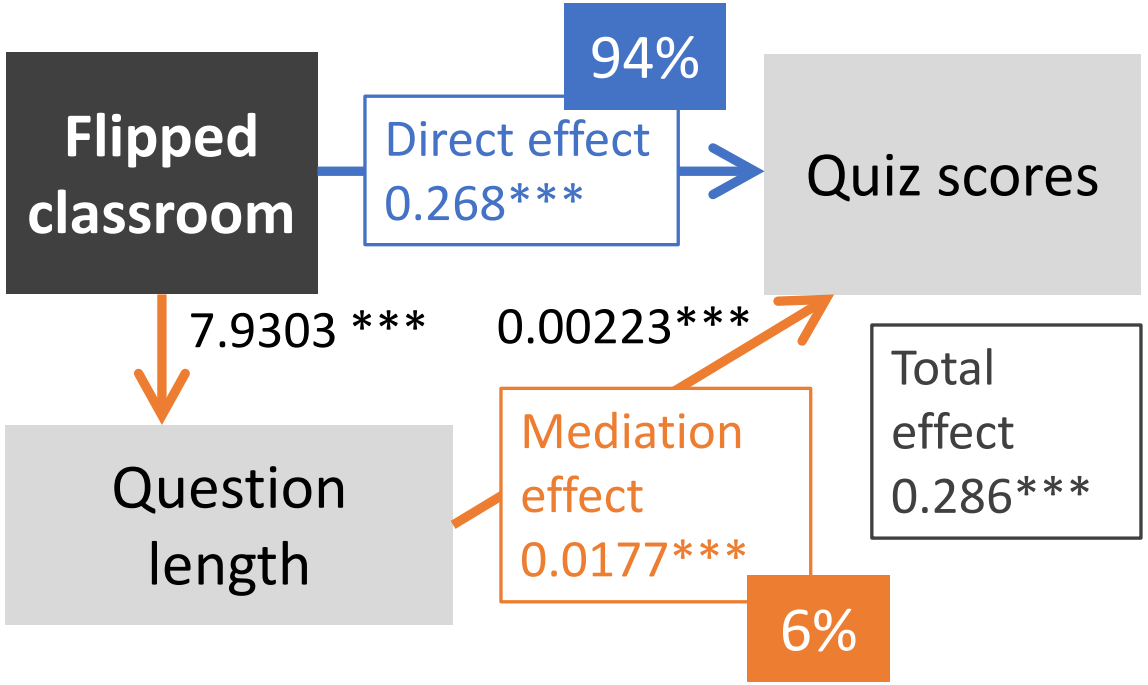
Causal mediation analysis

$$\text{Leaning engagement}_{ij} = \alpha_2 + \boldsymbol{\beta_2}\text{Flipped}_{ij} + \sum_k \gamma_k \text{Student characteristics}_{ki} + \sum_j \theta_j \text{Lesson dummies}_j + \varepsilon_{2ij}$$

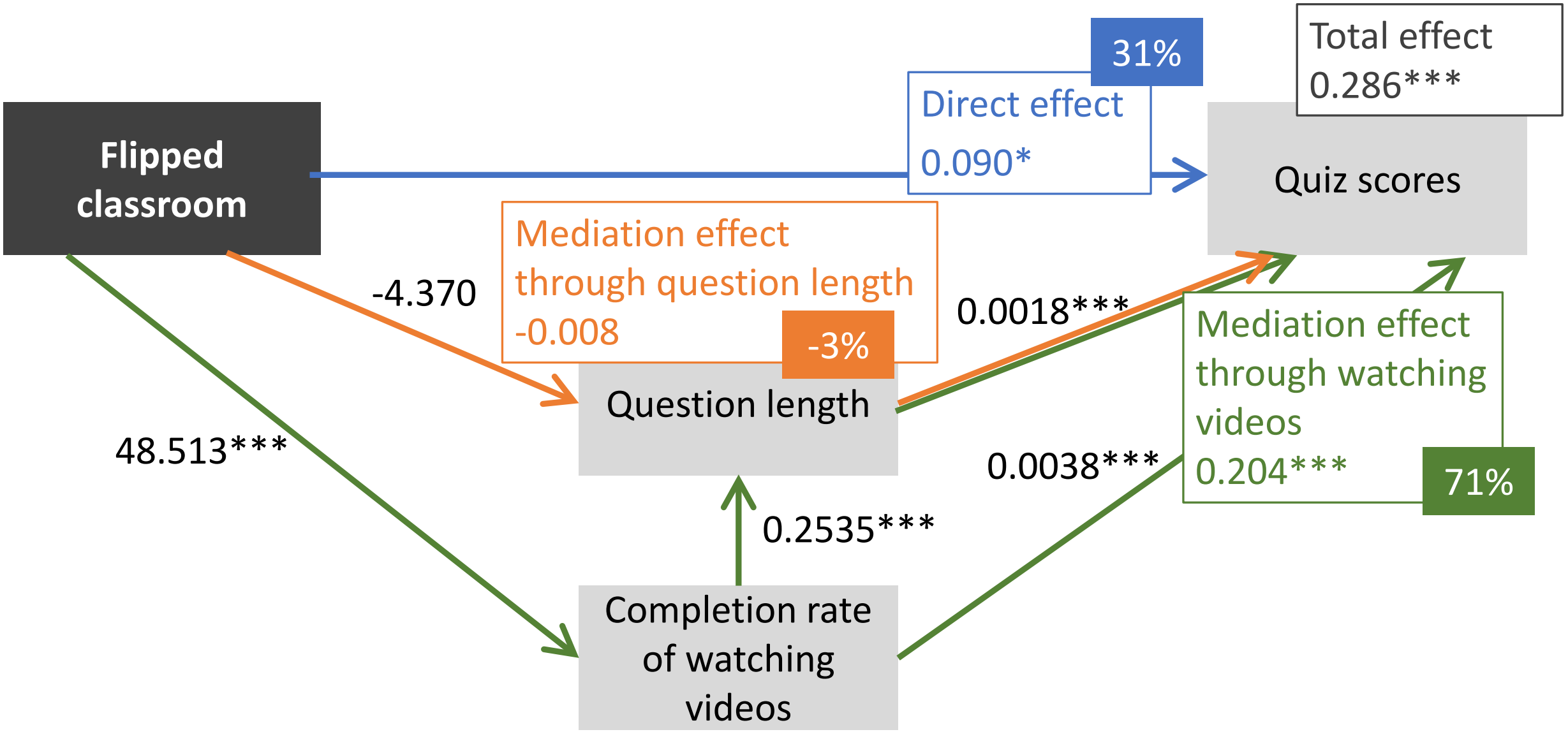
$$\text{Leaning outcome}_{ij} = \alpha_3 + \boldsymbol{\beta_3}\text{Flipped}_{ij} + \boldsymbol{\delta}\text{Learning engagement}_{ij} + \sum_k \gamma_k \text{Student characteristics}_{ki} + \sum_j \theta_j \text{Lesson dummies}_j + \varepsilon_{3ij}$$



Causal mediation analysis: results



Two-mediator mediation analysis



Summary statistics：learning outcomes

		Mean	Std. dev.	Min	Max	# of obs.
Quiz scores	**Flipped**	3.25	1.27	0	5	1001
	Traditional	3.04	1.39	0	5	966
Final exam scores	**Flipped**	1.41	0.99	0	3	1082
	Traditional	1.39	0.95	0	3	1102

Summary statistics: learning engagements

		Mean	Std. dev.	Min	Max	# of obs.
The scores of exercise problems	Flipped	1.72	0.70	0	2	1172
	Traditional	1.59	0.81	0	2	1194
Question submission (submitted=1, not=0)	Flipped	0.78	0.42	0	1	1172
	Traditional	0.76	0.43	0	1	1194
Question length	Flipped	61.84	58.95	0	381	1172
	Traditional	51.98	55.11	0	374	1194
Attendance (Attended=1, not=0)	Flipped	0.85	0.35	0	1	1172
	Traditional	0.81	0.39	0	1	1194

		% of students who ever watched videos	Completion rate of watching videos among the students who ever watched videos(%)				
			Mean	Std. dev.	Min	Max	# of obs.
Watching videos before taking quizzes	Flipped	58.45	79.12	39.98	0.10	243.40	685
	Traditional	4.77	77.45	43.05	0.08	137.29	57

Summary statistics：Survey before the experiment

		Section	Mean	Std. dev.	Min	Max	# of obs.
Attitude toward group learning		C	3.77	0.64	1.88	5.00	175
		D	3.69	0.74	1.50	5.00	155
Eagerness to learn		C	3.50	0.61	1.00	4.00	170
		D	3.60	0.56	2.00	4.00	149
Self-regulated learning strategies	Behavioral	C	3.26	0.89	1.00	5.00	176
		D	3.14	0.89	1.00	5.00	155
	Cognitive	C	3.59	0.67	1.75	5.00	175
		D	3.38	0.67	1.38	5.00	154
	Emotional	C	3.02	0.98	1.00	5.00	176
		D	2.97	1.09	1.00	5.00	155
	Motivational	C	3.36	0.81	1.17	5.00	175
		D	3.12	0.85	1.00	5.00	155

Summary statistics：Survey after flipped classrooms and after traditional lectures

			Mean	Std. dev.	Min	Max	# of obs.
Satisfaction		Flipped	3.81	1.02	1.00	5.00	324
		Traditional	4.15	0.80	1.00	5.00	322
Attitude toward group learning		Flipped	3.79	0.69	1.25	5.00	321
		Traditional	3.80	0.70	1.00	5.00	322
Eagerness to learn		Flipped	3.24	0.63	1.00	4.00	324
		Traditional	3.27	0.66	1.00	4.00	324
Self-regulated learning strategies	Behavioral	Flipped	3.32	0.86	1.00	5.00	322
		Traditional	3.39	0.92	1.00	5.00	321
	Cognitive	Flipped	3.56	0.68	1.00	5.00	323
		Traditional	3.60	0.69	1.25	5.00	323
	Emotional	Flipped	3.29	1.00	1.00	5.00	321
		Traditional	3.42	0.93	1.00	5.00	323
	Motivational	Flipped	3.45	0.79	1.00	5.00	320
		Traditional	3.67	0.76	1.67	5.00	323