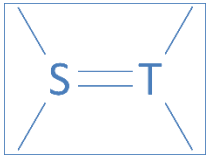
POLITECNICO
MILANO 1863

Measurements in STEM Education (MESE1)



Experimental
Teaching lab. (ST2)

Peer learning in higher education: An effective response to the university students' dropout problem

Matteo Bozzi, Roberto Mazzola, Maurizio Zani

Napoli 30/01/2023

Introduction

Overcrowding

CHALLENGES

Dropout

Italian National Agency for the Evaluation of University and Research Institutes

Report 2018

- Dropout rate: 28.3%
- Dropout rate in the first 2 years: 20%

A few CFU in 1° term 1° a.y. (*)

CAUSE

(*) 2022 M. Cannistrà et al. – Studies in Higher Education, vol. 47, n. 9, pp. 1935-1956

Introduction

Overcrowding

CHALLENGES

Dropout

- Pedagogical innovation (peer learning)
- Adoption of technologies to «amplify» the teachers' activities (SRS)

Our research: an innovative educational strategy

Integrated Teaching Methodology

Peer learning (PL)

Technology

Lectures and drills

Novelties of our research

1. **Integration** of peer learning activities, strengthened by the use of technology, into traditional (physics) lectures (**no replacement**)
2. Employment of active methods in **large size formats**

- 2021 M. Bozzi, J. E. Raffaghelli, M. Zani – Education Sciences, vol. 11, n. 2, art. 67
- European Commission, Directorate-General for Education, Youth, Sport and Culture, Fack, G., Agasisti, T., Bonal, X. (2022). Interim report of the Commission expert group on quality investment in education and training, Publications Office of the European Union

Research question

Does this integrated teaching methodology improve the students' final examination pass rate, thus contributing to mitigating one major cause of university dropout?

Research design: context and participants

- Chemical Engineering and Materials and Nanotechnology Engineering at POLIMI
- Fisica sperimentale A+B (I term)
- Possibility to attend the course both in presence and on line
- a. y. 2021/2022

Studied group (SG)
Students exposed to PL

Criterion: attended PL sessions > 50%

Control group (CG)
Students not exposed to PL

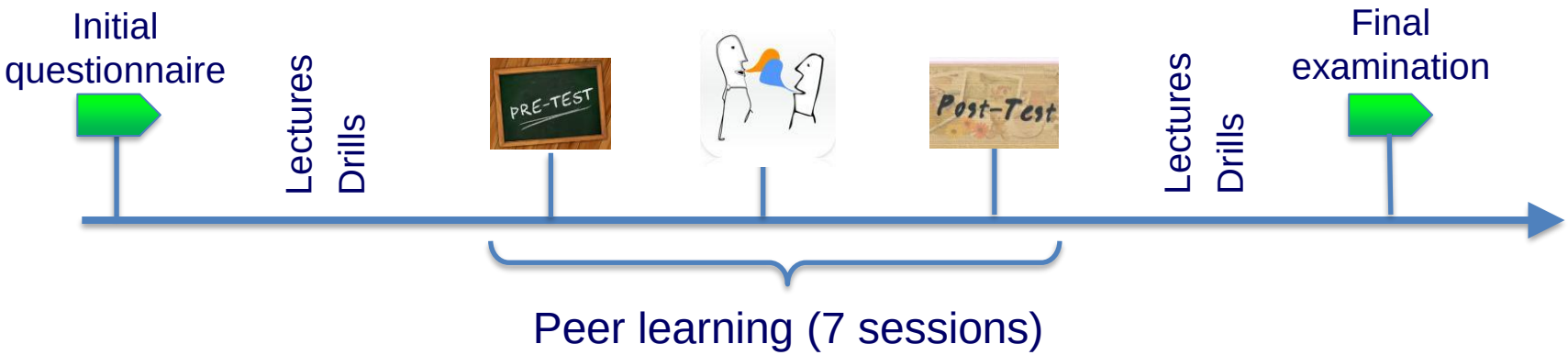
Criterion: attended PL sessions ≤ 50%

Same instructor, lectures and drills

Learning design of the course

Course schedule

- Lectures: 57 h
- PL sessions: ≈ 3 h (peer discussion (PD): ≈ 1.5 h)
- Drills: 40 h



Learning design of the course

Course schedule

- Lectures: 57 h
- PL sessions: ≈ 3 h (peer discussion (PD): ≈ 1.5 h)
- Drills: 40 h

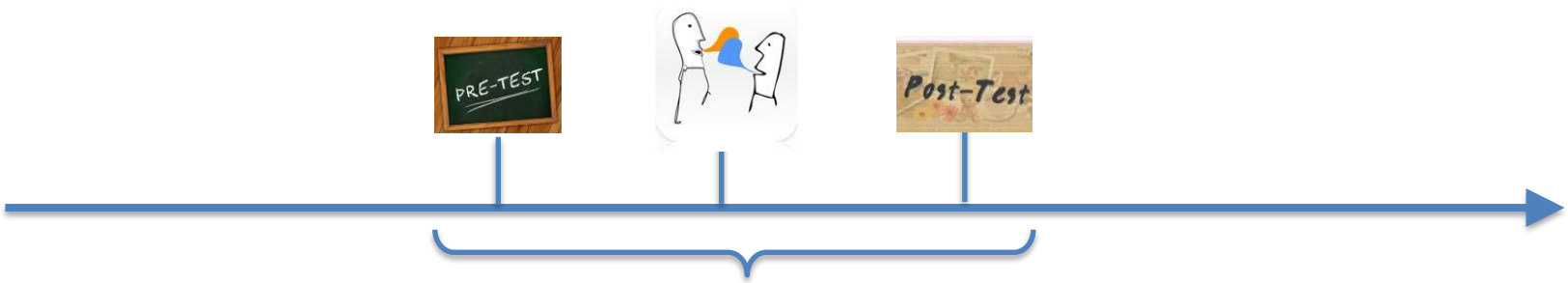
Initial questionnaire

- 18 multiple-choice items (6 Mc + 6 Td + 6 Em)
- Administered through the online portal
- Use of students' own electronic devices (BYOD strategy)

Learning design of the course

Course schedule

- Lectures: 57 h
- PL sessions: ≈ 3 h (peer discussion (PD): ≈ 1.5 h)
- Drills: 40 h



PL session

- 3 multiple-choice items (1.5 min per item) before PD
- PD about those 3 items (3 min – 5 min)
- Same 3 multiple-choice items (1.5 min per item) after PD
- Brief explanation of the answers by teacher (2 min – 3 min)

Results 1: initial level of knowledge

Initial level of knowledge in Physics

SG+CG freshmen
vs
Other POLIMI freshmen (O)

Question 1

SG+CG and O equivalent before the Physics course?
(Measured through initial questionnaire)

O
better than
SG+CG

Initial level of knowledge in Physics

SG (YES PL)
vs
CG (NO PL)

Question 2

SG and CG equivalent before the Physics course?
(Measured through initial questionnaire)

SG
equivalent of
CG

Results 2: final exam pass rate

Passing final exam
(in the first session)

SG (YES PL)
vs
CG (NO PL)

Question 3

Do SG and CG show the same final exam pass rate?
Statistical association between this rate and the variable PL YES/NO?

Contingency table – Observed distribution

Group	Pass Number (%)	Failure Number (%)
CG	24 (22.86)	81 (77.14)
SG	64 (65.98)	33 (34.02)

CG (PL NO) and SG (PL YES) seem to highlight a notable difference

Results 2: final exam pass rate

Chi-square test

Contingency table – Observed distribution

PL	Pass Number	Failure Number	TOT
NO (CG)	24	81	105
YES (SG)	64	33	97
TOT	88	114	202

Contingency table – Expected distribution

PL	Pass Number	Failure Number	TOT
NO (CG)	45.74	59.26	105
YES (SG)	42.26	54.74	97
TOT	88	114	202

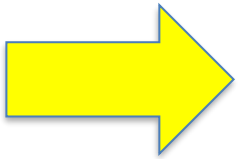
Results 2: final exam pass rate

Test	Parameter	df	p-value
Chi-square test	$\chi 2 = 38.13533$	1	6.60E-10 << 0.05
Yates's continuity correction	$\chi 2 = 36.40155$	1	1.61E-09 << 0.05
Fisher's exact test			6.00E-10 << 0.05

Statistically highly significant association between exam pass rate and the variable PL YES/NO

Results 3: final exam pass proportion vs PL sessions attended

Final exam pass
(in the 1st session)



Pass proportion
vs
PL sessions attended

Question 4

Does the final exam pass proportion change as a result of the number of PL sessions attended?

Statistical association between this proportion and the number of PL sessions attended?

Results 3: final exam pass proportion vs PL sessions attended

Chi-square test

Expected P_i if NO association

Observed distribution

	PL sessions attended (Number)								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**TOT**
PASS (Number)	9	6	5	4	10	17	12	25	88
FAILURE (Number)	39	12	18	12	9	9	10	5	114
TOT (Number)	48	18	23	16	19	26	22	30	202
P_i (Pass proportion)	0.188	0.333	0.217	0.250	0.526	0.654	0.545	0.833	**0.436**

$P_i < 0.436$

$P_i > 0.436$

Lowest P_i

Highest P_i

Significant difference ?

Results 3: final exam pass proportion vs PL sessions attended

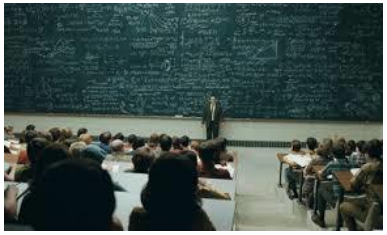
Test	Parameter	df	p-value
Chi-square	$\chi 2 = 45.53499134$	7	1,08E-07 << 0.05

Difference between **at least** one P_i couple is statistically highly significant

Statistical association between pass proportion and number of PL sessions attended

Conclusions

Integrated teaching method



Learning physics in large size classes

Final exam pass rate increasing

Dropout mitigation

Thanks

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Disegno della ricerca: contesto e partecipanti

- Matricole di Ingegneria Chimica e di Ingegneria dei Materiali e delle Nanotecnologie POLIMI
- Fisica sperimentale A+B (I semestre)
- Possibilità di seguire sia in presenza sia a distanza
- a. a. 2021/2022

Gruppo di studio (SG)
Studenti esposti al PL

- Criterio A (PLA): sessioni fatte > 50%
- Criterio B (PLB): items fatti > 50%

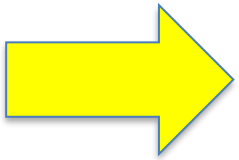
Gruppo di controllo (CG)
Studenti non esposti al PL

- Criterio A (PLA): sessioni fatte ≤ 50%
- Criterio B (PLB): items fatti ≤ 50%

Stesso docente, stesse lezioni ed esercitazioni

Risultati della ricerca: caratterizzazione iniziale 1

Livello di preparazione iniziale in Fisica



Matricole SG+CG
vs
matricole di altri docenti (A)

Domanda 1

SG+CG e A hanno uguale livello di preparazione iniziale?
(Misurato mediante punteggio in questionario iniziale)

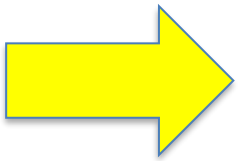
Statistica descrittiva

Squadra	Numero studenti (N)	Punteggio medio (S/18)	Errore standard (SE)	Deviazione standard (SD)
A	239	6.021	0.141	2.172
SG+CG	104	5.538	0.176	1.795

$S_A \neq S_{SG+CG}$ imputabile al caso?

Risultati della ricerca: caratterizzazione iniziale 1

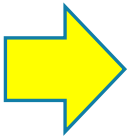
Livello di preparazione iniziale in Fisica



Matricole SG+CG
vs
matricole di altri docenti (A)

Test	Parameter	df	p-value	Effect Size	Meaning
Welch t-test	t = 2.1423	234.83	0.0332 < 0.05	d=0.234	Small

$S_A \neq S_{SG+CG}$
non imputabile al caso



Livello preparazione iniziale A migliore rispetto a SG+CG

Effect size	Very small	Small	Medium	Large	Very large	Huge
Cohen d (d)	0.01 ≤ d < 0.20	0.20 ≤ d < 0.50	0.50 ≤ d < 0.80	0.80 ≤ d < 1.20	1.20 ≤ d < 2.00	d ≥ 2.00

2009 S. Sawilowsky - Journal of Modern Applied Statistical Methods vol. 8 n. 2 art 26

Risultati della ricerca: caratterizzazione iniziale 2

Livello di preparazione iniziale in Fisica

SG (SI PL)
vs
CG (NO PL)

Domanda 2

SG e CG hanno uguale livello di preparazione iniziale?
(Misurato mediante punteggio in questionario iniziale)

Statistica descrittiva

Condizione PL	Squadra	Numero studenti (N)	Punteggio medio (S/18)	Errore standard (SE)
A	NO	41	5.537	0.266
	SI	63	5.540	0.235
B	NO	71	5.451	0.197
	SI	33	5.727	0.360

Non sembrano esserci grandi differenze tra NO e SI

Risultati della ricerca: caratterizzazione iniziale 2

Livello di preparazione iniziale in Fisica

SG (SI PL)
vs
CG (NO PL)

Normalità della popolazione

Shapiro-Francia test (PLA): $p_{CG} = 0.04373 < 0.05$ (No); $p_{SG} = 0.08490 > 0.05$ (Si)
Shapiro-Francia test (PLB): $p_{CG} = 0.03047 < 0.05$ (No); $p_{SG} = 0.05383 > 0.05$ (Si)

Omogeneità della varianza

Levene test (PLA): Pr(>F) = 0.4499 >> 0.05 (Si)
Brown-Forsythe test (PLA): Pr(>F) = 0.5718 >> 0.05 (Si)
Levene test (PLB): Pr(>F) = 0.136 >> 0.05 (Si)
Brown-Forsythe test (PLA): Pr(>F) = 0.1521 >> 0.05 (Si)

No normalità
si omogeneità varianza

- ANOVA robusta
- Mann-Whitney U-test

Risultati della ricerca: caratterizzazione iniziale 2

Livello di preparazione iniziale in Fisica

SG (SI PL)
vs
CG (NO PL)

Condizione PL	Test	Parameter	df	p-value	Effect Size	Meaning
A	ANOVA robusta	F = 0.1089	1; 53.36	0.74266 >> 0.05	ω = 0.0924	Negligible
	Mann-Whitney U	Z = 0.18563		0.8504 >> 0.05		
B	ANOVA robusta	F = 0.1408	1; 37.86	0.70954 >> 0.05	ω = 0.0675	Negligible
	Mann-Whitney U	Z = 0.18563		0.8504 >> 0.05		

$S_{NO} \neq S_{SI}$
imputabile al caso

Livello preparazione iniziale
SG e CG equivalente

Effect size	Negligible	Small	Medium	Large
Omega (ω)	0.00 ≤ ω < 0.10	0.10 ≤ ω < 0.243	0.243 ≤ ω < 0.371	ω ≥ 0.371

1996 R. E. Kirk - Educational and Psychological Measurement vol. 56 n. 5 746-759

Risultati della ricerca: tassi di promozione

Chi-squared test

Distribuzione osservata - PLA

PL	N° PROMOSSI	N° NON PROMOSSI	TOT
NO	24	81	105
SI	64	33	97
TOT	88	114	202

Distribuzione osservata - PLB

PL	N° PROMOSSI	N° NON PROMOSSI	TOT
NO	52	99	151
SI	36	15	51
TOT	88	114	202

Distribuzione attesa - PLA

PL	N° PROMOSSI	N° NON PROMOSSI	TOT
NO	45.74	59.26	105
SI	42.26	54.74	97
TOT	88	114	202

Distribuzione attesa - PLB

PL	N° PROMOSSI	N° NON PROMOSSI	TOT
NO	65.78	85.22	151
SI	22.22	28.78	51
TOT	88	114	202

Risultati della ricerca: tassi di promozione

Criterio PL	Test	Parameter	df	p-value	Effect Size 1 (Cramer's V)	Effect size 2 (Odds ratio)
A	Chi-squared test	$\chi 2 = 38.13533$	1	6.60E-10 << 0.05	0.434 (Relatively strong)	6.545 (Large or strong)
	Chi-squared test (correzione Yates)	$\chi 2 = 36.40155$	1	1.61E-09 << 0.05		
	Fisher's exact test			6.00E-10 << 0.05		
B	Chi-squared test	$\chi 2 = 20.2654$	1	6.74E-06 << 0.05	0.317 (Moderate)	4.569 (Large or strong)
	Chi-squared test (correzione Yates)	$\chi 2 = 18.8167$	1	1.44E-05 << 0.05		
	Fisher's exact test			8.34E-06 << 0.05		

Associazione tasso di promozione – PL statisticamente altamente significativa

Intensità di tale associazione significativa

$$\text{Odds ratio} = \frac{\text{Frequenza di promozione all'esame finale SG}}{\text{Frequenza di promozione all'esame finale CG}}$$

Effect size	Small (Weak)	Medium (Moderate)	Large (Strong)	Very large (Very strong)
Odds ratio (OR)	$1.50 \leq OR < 2.50$	$2.50 \leq OR < 4.00$	$4.00 \leq OR < 10.0$	$OR \geq 10.0$

1996 J. A. Rosenthal - Journal of Social Service Research vol. 21 n. 4 pp. 37-59