robotics — Swiss National Centre of Competence in Research

Are Primary School Computer Science curricular reforms achieving equity goals? Impact on student learning

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Early exposure to Computer Science (CS) & Computational Thinking (CT) is important

To broaden participation in the field & promote equity, two types of barriers need to be addressed (Wang & Hajazi Moghadam, 2017)

- **Structural barriers :** lack of access to Computer Science and Computational Thinking experiences
- **Social barriers :** often stereotype induced, arising despite equal access and similar socio-economic status

→ Lead to under-representation in the field

→ Require a system-wide implementation of Computer Science and Computational Thinking curricula for all students starting early foundational years (Ottenbreit-Leftwich & Yadav, 2022; Bers et al., 2022)

Early CS & CT experiences can help address performance gaps

Unequal access to (high-quality) CS education contributes to performance gaps (Wang & Hajazi Moghadam, 2017; Bers et al., 2022) w.r.t

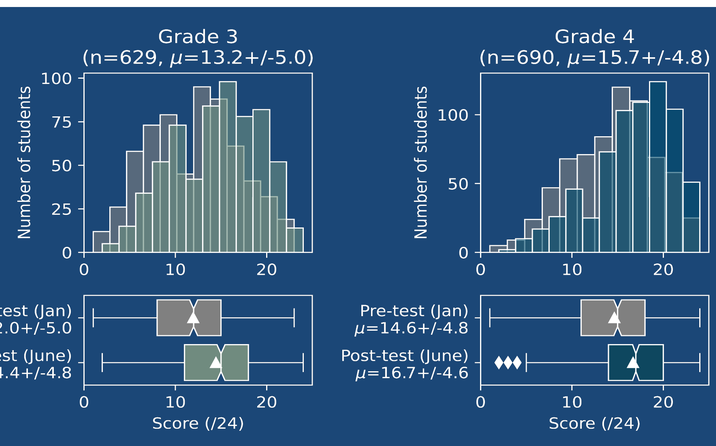
- **Socio-economic status :** Karpinski et. al (2021) found that students from "less advantaged backgrounds had lower levels of computer skills [...], especially in CT" (n=46'000 students)
- **Gender :** numerous studies have found that boys tend to perform better than girls (Román-González et al., 2017; Polat et al., 2021; Kong and Lai, 2022; El-Hamamsy et al., 2022), even in kindergarten (Sullivan & Bers, 2016)

But are curricular reforms contributing to learning and reducing performance gaps?

- Many initiatives are introducing CS & CT into formal K-12 education
- Curricular reforms and professional development programs are seldom evaluated at the student-level (Mason & Rich 2019; Kong & Lai 2022).
- The effectiveness of CS-curricular reforms in terms of student learning and learning gaps must be established to
  i) improve the proposed curricula and PD programs (Hickmott & Prieto-Rodriguez al. 2018)
  ii) sustain the changes in teachers' practices
  iii) alleviate concerns of funding agencies and government bodies (Hickmott & Prieto-Rodriguez al. 2018)

→ We evaluate the implementation of a regional CS-curricular reform with two student learning datasets involving 3383 grade 3-6 students from 7 schools through ANOVA and hierarchical regression

Students are progressing



Grade 3 Post > Pre	Δ = 2.485pts, p=0.0, D=0.51
Grade 4 Post > Pre	Δ = 2.048pts, p=0.0, D=0.436
Grade 4 Pre ~ Grade 3 Post	Δ = 0.201pts, p=0.44, D=0.042

Dataset: Grade 3-4 January 2021 & June 2021 test data, n=1319

Gender gaps appear to be closing

Grade 3 - Pre - Boys ~ Girls	Δ = 0.764pts, p=0.0526, **D=0.161**
Grade 3 - Post - Boys > Girls	Δ = 0.687pts, p=0.0422, **D=0.139**
Grade 4 - Pre - Boys ~ Girls	Δ = 0.727pts, p=0.0624, **D=0.151**
Grade 4 - Post - Boys ~ Girls	Δ = 0.211pts, p=0.5046, **D=0.046**

Dataset: Grade 3-4 January 2021 & June 2021 test data, n=1319

Performance gaps are closing but there is no direct link with what was taught

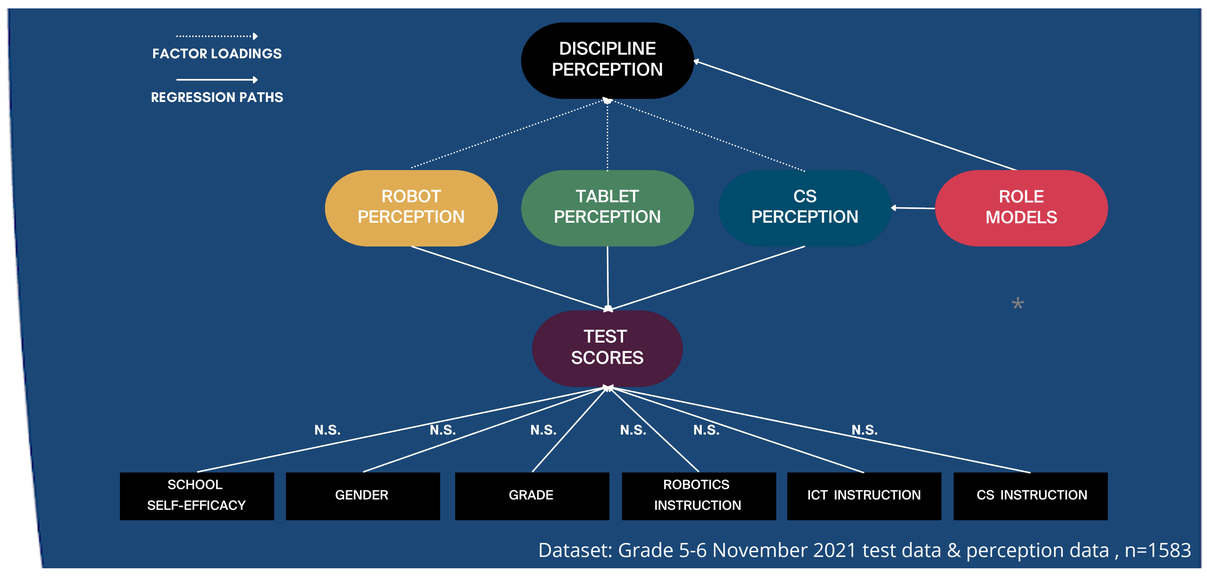
Students with lower performance at the pre-test are progressing more

Hierarchical regression model for student learning (Delta, n=989) with significant variables in bold. $R^2 = 0.285$, RMSE=2.89, AIC=5132, BIC=5225, Log-Likelihood=-2547. Abbreviations : NCS=Number of CS activities taught.

	Estimate	Std.Error	Degrees of Freedom	t-value	p-value
(Intercept)	7.11	1.04	922	6.86	p<0.0001
Pre-test score	-0.379	0.0722	922	-5.25	**p<0.0001**
Gender (girls)	0.697	1.18	922	0.591	0.555
Grade (4)	1.15	1.55	45	0.741	0.462
NCS	0.122	0.275	45	0.442	0.661
Pre-test score:Gender (girls)	-0.0221	0.0906	922	-0.243	0.808
Pre-test score:Grade (4)	-0.0383	0.101	922	-0.377	0.706
Gender (girls):Grade (4)	-0.880	1.86	922	-0.474	0.636
Pre-test score:NCS	-0.00386	0.0198	922	-0.194	0.846
Gender (girls):NCS	-0.346	0.311	922	-1.11	0.267
Grade 4:NCS	-0.260	0.478	45	-0.544	0.589
Pre-test score:Gender (girls):Grade (4)	0.0308	0.131	922	0.235	0.814
Pre-test score:Gender (girls):NCS	0.0224	0.0255	922	0.876	0.381
Pre-test score:Grade (4):NCS	0.00979	0.0326	922	0.300	0.764
Gender (girls):Grade (4):NCS	0.195	0.562	922	0.347	0.729
Pre-test score:Gender (girls):Grade (4):NCS	-0.0129	0.0412	922	-0.313	0.755

Dataset: Grade 3-4 January 2021 & June 2021 test data & teacher adoption data , n=989

Learning is unrelated to perception of CS



Dataset: Grade 5-6 November 2021 test data & perception data , n=1583

But it depends on teachers' perception of the professional development program

Hierarchical regression model for student learning with respect to student-, and teacher-level variables (Delta, n=1027 students in 57 classes in 6 schools). Significant variables are highlighted in bold. $R^2 = 0.279$, AIC=5386, BIC=5474, RMSE=3.04

Variables		Estimate	Std.Error	Degrees of Freedom	t-value	p-value
	(Intercept)	10.48	2.579	968	4.06	0.0001
Student-level	**Pre-test score**	-0.35	0.023	968	-15.54	**0.0000**
	Gender (girl)	0.17	0.198	968	0.84	0.4021
	Grade (3)	0.35	0.823	39	0.42	0.6746
	Grade (4)	1.15	0.814	39	1.41	0.1663
Teacher-perception	**CS-PD program evaluation**	**1.02**	0.344	39	2.96	**0.0053**
	CS utility perception	0.15	0.628	39	0.24	0.8122
	CS non-utility perception	0.27	0.600	39	0.45	0.6561
	CS autonomous motivation	-0.21	0.380	39	-0.54	0.5896
Teacher demographics	Age	-0.14	0.078	39	-1.83	0.0743
	Experience with informatics	0.01	0.036	39	0.41	0.6828
	Teaching experience	0.11	0.079	39	1.42	0.1640
	Digital education teaching experience	-0.10	0.104	39	-0.94	0.3552
	Perceived ICT competence	-0.57	0.376	39	-1.53	0.1345
	Perceived relative ICT competence	0.20	0.421	39	0.47	0.6387

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