Table S1. recent empirical and conceptual research that explored how virtual reality learning environments affect students' thinking and learning processes.

Study / Year	Participants and Context	Focus	Methodology	Findings	Relevance to current study
Makransky et al. (2021)	n = 153, university students in the VR lab	VRI and interactivity → motivation, learning outcomes	2×2 experiment; ANOVA and SEM	Immersion and interactivity enhance presence, agency, and learning	Studied affective mediators in VR but not SR, CRIT, or CRET as outcomes
Ariyati & Fitriyah (2024)	n = 35, Indonesian secondary school students	SR → critical and creative thinking	Pre–post test control group design	SR significantly improved CRIT and CRET	Did not examine VR immersion or flow as influencing SR
Hyytinen et al. (2021)	n = 1,045, Finnish university students	SR → critical thinking	Cross-sectional survey; SEM	Planning, monitoring, and evaluation predicted CRIT	Large-scale evidence lacks VR and flow integration
Ghanizadeh & Mizaee (2012)	n = 138, Iranian EFL learners	SR → CRIT and academic achievement	Correlational and regression analysis	SR positively predicted CRIT abilities	Language learning context: no VR or flow mediation
Ghabri & Harahsheh (2024)	n = 481, Saudi undergraduate students	SR and academic hope → CRET	Survey; regression analysis	SR significantly predicted CRET	No link to immersive environments or motivation/flow pathways
Filgona et al. (2020)	Nigerian secondary school students	Motivation → academic achievement	Structured questionnaire; regression	Intrinsic/extrinsic motivation predicted achievement	Focused on motivation, not mediated pathways through SR or flow
Macchi & De Pisapia (2024)	n = 40, employees in workplace VR vs. F2F vs. video	VR immersion → flow, creativity, decision-making	Within-subjects design; ANOVA	VR increased flow and creativity despite initial fatigue	Explores the VR–flow–creativity link, but not in an educational setting with students