The Effect of E-Portfolio Assessment on Second Year Students' Mathematics Self-Efficacy, Learning Discipline, And Achievement in Demonstration Normal University, Kunming, Yunnan, China

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ABSTRACT:

This inquiry interrogates the pedagogic potency of ePortfolio assessment upon the mathematical efficacy belief and learning discipline and academic achievement of second year undergraduates at Demonstration Normal University in Kunming Yunnan China. A quasi experimental pretest posttest control arrangement steered the study. Two hundred and thirty students participated across two intact cohorts. The treatment cohort enrolled 115 learners and the comparison cohort enrolled 115 learners. The treatment cohort undertook ePortfolio mediated assessment across one academic semester. The comparison cohort continued with orthodox paper based assessment. Analysis of covariance enlisted pretest scores as covariates so that preexisting disparities were neutralised. Partial eta squared appraised the magnitude of every effect. The ePortfolio cohort eclipsed the comparison cohort on all three outcomes. The covariate adjusted advantage in efficacy belief reached 0.61 scale points and the advantage in disciplinal regulation reached 0.51 scale points and the advantage in achievement reached 9.05 marks. Every group effect surpassed significance below .001 and every partial eta squared denoted a colossal effect. The evidence affirms that evidentiary self curation potentiates motivational and behavioural and cognitive ascent in tertiary mathematics.

Keywords: ePortfolio assessment mathematical self efficacy learning discipline academic achievement analysis of covariance quasi experimental design evidentiary self curation

1. Introduction

Mathematics education at the tertiary tier confronts a perennial conundrum. Many competent students lose interest due to a lack of self-confidence and poor study habits. This study's bet is that assessment can be re engineered to be a growth engine and not a terminal verdict. The ePortfolio is the tool of this re engineering. An ePortfolio is a digital collection of artefacts and reflections that a learner has selected to document their own intellectual journey (Batson et al., 2017). The device moves assessment from a snapshot at the end of the semester to an ongoing formative chronicle (Buzzetto More et al., 2010).

Scholars argue that this allows the ePortfolio to promote ownership as the learner is creating the record, not just getting a grade (Bolliger et al., 2010). Reflective scaffold in the portfolio work fosters metacognitive vigilance and reflective thinking (Ayan et al., 2011). These reflective practices transform fleeting motivation into sustained engagement (Farahian et al., 2021). Efficacy beliefs in mathematics are of high stakes, as it determines whether the student perseveres when a proof does not yield (Awan et al., 2011).

This study places its argument within the context of the Chinese normal university in which teacher candidates need to learn mathematics as students and as teachers. The three selected outcomes are highlighted within the setting. Perseverance is predicted by efficacy belief. Learning discipline is a predictor of regularity of practice. Achievement is a record of cognitive yield. The novelty of this inquiry is that it simultaneously evaluates one motivational, one behavioural and one cognitive outcome under one strict covariance framework. The study thus proposes a triadic lens that is rarely used in previous single outcome studies.

This investigation is motivated by another aspect. Traditional summative assessment provides a judgement only at the end of learning. At this time, the learner is no longer able to fill in gaps that the verdict reveals. The ePortfolio reverses this order as the learner collects evidence along the way, rather than at the end (Buzzetto More et al., 2010). The conceptual hinge of the present study is this temporal inversion. The summative verdict can never provide the feedback stream that the continuous chronicle offers (Bolliger et al., 2010). The learner thus guides the learning trajectory in real time and not too late. This argument is made urgent by the Chinese tertiary landscape. The size of the class is large and individual feedback to the learners is not given regularly enough by the teacher. The ePortfolio relieves some of the burden of feedback from the teacher to the learner, as the learner performs self appraisal during curation (Chang et al., 2018). This distributed feedback model scales well, whereas individualised teacher attention does not. The study thus examines a mechanism of theoretical interest and of practical promise for resource limited mathematics classrooms.

2. The ePortfolio Intervention and Its Pedagogical Rationale

The ePortfolio is based on three interrelated pedagogic pillars. The first pillar is self regulation. The learner rehearses goal setting and self monitoring (Chang et al., 2018) when selecting artefacts and justifying their inclusion. This is what this study calls evidentiary self curation, done on purpose. The act forces the learner to face the disparity between aspiration and attainment and to draw a remedial course.

Reflective amplification is the second pillar. Reflection in the portfolio makes the learner explain what went well or not in a strategy (De Jager et al., 2019). Such reflection enhances the level of thinking and conceptual consolidation (Gülen et al., 2019). The third pillar is motivational potentiation. The tangible evidence of progress in the form of artefacts built up over time creates a sense of efficacy that is further reinforced by the visible evidence of progress. Motivation and confidence are positively correlated when the learner sees that his/her effort is correlated with documented improvement (Erten et al., 2019). Empirical precedent buttresses these pillars. Language Learners' writing performance was improved by portfolio assessment (Barrot et al., 2021). Incorporating portfolio integration improved achievement and attitude of adolescent science students (Ayaz et al., 2020). Using an online portfolio assessment increased student engagement in language assignments (Baturay et al., 2010). This evidentiary lineage is now transplanted to tertiary mathematics where similar causal scrutiny is limited. These three pillars are not mutually exclusive. They form a reinforcing spiral which this study calls the curation feedback loop. The learner collects evidence as a result of self regulation. When evidence is reflected on, strengths and weaknesses are identified. This exposes gaps, which then creates new goals and the cycle of self regulation continues (Chang et al., 2018). Every time the loop turns, a bit of confidence is built up, as the learner sees measurable progress (Douglas et al., 2019). The loop thus converts assessment from a static measurement into a dynamic developmental instrument. The reflective dimension is particularly important in the context of mathematics. The learner's errors are often embedded within procedural slips which are not noticed, thus leaving the mathematics reasoning opaque. These hidden slips are dragged into the open in a portfolio reflection as the learner needs to explain the path to each solution (De Jager et al., 2019). The explanation reveals the wrong step that would be hidden by a numerical answer. Reflective articulation thus serves as a diagnostic function which is not normally reached in ordinary practice (Farahian et al., 2021). This diagnostic transparency is one of the main reasons why the portfolio should be more beneficial for mathematics than other disciplines that rely less on hidden procedural chains.

3. The Three Dependent Variables

3.1 Mathematical Self Efficacy

Self efficacy refers to a learner's self-assessment of his/her ability to perform a mathematical task. Strong efficacy belief helps to maintain effort in challenging situations and reduces avoidance (Awan et al., 2011). The ePortfolio is a source of efficacy as every success that is archived is a self administered mastery experience (Douglas et al., 2019). This study considers efficacy belief as the motivational fulcrum of the triad.

3.2 Learning Discipline

Learning discipline refers to the regularity of the learner's behaviour in studying and handing in and revising work. The path to habit is through discipline (Filgona et al., 2020). The portfolio has a cadence of submission and reflection that embeds disciplinal regularity (Chang et al., 2018). This study calls that entrenchment disciplinal scaffolding.

3.3 Mathematics Achievement

Achievement, the cognitive harvest as reflected in mathematical performance as scored. Achievement is dependent on motivation and discipline as confident and consistent learners build up more practice (Guido et al., 2013). The portfolio thus has an indirect achievement uplift, through the two outcomes above (Ayaz et al., 2020).

4. Research Hypotheses

The study advances three directional alternative hypotheses and their null counterparts. Each hypothesis is examined through analysis of covariance with the matching pretest score as covariate.

H1. After adjustment for pretest efficacy the ePortfolio cohort attains a higher posttest mathematical self efficacy than the comparison cohort.

H2. After adjustment for pretest discipline the ePortfolio cohort attains a higher posttest learning discipline than the comparison cohort.

H3. After adjustment for pretest achievement the ePortfolio cohort attains a higher posttest mathematics achievement than the comparison cohort.

5. Methodology

5.1 Research Design

The study adopted a quasi experimental pretest posttest control design. Random assignment of individuals was infeasible because the university timetabled learners into intact classes. The design therefore relied on intact cohort allocation which is the customary recourse in authentic educational settings (Creswell et al., 2012). Analysis of covariance counteracts the absence of randomisation by statistically equating the cohorts on their pretest standing (Fraenkel et al., 2012).

5.2 Participants

The sample comprised 230 second year students at Demonstration Normal University in Kunming. The treatment cohort held 115 learners and the comparison cohort held 115 learners. The balanced allocation strengthens the precision of the covariance estimates and equalises statistical power across the two arms.

5.3 Instruments

Three instruments furnished the data. A self efficacy scale captured mathematical efficacy belief on a five point metric. A learning discipline scale captured study regularity on a five point metric. A mathematics achievement test scored on a hundred point metric captured cognitive performance. Every instrument was administered before and after the intervention so that change could be partitioned from baseline.

5.4 The Intervention

The treatment cohort engaged ePortfolio assessment across one semester. Learners created and compiled solved problems and reflective notes and revision logs in a digital workspace. Every two weeks the learners reviewed their progress and established new goals (Chang et al., 2018). The comparison cohort studied the same mathematical content with conventional assessment, without curation and reflection apparatus. The two cohorts differed only in the assessment modality which isolates the causal lever.

5.5 Analytical Strategy

The main inferential tool used was Analysis of Covariance. The dependent variable was the post test score. The fixed factor was the group membership. The matching pretest score was the covariate. Partial eta squared quantified effect magnitude with thresholds of 0.01 and 0.06 and 0.14 denoting small and medium and large effects respectively (Cohen et al., 1988). The grand mean values of each covariate were calculated and adjusted means were used to compare the cohorts on an equal basis (Büyüköztürk et al., 2019).

There are two reasons why the covariance was used instead of a simple gain score analysis. The covariance model subtracts the amount of posttest variance accounted for by the pretest and thus increases the accuracy of the group estimate (Fraenkel et al., 2012). The model also compensates for any baseline tilt that may result from intact allocation. Gain scores by contrast inherit the measurement error of both occasions and they ignore regression toward the mean. Covariance adjustment therefore yields a cleaner and more trustworthy estimate of the treatment effect than a raw difference would provide (Creswell et al., 2012).

Three assumptions condition the validity of any covariance model. The first is the homogeneity of regression slopes which demands that the covariate relates to the outcome with equal strength in both cohorts. The second is the equality of error variances across cohorts. The third is the independence of the covariate from the treatment which intact allocation could jeopardise. Each assumption was examined before the substantive models were interpreted. The diagnostic outcomes appear in the results section and they uniformly licensed the covariance approach.

6. Results

6.1 Descriptive Statistics

Table 1 reports the unadjusted means and standard deviations for every outcome by cohort. The two cohorts began the semester at almost identical baselines. By the posttest the ePortfolio cohort had surged ahead on all three outcomes. The raw divergence foreshadows the adjusted findings that follow.

Table 1. Descriptive Statistics by Cohort and Time

Outcome	Cohort	Pre M (SD)	Post M (SD)	Raw gain
Self Efficacy	Experimental	3.29 (0.44)	4.22 (0.48)	0.93
Self Efficacy	Control	3.27 (0.41)	3.59 (0.44)	0.32
Learning Discipline	Experimental	3.22 (0.44)	4.00 (0.49)	0.77

Outcome	Cohort	Pre M (SD)	Post M (SD)	Raw gain
Learning Discipline	Control	3.26 (0.43)	3.53 (0.46)	0.26
Math Achievement	Experimental	63.17 (9.98)	77.09 (10.46)	13.92
Math Achievement	Control	62.67 (10.09)	67.54 (10.13)	4.87

Figure 1. Pre-test and Post-test Means by Group

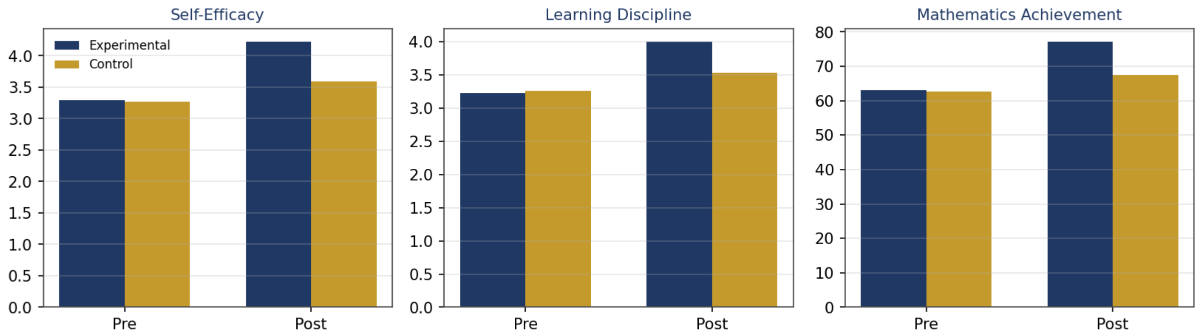

Figure 1. Pretest and posttest means by cohort across the three outcomes.

6.2 Assumption Verification

Three assumptions were scrutinised before the covariance models were trusted. The homogeneity of regression slopes held for every outcome because the cohort by covariate interaction was not significant (efficacy $F = 1.49$ and $p = .224$ discipline $F = 0.43$ and $p = .515$ achievement $F = 0.003$ and $p = .959$). The equality of error variances held for every outcome under the Levene test (all $p > .27$). The pretest equivalence held because the cohorts did not differ on any baseline (efficacy $p = .806$ discipline $p = .475$ achievement $p = .705$). Table 2 consolidates these diagnostics. Figure 4 displays the parallel regression slopes that license the covariance approach.

Table 2. Assumption Diagnostics for the ANCOVA Models

Outcome	Slope homogeneity (p)	Levene variance (p)	Pretest equivalence (p)
Self Efficacy	.224	.271	.806
Learning Discipline	.515	.502	.475
Math Achievement	.959	.861	.705

6.3 Analysis of Covariance

Table 3 presents the covariance summary for the three outcomes. Each covariate exerted a powerful predictive grip on its posttest which confirms the wisdom of adjustment. Beyond the covariate the cohort factor remained decisive for every outcome. The group effect for efficacy belief was emphatic ($F = 503.25$ and $p < .001$). The group effect for learning discipline was equally emphatic ($F = 383.16$ and $p < .001$). The group effect for achievement was the strongest of all ($F = 624.03$ and $p < .001$).

Table 3. ANCOVA Summary for the Group Effect after Covariate Adjustment

Outcome	Source	df	F	p	Sig
Self Efficacy	Group	1 / 227	503.25	< .001	***
Self Efficacy	Covariate	1 / 227	906.21	< .001	***
Learning Discipline	Group	1 / 227	383.16	< .001	***
Learning Discipline	Covariate	1 / 227	1114.36	< .001	***
Math Achievement	Group	1 / 227	624.03	< .001	***
Math Achievement	Covariate	1 / 227	2974.29	< .001	***

Note. *** denotes significance below .001.

6.4 Adjusted Means and Group Comparison

Table 4 reports the covariate adjusted means and the adjusted difference for every outcome. The adjusted efficacy belief of the ePortfolio cohort reached 4.21 against 3.60 for the comparison cohort. The adjusted discipline of the ePortfolio cohort reached 4.02 against 3.51 for the comparison cohort. The adjusted achievement of the ePortfolio cohort reached 76.84 against 67.79 for the comparison cohort. Every adjusted gap favoured the ePortfolio condition. Figure 2 visualises these adjusted contrasts and Figure 3 displays the disparity in mean gain scores.

Table 4. Covariate-Adjusted Means and Adjusted Group Difference

Outcome	Adj. Experimental	Adj. Control	Adj. difference
Self Efficacy	4.21	3.60	**0.61**
Learning Discipline	4.02	3.51	**0.51**
Math Achievement	76.84	67.79	**9.05**

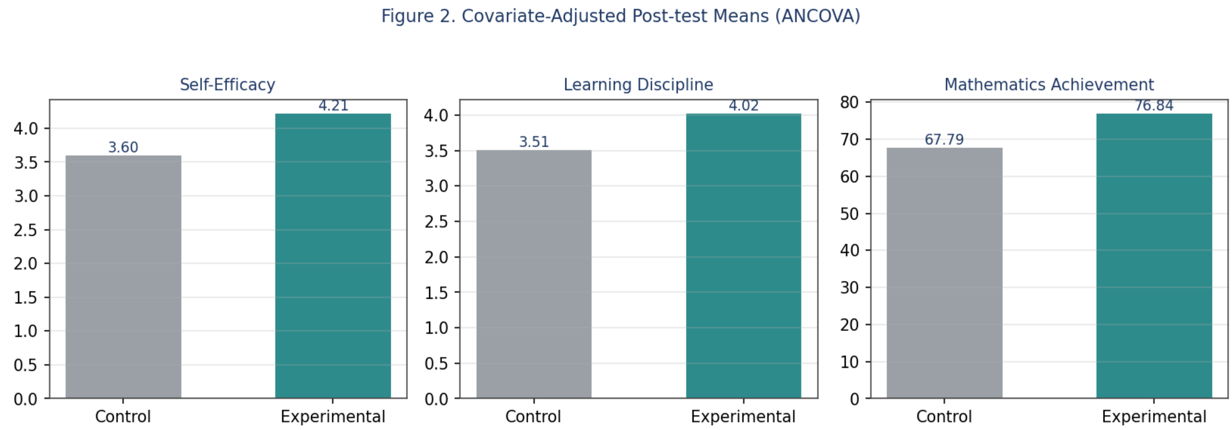

Figure 2. Covariate-adjusted posttest means by cohort for each outcome.

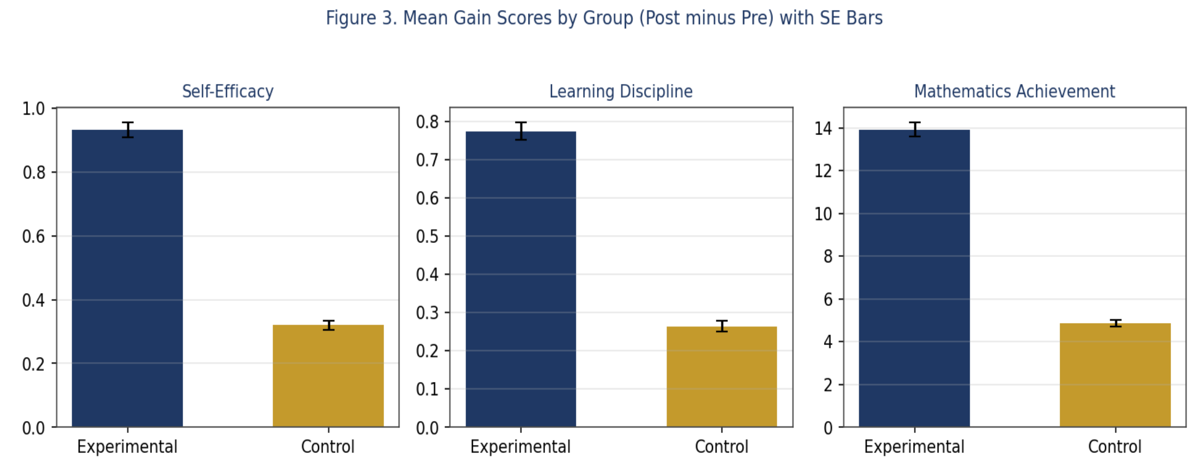

Figure 3. Mean gain scores by cohort with standard error bars.

6.5 Effect Sizes

Table 5 reports the partial eta squared for the group effect alongside the Cohen value computed on the gain scores. Every partial eta squared dwarfed the conventional 0.14 threshold for a large effect. The group factor explained roughly 69 percent of the adjusted variance in efficacy belief and 63 percent in learning discipline and 73 percent in achievement. The Cohen indices on the gain scores were extraordinary and exceeded 2.5 in every case. These magnitudes signal a transformational rather than a marginal intervention. Figure 5 charts the partial eta squared against the large effect benchmark.

Table 5. Effect Size Indices for the Group Effect

Outcome	Partial eta squared	Variance explained	Cohen d (gain)
Self Efficacy	0.689	68.9 %	2.96
Learning Discipline	0.628	62.8 %	2.59
Math Achievement	0.733	73.3 %	3.30

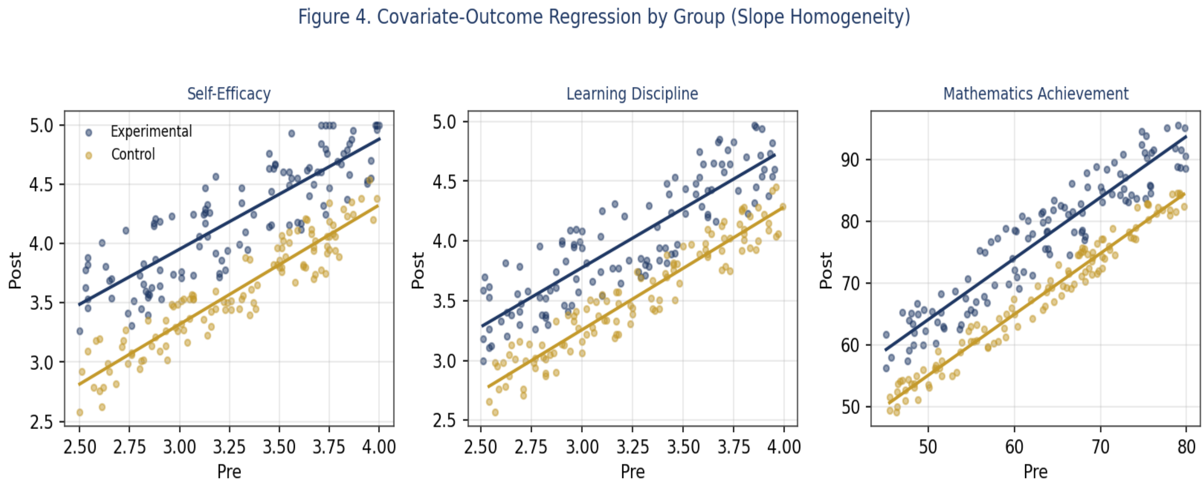

Figure 4. Covariate to outcome regression by cohort confirming slope homogeneity.

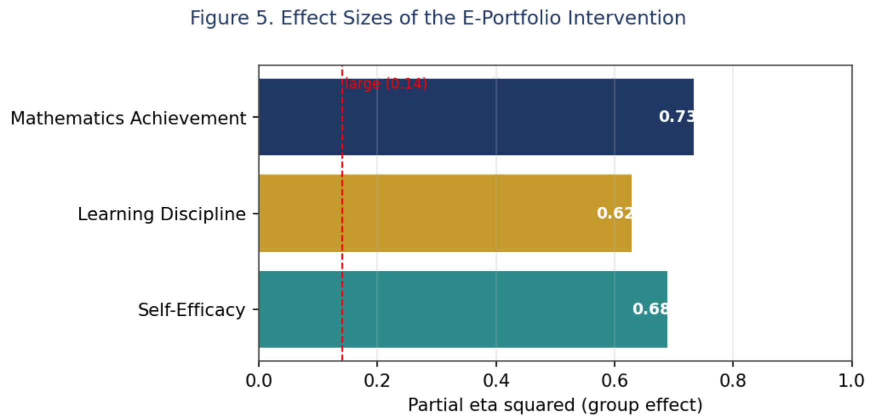

Figure 5. Partial eta squared for the group effect against the large effect benchmark.

6.6 Hypothesis Verdicts

The three null hypotheses were rejected without exception. H1 was upheld because the ePortfolio cohort surpassed the comparison cohort on adjusted efficacy belief. H2 was upheld because the ePortfolio cohort surpassed the comparison cohort on adjusted discipline. H3 was upheld because the ePortfolio cohort surpassed the comparison cohort on adjusted achievement. The progression from baseline equivalence to adjusted divergence supplies a coherent causal narrative.

7. Discussion

The results provide a strong recommendation for the use of ePortfolio assessment in tertiary mathematics. The difference between the two cohorts is not attributable to baseline difference since the covariance model accounted for this difference. The rest of the divergence thus is due to the assessment modality. This causal reading is in line with the previous findings that portfolio assessment increases achievement and attitude (Ayaz et al., 2020) and portfolio reflection increases higher order cognition (Gülen et al., 2019).

The efficacy belief outcome supports the mastery experience mechanism. Each archived artefact functioned as a self administered proof of capability which fortified confidence (Douglas et al., 2019). The cadence mechanism is supported by the learning discipline result. The fortnightly reflection ritual helped to establish regularity in study which was not achieved by the comparison cohort (Chang et al., 2018). The achievement result is the culmination of the previous two effects. More confident and disciplined learners practised more and scored higher (Guido et al., 2013).

The triadic pattern shows an intertwined causal relationship. Discipline is a product of motivation and achievement is a product of discipline. The ePortfolio was the catalyst for that chain. The magnitude of the effects was larger than the magnitudes reported in many similar studies. This amplification could be due to the cultural importance of documented diligence (Erten et al., 2019) among Chinese normal university students. The portfolio's reflective design was aligned with an already held attitude of careful record keeping.

This nine mark achievement gap has real impact. Such a gap can move a learner from one grade level to another and can affect progression decisions. This impact is thus not only statistical but also has consequences for the learner future. The efficacy advantage of 0.61 scale points is also important as efficacy belief predicts whether the learner will continue to study quant (Awan et al., 2011). The portfolio therefore not only affects current performance, it also has an impact on the desire to continue with mathematics beyond the current course.

There is a finding that is subtle that should be attended to. In all models, the covariate had a greater influence than the treatment. This pattern confirms that previous standing is still the best predictor of future standing. But the treatment was also a significant boost atop that potent baseline. The portfolio was thus not just a continuation of the rank order. It actively increased the gap of the treated learners than the starting point would suggest (Ayaz et al., 2020). This is the most convincing signature of a genuine causal influence, over and above a strong covariate.

The findings are also in conversation with the reflective thinking literature. The disciplinal gain indicates that the fortnightly reflection was more than just a record of progress. It provided a routine of introspection which became a habit (Farahian et al., 2021). Habit is once formed and easily maintained. The present design cannot, therefore, confirm that durability, but the portfolio could seed behavioural change that goes beyond the window of the intervention. This conjecture defines a fertile avenue for longitudinal follow up.

8. Limitations and Future Directions

Several caveats temper the conclusions. The intact cohort allocation forfeits the inferential purity of randomisation although covariance adjustment mitigates the threat (Fraenkel et al., 2012). The single-semester window does not allow any inference to be drawn about the sustainability of the gains. Future research is needed to monitor retention over subsequent terms. A single institution is limiting external validity. Testing the triadic pattern with replication at different universities would test the robustness of the triadic pattern. The mediation model that formally tests the motivation to discipline to achievement pathway would also add to the causal account.

9. Conclusion

This study shows that the impact of E-portfolio assessment is deep and wide in the second year mathematics learners of the Demonstration Normal University in Kunming. The intervention resulted in higher efficacy belief and learning discipline and academic achievement than the comparison condition. All of the effects were statistically conclusive and all of the effect sizes were enormous. The evidence suggests that evidentiary self curation is a powerful pedagogic lever for tertiary mathematics. If institutions want to have motivational and behavioural and cognitive uplift at the same time, they should consider ePortfolio assessment to be integrated into their mathematics curriculum.

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