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What studying problems are faced by the adolescent grade repeaters in Macao: uncovering underlying mechanisms based on evidences from the PISA 2012 Study

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Abstract Most schools in Macao are private schools, and there is a variety of grade repetition policy practiced in the 45 secondary schools. The policies are translated into school-based accountability of some kind of minimum competency standards. The objective of this study is to uncover the mediation mechanisms accounting for the influences of grade repetition on student performance. Three mechanisms are postulated to explain the performance of the adolescent grade repeaters: (1) insufficient opportunity to learn, (2) inadequate self-regulation of students, and (3) inappropriate teacher guidance and management. Based on the Programme for International Student Assessment 2012 Study, the three identified mechanisms (involving eight mediation variables) together explain 0.7 grade level worth of schooling. The implication is that unless remedial programs and courses of action for the grade repeaters can be shown empirically to be effective, it is not a good idea for Macao schools to maintain their grade repetition policies without teachers' proper guidance and instruction.

Keywords Grade repetition · Mathematics literacy performance · Mediation analysis · PISA · Macao

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The three thorny issues of grade repetition

In Macao, grade repetition is undertaken in schools as early as at the primary grade levels. It is a school-based policy adopted by nearly every school in order to remediate academic or other deficiencies. Because of Macao's very high rate of grade repetition reported in PISA assessments (OECD 2011, 2012, 2014), there are fervent calls of the stakeholders to school principals to reduce this alarming rate and answer queries regarding the effectiveness of the courses of action presumed to help the adolescent grade repeaters (Lei 2014; The Chinese Educators of Association of Macau 2014). Most schools in Macao are private, and they need to show accountability and standards to attract student enrollment. Hence, many school principals uphold that grade repetition is a useful quality assurance mechanism. Believing that their remedial programs are effective, principals are very reluctant to abolish this longstanding policy for fear that there will be a decline of student achievement. According to Macao Law, all registered schools are fully autonomous. So, the grade promotion/repetition policy is entirely at the disposal of the individual school, and every school in Macao sets its own passing criteria at a level that ensures a certain proportion of students proceeding through the grades at the expected rate.

The crux of the grade repetition problem is that schools do differ in practices on how to help the struggling

repeaters to remediate their academic (and, perhaps, behavioral) deficiencies to progress to the next grade in the next academic year. Up to now there is still a lack of research evidence supporting the argument that students who repeat a grade do better academically after the remediation, nor is there evidence showing that students who repeat a grade would be worse-off if they had been promoted (Jimerson 2001). For the best courses of action recommended for helping the grade repeaters, the challenge to teachers is to figure out what it takes to help the struggling learners catch up and understand why they have fallen behind their peers. When suggesting the best courses of action there is a need for the teachers to answer the important question: "After all, why should repeating the same schooling experiences for another academic year produce a different and better result for the struggling learners?" Regarding this, three issues engender the three hypotheses examined in this study: (1) insufficient opportunity to learn; (2) inadequate student self-regulation, and (3) inappropriate teacher guidance and management. These three issues succinctly recapitulate the three key concerns of a large-scale investigation on grade repetition in Macao (The Chinese Educators of Association of Macau 2014). As the concerns are mainly based on the views of teachers and principals, empirical evidences based on the views and academic performances of the grade repeaters and non-repeaters in a full student cohort are yet to be sought and examined thoroughly.

Previous research

In a review of educational research some 40 years ago, Jackson (1975) concluded that research evidence was not sufficient to support that grade repetition is more beneficial than grade promotion. Later review conducted by Homes and Matthews (1984) revealed that grade promotion instead is more beneficial than grade repetition in terms of academic achievement, attitudes, and personal adjustment. In a more recent review, Brophy (2006) asserted that school-imposed grade repetition is particularly stressful to students, and is often associated with reduced self-esteem, impaired peer relationships, and alienation from school. Although hundreds of studies have been undertaken on grade repetition in the past century, there is still a lack of research documenting the educational experiences of students who are not promoted.

In Programme for International Student Assessment (PISA) 2012 Study, Macao tops the other 63 economies in grade repetition (OECD 2014, p. 2). Of Macao's 15-year-olds, 41.2 % have repeated in primary and/or junior secondary grades, and as a result most repeaters study in grade levels below the modal grade (Cheung et al. 2013). In addition, in the *PISA in Focus* report, 48 % of Macao's disadvantaged 15-year-olds have repeated a grade at least once (OECD 2014, p. 3). While it is not possible to make use of the PISA 2012 data to find out why Macao students have undergone grade repetition, it is feasible to conduct mediation analyses to unveil the processes underlying the influences of grade repetition on mathematics literacy performance. The processes or mechanisms, if identified, will expose the educational experiences of the struggling learners and point to new directions to help them. With this, the present study seeks to verify three hypotheses regarding the mediation effects of grade repetition of Macao's adolescents.

Opportunity to learn

One argument in favor of the grade repetition is that students who have not met grade-level criteria will fall further and further behind their peers as they move through the grades. Hence, whether a struggling learner is able to benefit more from repeating a grade, or from moving ahead with his/her same-age peers, hinges upon whether he/she has the opportunity to learn the requisite course contents and materials for the onward promotion to the next grade level of study. If repetition means duplication of an entire academic year of schooling without early diagnosis and targeted intervention, seeking to make use of the extra time in more instructionally effective ways, struggling learners are unlikely to catch up to the school's stipulated minimum competence standards and meet the criteria required for grade promotion. Bock's (1977) review of studies concluded that grade repetition is not an effective device to ensure greater mastery of elementary school subject matter. Rose et al. (1983) also come to a similar conclusion. The consequence of grade repetition without appropriate courses of action is that retention leaves the struggling learners who are already lagging behind their same-age peers even further and further behind.

Student self-regulation

Grade repetition/retention, in the eyes of the struggling learners, is often a sign of academic failure, and this perception has deleterious effects on their cognitive and affective development (Holmes 1989; McCoy and Reynolds 1999; Meisels and Liaw 1993; Rose et al. 1983). From the self-regulatory learning perspective (Pintrich and De Groot 1990; Pintrich 2004), grade repetition requires the struggling learners academic resiliency so as to circumvent the adversities ahead of them, and a number of cognitive and emotional traits which are central to the functioning of the brain manifested during learning, such as self-efficacy, self-concept, motivation, and anxiety, are

affected (Anderson et al. 2005; Finlayson 1977; Goodlad 1954; Pajares 1996; Pajares and Schunk 2001; Pintrich 2003a, b; White and Lee 1973; Wigfield et al. 2012; Wu et al. 2010). Research in past decades shows that influences of the academic failures are generally adverse, affecting strongly on student learning, career opportunities, and even adult employment in the long run (Eide and Showalter 2001; Jacob and Lefgren 2009; Jimerson 1999, 2001; Reshly and Christenson 2013; Yamamoto and Byrnes 1987). The situation is even worse for the overage grade repeaters studying below the modal grade for an additional year or more (Morrison and Perry 1956). On the other hand, because of the improved research methodology, there emerged recently research findings suggesting that grade repetition may *not* have the negative effects so widely reported in the literature (Allen et al. 2009; see Cham et al. 2014).

Teacher guidance and management

Although grade repetition is an intervention based on the school's good intentions and offers a second chance to the repeaters, this practice does have serious psychosocial consequences. On the one hand, grade repeaters are generally overage and most have adjustment problems which may not be treated sympathetically by their younger peers (Morrison and Perry 1956). Peer rejection, victimization, and exclusion affect grade repeater's self-concept, school engagement, and adjustment, and these have mediating effects on academic performance (Buhs 2005). On the other hand, some grade repeaters who are anxious, inattentive, and disruptive have their behaviors worsened after an extended period of grade repetition (Pagani et al. 2001). This deterioration of behaviors is often long lasting and is more pronounced when grade repetition occurs early in the primary schooling. Regarding this, teachers who are responsible for taking care of the grade repeaters are required to exercise appropriate teacher guidance and management of disruptive classroom behaviors.

Motivational dynamics of engagement and disaffection

According to Deci and Ryan's (1985, 2000) self-determination theory (SDT), there are three fundamental psychological needs of human beings: (1) relatedness, need to have close affectionate relationships with others; (2) competence, need to be effective in dealing with the social and physical environments; and (3) autonomy, need to control the course of our lives. SDT posits that when these needs are met satisfactorily by means of challenging tasks and worthwhile activities, students will engage

constructively with them. Recently, based on SDT, Skinner and Pitzer (2012) develop a conceptual model explaining the motivational dynamics of engagement and disaffection. This model is useful for an integrative understanding of the three mediational processes of grade repetition uncovered in this study: (1) insufficient opportunity to learn, (2) inadequate self-regulation of students, and (3) inappropriate teacher guidance and management. According to this model, school contexts differentially provide students with opportunities (e.g., through provision of graded mathematics instruction, homework and assignments, and classroom management of class activities) with due attention paid to affectionate relationships, orderly lesson structure, and autonomous academic support so as to fulfill their fundamental psychological needs. Based on these experiences with teachers and peers, students construct self-system processes (e.g., self-efficacy, self-concept, interest, and anxiety) which are organized around relatedness, competence, and autonomy, resulting in constructive engagement and positive effects on student learning and achievement.

Pragmatic grounding of the hypotheses of the grade repetition mechanisms examined in this study

There are a few observations regarding the mathematics education of the adolescent grade repeaters in Macao. These observations furnish the pragmatic grounding of three hypotheses to be examined for statistical and educational significance in this study (see also, The Chinese Educators of Association of Macau 2014 for an inspiration of these observations).

The first observation is that many grade repeaters, after an additional year of schooling, have not yet familiarized themselves with some basic mathematics concepts that should have been remediated during their grade repetition period. At the same time, because of grade repetition, they do not have the opportunity to learn those basic mathematics concepts that should be learned at the higher grade levels should they be allowed for promotion to those levels. Regarding this observation, the following hypothesis is proposed for examination in this study:

Hypothesis 1 *(H1)* Regardless of the economic, social, and cultural status (ESCS) and gender of student, *familiarity with mathematics concepts* learned in the junior secondary grade levels and *experiences with pure mathematics tasks* learned in the senior secondary levels mediate the effects of grade repetition on student mathematics literacy performance.

The second observation is that proliferation of grade repetition in Macao schools as a quality education

assurance policy hits a hard blow on the psychological minds of the struggling learners. Grade repeaters are therefore likely not self-regulatory learners, who generally fall short of mobilizing their efforts to acquire the requisite knowledge and skills in their studies. Their academic self-efficacy beliefs and self-regulatory processes in terms of self-observation, self-judgment, and self-reaction are also far from satisfactory. Regarding this observation, guided by Skinner and Pitzer's (2012) conceptual model of motivational dynamics of engagement and disaffection, the following hypothesis is examined in this study:

Hypothesis 2 *(H2)* Regardless of the ESCS and gender of student, learning mathematics variables such as *mathematics self-efficacy*, *mathematics self-concept*, *mathematics interest*, and *mathematics anxiety* mediate the effects of grade repetition on student mathematics literacy performance.

The third observation is that sending the struggling learners to study the same course materials using the same instructional methods poses classroom management and homework guidance problems. In classes with a high proportion of grade repeaters, some teachers may find it difficult to keep the class orderly and start lessons on time. Without appropriate teacher guidance, students are not remediated well the course materials that should have been mastered in the previous years of schooling. Regarding this observation, again guided by Skinner and Pitzer's (2012) conceptual model of motivational dynamics of engagement and disaffection on learning and achievement, and in the light of the findings of mediational effects of the engagement of ICT-related tasks on performance in Chan's (2012) study based on PISA 2006 study data, the following hypothesis is proposed for investigation in this study:

Hypothesis 3 *(H3)* Regardless of the ESCS and gender of student, classroom process variable such as *mathematics teacher's classroom management* and teacher guidance variable such as *ICT use at home for school-related tasks* mediate the effects of grade repetition on mathematics literacy performance.

Method

Participants

The data used in this study are drawn from the database of Macao's PISA 2012 Study (see Cheung et al. 2013; OECD 2013a, b). Because all eligible students are included, the Macao Study with valid data ($N = 5335$) is essentially a census of mathematics learning processes and outcomes of 15-year-old students studying in the 45 secondary schools in Macao. Table 1 presents the grade level studied of the grade repeaters and non-repeaters in the Macao PISA 2012 sample, broken down by gender.

Measures

The dependent variable of the mediation analyses is mathematics literacy performance, the rotated test design of which affords each student to be measured by a set of five plausible values (MATHPVs). Regarding this, plausible value analysis is needed (OECD 2009). The PISA mathematics literacy performance is considered an appropriate dependent variable in grade repetition research because this measure is not curriculum-specific to any grade level of study, and it measures the cumulative effects of primary and secondary mathematics schooling of a 15-year-old student, whether he/she has been repeated or not in his/her earlier grades of study. In addition, mathematics is also a key subject considered for promotion/retention in Macao schools.

The independent variable is grade repetition during primary and secondary education: REPEAT = 0 (not repeated); REPEAT = 1 (has repeated one time or more). There are two other independent variables serving as covariates in the mediation analyses, namely GENDER and ESCS. GENDER is a dichotomous variable: female = 0 and male = 1, whereas ESCS is a continuous variable standardized across the 34 OECD countries participating in PISA 2012, with mean = 0 and SD = 1.

The variables used as mediation variables in this study are the eight mathematics education quality indicators identified for school improvement in Macao (Cheung et al. 2013, p. 34). The Pearson correlation between these indicators with mathematics literacy performance ranges from 0.15 to 0.51 (all except mathematics anxiety the other correlations are positive).

The mediation variables selected for use in the examination of the aforementioned three hypotheses are:

- Familiarity with mathematical concepts (FAMCON);
- Experience with pure mathematics tasks at school (EXPUREM);
- Mathematics self-efficacy (MATHEFF);
- Mathematics self-concept (ANSCMAT);
- Mathematics interest (ANINTMA);
- Mathematics anxiety (ANXMAT);
- Mathematics teachers' classroom management (ANCLSMA);
- ICT use at home for school-related tasks (HOMSCH).

Table 2 presents some sample items in the PISA 2012 student questionnaire. Student responses to these items are used to scale the mediation variables of this study (OECD 2013b). The Cronbach alpha reliabilities are also presented.

Table 1 Distribution of the grade level studied of the 15-year-old grade repeaters and non-repeaters in the Macao PISA 2012 sample, broken down by gender

Grade level studied	Male		Female		Total	
	Non-repeat	Repeat	Non-repeat	Repeat	Non-repeat	Repeat
7	5	187	3	88	8	275
8	38	483	17	326	55	809
9	342	564	367	493	709	1057
10	1072	20	1265	21	2337	41
11	6	0	17	0	23	0
12	1	0	0	0	1	0
Total	1464	1254	1669	928	3133	2182

Note: Number of students with missing data is 20

Table 2 Sample items and reliabilities of potential mediation variables in the PISA 2012 student questionnaire

Mediation variables	Reliabilities	Sample items
Familiarity with mathematical concepts (FAMCON)	0.837	Thinking about mathematical concepts: How familiar are you with the following terms?
		Rational number. (16 items/5-point Likert scale from "Never heard of it" to "Know it well, understand the concept")
Experience with pure mathematics tasks at school (EXPUREM)	0.890	How often have you encountered the following types of mathematics tasks during your time at school?
		Solving an equation like $6x^2 + 5 = 29$. (3 items/4-point Likert scale from "Frequently" to "Never"
Mathematics self-efficacy (MATHEFF)	0.855	How confident do you feel about having to do the following mathematics tasks?
		Understanding graphs presented in newspapers. (8 items/4-point Likert scale from "Very confident" to "Not at all confident")
Mathematics self-concept (ANSCMAT)	0.898	Thinking about studying mathematics: To what extent do you agree with the following statements?
		I am just not good at mathematics. (5 items/4-point Likert scale from "Strongly agree" to "Strongly disagree")
Mathematics interest (ANINTMA)	0.899	Thinking about your views on mathematics: To what extent do you agree with following statements?
		I enjoy reading about mathematics. (4 items/4-point Likert scale from "Strongly agree" to "Strongly disagree")
Mathematics anxiety (ANXMAT)	0.861	Thinking about studying mathematics: To what extent do you agree with the following statements?
		I feel helpless when doing a mathematics problem. (5 items/4-point Likert scale from "Strongly agree" to "Strongly disagree")
Mathematics teacher's classroom management (ANCLSMA)	0.717	Thinking about the mathematics teacher who taught your last mathematics class: To what extent do you agree with the following statements?
		My teacher keeps the class orderly. (4 items/4-point Likert scale from "Strongly agree" to "Strongly disagree")
ICT use at home for school-related tasks (HOMSCH)	0.796	How often do you use a computer for the following activities outside of school?
		Doing homework on the computer. (7 items/5-point Likert scale from "Never hardly ever" to "Every day")

Analytic strategies

Figure 1 depicts the relationships of three kinds of variables (IV, DV, and MV) formulated in Baron and Kenny's (1986) mediation analysis. A mediator (MV) carries the influence of an independent variable (IV) onto a dependent variable (DV). Pedagogically, it indicates the underlying educational processes through which the IV exerts its effect on the DV. Four criteria must be met simultaneously for a mediation to happen: (1) The effect of IV on DV is statistically significant; (2) the effect of IV on MV is statistically significant; (3) MV has an independent statistically significant effect on DV after accounting for the effect of IV; and (4) the effect of IV on DV shrinks upon the addition of the MV to explain DV together with it.

WesVar 5.1 is used to examine the mediation effect of grade repetition on mathematics literacy performance after accounting for the effect of GENDER and ESCS (WESTAT
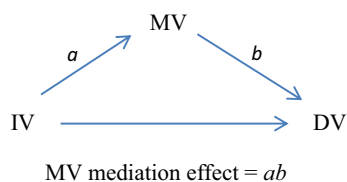
Fig. 1 Relationships of variables in Baron and Kenny's (1986) mediation analysis. *IV* independent variable, *MV* mediation variable, *DV* dependent variable

2007). As recommended by Li (2011), the use of WesVar in statistical data analysis on the one hand takes care of the complex two-stage stratified sample design and on the other hand handles appropriately the rotated test forms of the PISA 2012 (OECD 2009, 2013a). Unfortunately, because of the complicated rotated PISA 2012 questionnaire design, special treatment of missing data is needed. Based on the iterative Markov Chain Monte Carlo (MCMC) method, missing values are imputed by the SPSS multiple imputation procedures. Multiple imputations of forty datasets are done in accordance with Rubin (1987) and Graham (2009).

In this study, REPEAT is the IV and the set of plausible values MATHPVs is the DV. Variables hypothesized and tested for statistical significance for mediation effects ($p < 0.05$) include the aforementioned eight mathematics education quality indicators identified in Macao's PISA 2012. There are two control variables, namely GENDER and ESCS of the students. To execute mediation analysis in accordance with Baron and Kenny's (1986) formulation as shown in Fig. 1, three multiple regression models are analyzed. Model 1 is multiple regression of REPEAT on each of the eight MVs, and Model 2 is multiple regression of REPEAT and one by one each of the eight MVs on the MATHPVs. Finally, Model 3 is the multiple regression of REPEAT on MATHPVs.

Results

Table 3 details the mediation results of MATHEFF, which is the most powerful among all the eight MVs. All the four criteria for a mediation to happen are met simultaneously: (1) The effect of REPEAT on MATHPVs ($b = -88.465$) is statistically significant ($p < 0.05$); (2) the effect of REPEAT on MATHEFF ($b = -0.427$) is statistically significant ($p < 0.05$); (3) MATHEFF has an independent statistically significant effect ($b = 40.573$) on MATHPVs ($p < 0.05$) after accounting for the effect of IV; and (4) the effect of REPEAT on MATHPVs shrinks from -88.465 to -71.126 upon the addition of MATHEFF to explain MATHPVs together with it.

Figure 2 presents the mediation results of MATHEFF diagrammatically. The mediation effect (17.339) from

Table 3 Mediation variable MATHEFF (estimated standardized and unstandardized regression coefficients)

Variable	b	SE_b	β	SE_β
Model 1				
REPEAT to MATHEFF	−0.427	0.029	−0.219	0.015
Model 2				
MATHEFF and	40.573	1.214	0.412	0.012
REPEAT to MATHPVs	−71.126	2.232	−0.371	0.012
Model 3				
REPEAT to MATHPVs	−88.465	2.213	−0.470	0.010

R^2 for Model 1, Model 2, and Model 3 are 0.087, 0.401, and 0.241, respectively. In all regression models, the effects of ESCS and GENDER have been controlled
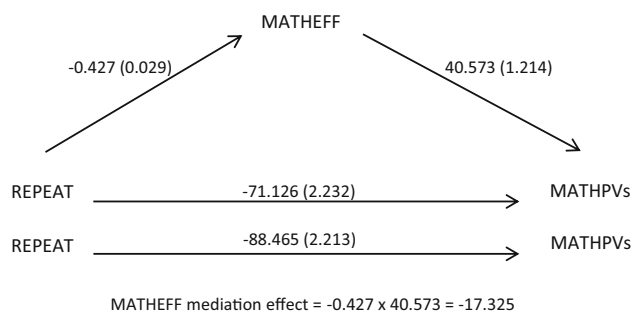

Fig. 2 Mediation effect of MATHEFF from grade repetition on mathematics performance

grade repetition on mathematics performance is equivalent to 0.44 grade level of schooling.

Apart from the most powerful MATHEFF just reported, Table 4 presents the mediation analysis results of the rest of the seven MVs. The motivational dynamics of these eight MVs affecting student engagement and disaffection on mathematics learning and achievement can be interpreted in accordance with Skinner and Pitzer (2012). All satisfy the four criteria for a mediation to happen, though the mediation is partial and not full.

Using Sobel (1982) and PRODCLIN (MacKinnon and Fritz 2007) test of the indirect effect, the MATHEFF mediation effect in both tests are statistically significant ($p < 0.05$); 16.0 % of additional MATHPVs variance can be explained by MATHEFF. Table 5 presents the results of the significance testing of indirect mediation effects in the explanation of the grade repetition performance gap in mathematics literacy of all the eight mediation variables examined in this study. All the mediation effects are negative, indicating that they are not in favor of those who repeat grades so as to attain well in mathematics literacy.

Table 6 presents the final mediation model of grade repetition on mathematics literacy performance. This model involves a set of seven MVs (ANINTMA is omitted in the full model. In the light of other MVs correlated with

Table 4 Summary of the mediation variables (estimated standardized regression coefficients)

Mediation variables (MVs)	Model 1		Model 2			
	REPEAT to MV		MV to MATHPVs (with REPEAT in the model)		REPEAT to MATHPVs (with MV in the model)	
	β	SE_β	β	SE_β	β	SE_β
FAMCON	−0.333	0.016	0.334	0.018	−0.350	0.013
EXPUREM	−0.067	0.018	0.114	0.016	−0.453	0.012
MATHEFF	−0.219	0.015	0.412	0.012	−0.371	0.012
ANSCMAT	−0.112	0.018	0.293	0.013	−0.428	0.012
ANINTMA	−0.092	0.019	0.241	0.016	−0.439	0.012
ANXMAT	0.0078	0.015	−0.283	0.012	−0.439	0.011
ANCLSMA	−0.111	0.016	0.137	0.015	−0.446	0.012
HOMSCH	−0.149	0.013	0.119	0.014	−0.443	0.012

Table 5 Significance testing of indirect mediation effects explaining the grade repetition performance gap in mathematics literacy

Mediation variables (MVs)	Mediation effect ab	Standard error (Sobel) S_{ab}	Asymmetric interval of ab using PRODCLIN (95 % confidence)	Additional DV variance explained by MV R^2
FAMCON	−0.111	0.0080	[−0.127, −0.096]	0.101
EXPUREM	−0.008	0.0023	[−0.013, −0.003]	0.014
MATHEFF	−0.090	0.0067	[−0.104, −0.077]	0.160
ANSCMAT	−0.033	0.0055	[−0.044, −0.022]	0.087
ANINTMA	−0.022	0.0048	[−0.032, −0.013]	0.060
ANXMAT	−0.022	0.0043	[−0.031, −0.014]	0.079
ANCLSMA	−0.015	0.0028	[−0.021, −.010]	0.019
HOMSCH	−0.018	0.0026	[−0.023, −0.013]	0.014

Mediating effect ab is statistically significant ($p < 0.05$) when asymmetric confidence interval using PRODCLIN (product confidence limits for the indirect effect) does not include zero

Table 6 Mediation variables FAMCON, EXPUREM, MATHEFF, ANSCMAT, ANXMAT, ANCLSMA, and HOMSCH in the final model: estimated standardized and unstandardized regression coefficients

Mediation Variables (MVs)	b	SE_b	β	SE_β
Model 2				
FAMCON	13.687	1.652	0.155	0.019
EXPUREM	6.992	1.704	0.059	0.014
MATHEFF	26.039	1.528	0.264	0.016
ANSCMAT	10.024	2.009	0.089	0.018
ANXMAT	−10.595	1.526	−0.112	0.016
ANCLSMA	5.677	1.814	0.051	0.016
HOMSCH	7.232	1.480	0.063	0.013
REPEAT to MATHPVs	−60.240	2.261	−0.314	0.012
Model 3				
REPEAT to MATHPVs	−88.465	2.213	−0.470	0.010

R^2 for Model 2 and Model 3 are 0.469 and 0.241, respectively. In all regression models, the effects of ESCS and GENDER have been controlled

it, the independent effect of ANINTMA on mathematics achievement in the full model is not statistically significant), each of which contributes an independent statistically significant mediation effect ($p < 0.05$) on mathematics literacy performance. The effect of REPEAT on MATHPVs shrinks from −88.465 to −60.240 upon the addition of the seven MVs to explain MATHPVs together with it. This shrinkage in effect is equivalent to 0.72 grade level of schooling in mathematics of the 15-year-old secondary students in Macao. The PRODCLIN confidence interval of each of the independent mediation effects in the full model is reported in Table 7.

Discussions of the findings

Corroborating with the findings hitherto in the research literature, Macao students who repeat grades do perform worse than those who do not repeat. The performance gap amounts to 88 score points of PISA 2012 mathematics

Table 7 Significance testing of independent indirect mediation effects explaining the grade repetition performance gap in mathematics literacy in the final model

Mediation variables (MVs)	Independent mediation effect ab	Standard error (Sobel) S_{ab}	Asymmetric interval of ab using PRODCLIN (95 % confidence)
FAMCON	−0.052	0.0068	[−0.065, −0.039]
EXPUREM	−0.004	0.0014	[−0.007, −0.001]
MATHEFF	−0.058	0.0053	[−0.069, −0.048]
ANSCMAT	−0.010	0.0026	[−0.015, −0.005]
ANXMAT	−0.006	0.0020	[−0.010, −0.002]
ANCLSMA	−0.009	0.0021	[−0.014, −0.005]
HOMSCH	−0.052	0.0068	[−0.065, −0.039]

Mediating effect ab is statistically significant ($p < 0.05$) when asymmetric confidence interval using PRODCLIN (product confidence limits for the indirect effect) does not include zero

literacy, which is equivalent to 2.3 grade level of schooling of the 15-year-old students around the world today.

Analyzing the contents of the mediation variables of grade repetition on mathematics, literacy performance in this study revealed that those who have repeated grades are not that familiar with those mathematics concepts that should be known to the 15-year-old students (e.g., divisor, rational number, polygon, and probability). They are not so confident in doing a variety of problem-solving tasks commonly encountered in the school mathematics curriculum (e.g., understanding graphs presented in newspapers, calculating the petrol consumption rate of a car, and solving an equation like $3x + 5 = 17$). Those who have repeated grades are also thinking that they cannot get good grades in mathematics and learn mathematics quickly, nor they can understand even the most difficult work. They generally do not enjoy about mathematics and are not interested in the things they learn in mathematics. Worse still is that they get very tense when they have to do mathematics homework and worry that they will get poor grades in mathematics They are not so well behaved in class, and class order is needed enforcement. Moreover, they have less incentive to put ICT use at home for school-related tasks. In sum, all the evidences point to that Macao's adolescent grade repeaters are unlikely self-regulatory learners and that tailor-made guidance and instruction should be highly appropriate for them.

Analyzing the contents of the joint effects of the seven mediation variables uncovered there are three key mediation processes/mechanisms in operation explaining grade repetition on mathematics literacy performance of the adolescents in Macao. These are concisely summarized below:

Mechanism 1: insufficient opportunity to learn the requisite course materials

The independent effects of FAMCON and EXPREM on mathematics performance, which are statistically significant

($p < 0.05$), are 13.687 and 6.992, respectively. This indicates that students who have repeated grades are not that familiar with important mathematics concepts that should be learned by the 15-year-olds, and their experiences with some pure mathematics tasks (e.g., solving quadratic equation) are also inferior to those who have not repeated grades before. This finding is sensible because, on the one hand, they do not have the opportunity to learn those key mathematics concepts that should be learned in the senior secondary grades (e.g., exponential function, cosine, and complex number) and, on the other hand, some important basic mathematics concepts (e.g., divisor, rational number, arithmetic mean) have not been remediated during their grade repetition period.

Mechanism 2: inadequate self-regulation of student's cognition and emotion

The independent effects of MATHEFF and ANSCMAT on mathematics performance, which are statistically significant ($p < 0.05$), are 26.039 and 10.024, respectively. The findings show that proliferation of grade repetition practices in Macao schools as a quality assurance policy hits a hard blow on the psychological minds of the struggling learners. Regarding the mathematical tasks commonly done well by the 15-year-olds, grade repeaters do not feel confident to solve them. Their self-concepts are not favorable and they view themselves just not good at mathematics. They are continuously struggling to get a pass grade in order to move on to the next grade. Also, the independent effects of ANXMAT on mathematics performance, which are statistically significant ($p < 0.05$), is −10.595. This result shows that not only learning motivation of the grade repeaters is affected, but also so nervous and tense that they always feel helpless when doing a mathematics problem. All in all, the implication is that unless schools have developed effective remedial programs

to help the grade repeaters academically and psychologically, it is not a good policy to uphold the grade repetition policy to send the struggling learners to study the same materials using the same instructional methods.

Mechanism 3: inappropriate teacher guidance and management

The independent effects of ANCLSMA and HOMSCH on mathematics performance, which are statistically significant ($p < 0.05$), are 5.677 and 7.232, respectively. This result shows that sending the struggling learners to study the same materials using the same instructional methods poses classroom management and homework guidance problems to the teachers. Struggling learners are generally not that self-regulatory in their studies. These academic failures really hope that their teachers can listen to them, and render their help promptly. If this is not so, behavioral problems germinate and teachers need to spend more efforts and time so as to keep them attentive and on-task. Inexperienced teachers may find it hard to keep the class orderly, and they have to wait a long time for students to quieten down. Nowadays, more and more mathematics classrooms are infused with information and communication technology (ICT). Without proper parental and teacher guidance, ICT use at home for school-related tasks are not supervised nor done well for the adolescent grade repeaters. In Macao schools, it is clear that time on task, a key variable explaining successful student academic performance, affects the struggling learners negatively and severely.

Implications of the study

Apart from Macao with 41 % of the 15-year-old cohort who repeated in their primary/junior secondary grades, the other PISA 2012 participating economies with similar high student grade repetition rates exceeding 30 % are: Colombia, Tunisia, Uruguay, Brazil, Belgium, Argentina, Luxembourg, Portugal, Costa Rica, and Spain. From a comparative education perspective, it is of considerable interests to examine whether the three grade repetition mediation mechanisms identified for the Macao schooling contexts are also applicable to the above-mentioned ten countries of high student grade repetition rates. In the light of the large number of statistically significant (also practically significant) correlations between the eight mediation variables with mathematics literacy performance and student grade repetition, researchers have confidence to demonstrate that some of the three mechanisms identified in Macao can also be observed in these countries. Together with the research findings gathered in their own countries (see, for example, Gomes-Neto and Hanushek 1994; Rosario et al. 2013; and Garcia-Perez et al. 2014, for the cases of Brazil,

Portugal, and Spain, respectively), these research results should inform a *local* theory (or sub-theory) of grade repetition for purposes of informed policy making.

Limitations and future research

The research design of PISA 2012 is a cross-sectional sampled survey, not an experimental intervention study. Hence, it proves difficult to estimate causal effects in mediation analysis using propensity scores (see Coffman 2011, for the data analysis methodology). In this study, the main difficulty in the establishment of the causality of the grade repetition mediation mechanisms lies in the measurement of *all* pre-repetition confounders for inclusion in the mediation analysis model. Noteworthily, the Macao students assessed in PISA 2012 are all 15-year-olds, and a sizable proportion (>40 %) of these students have begun to experience grade repetition as early as in their primary or junior secondary grades (see Table 1). Thus, the grade repetition mediation effects in the Macao basic education system should have been in operation for a number of years already, affecting a sizable share of 15-year-old students for an extended period of time. Admittedly, although the mediation processes as revealed in the final model of the present study (see Table 6) cannot be proved to be causal in this study, the findings nevertheless do help researchers to see what hypotheses of the mediation processes are tenable (such as the three hypotheses of this study), and what are not, as well as what competing theories may be ruled out in the light of the empirical evidences. The research design adopted in this study fulfills the purpose of the conduct of inquiry, i.e., to explore studying problems faced by Macao's adolescent grade repeaters through revelation of underlying mediation mechanisms that are congruent with the evidences from the PISA 2012 main survey. Clearly, the findings are limited by the availability of measures (e.g., time-on-task measures similar to the ICT use at home for school-related tasks in this study) to test the three hypotheses of the study, which are important questions needed answering in the Macao schooling contexts. Future studies should aim at developing other measures, particularly those associated with the pre-repetition confounding variables, to study the causality of other mediating grade repetition effects, as well as to generalize the Macao results to other countries/economies with high rates of student grade repetition.

Conclusions

Among the 64 participating economies in PISA 2012, Macao is high up in the league table of grade repetition. The data show that over 40 % of Macao's 15-year-olds

repeated one or more years in their primary and/or junior secondary years of education. Although it is not feasible to use the PISA data to ascertain the causes and reasons of their grade repetition, it is possible to base on the student's responses to the PISA 2012 student questionnaire to uncover the underlying processes and mechanisms mediating the effects of grade repetition on mathematics literacy performance. After adjusting for the effects of gender and ESCS of the sampled students, eight promising mediation variables are used to test the tenability of three hypotheses in this study, i.e., regardless of the economic, social, and cultural status and gender of student, selected sets of Macao's quality education indicators pertaining to: (1) opportunity to learn, (2) student self-regulation, and (3) teacher guidance and management, mediate the effects of grade repetition on student mathematics performance.

In the final model involving seven mediation variables exhibiting substantial independent effects, the total effect of grade repetition on mathematics literacy performance shrinks from 88 to 60 score points, equivalent to approximately 0.7 grade level of schooling. The joint mediation effects identified in the final model is only partial, mainly concerning with mathematics self-efficacy, self-concept, and anxiety, as well as familiarity with mathematical concepts, experiences with higher mathematics tasks at school, mathematics teacher's classroom environment, and use of ICT in school-related tasks at home. Macao schools are urged to review their grade repetition policy and the associated quality assurance mechanisms, paying due attention to the psychological dispositions and classroom management problems of the struggling learners. The conclusion of this study is that unless the remedial programs and courses of action can be shown to be effective empirically, it is not a good idea to continue repeating academic failures without teachers' proper guidance and instruction.

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