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The impact of supplemental instruction on learning competence and academic performance

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This study investigated the effects of supplemental instruction, a peer-assisted learning approach, on students, learning competence and academic performance. The supplemental instruction intervention facilitated by senior students focused on developing students' use of study skills and enhancing their motivation and academic performance. Pre- and post-intervention learning competence measures (the 10 scales of the Learning and Study Strategies Inventory) were available for 430 first year undergraduate business students (Supplemental Instruction, n = 109; Non-Supplemental Instruction, n = 321) from a university in Hong Kong. Structural equation modeling demonstrated that supplemental instruction had a significant effect on academic performance, both directly and indirectly via enhancement of student learning competence, after controlling for pre-intervention learning strategy scores and previous academic achievement. This study provides evidence that supplemental instruction can be a very effective instructional strategy for promoting undergraduate student learning.

Keywords: peer-assisted learning; learning competence; academic performance; longitudinal; structural equation modeling

Introduction

Peer-assisted learning is a well-established method for promoting student learning, and has a long tradition in higher education around the world (Anderson, Boud, and Sampson 1996; Magin and Churches 1995; Medina 2003; Peterfreund et al. 2008; Potter 1997; Widmar 1994; Wood 1997). A variety of different peer-assisted learning methods have previously been described (see Roscoe and Chi 2007), including the 'traditional' mode, which is also known as supplemental instruction, and encompasses a certain hierarchy of educational levels, where a senior student tutors a group of junior students (Blanc, DeBuhr, and Martin 1983; Martin and Blanc 1981); and the more innovative (unconventional) mode where same-year students form a learning group with the goal of teaching one another. Regardless of the variations in tutoring style, the theoretical framework underlying peer-assisted learning is constructivism, where the tutors take on the role of facilitators to help learners process and understand information and construct their own knowledge, rather than the role of information givers (Longfellow et al. 2008; Roscoe and Chi 2007) who provide knowledge for the student to assimilate. This type of learning environment is designed to support and challenge the learner's thinking (Duron, Limbach, and Waugh 2006) when the learner plays an active role in the learning process.

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While previous studies have demonstrated the effectiveness of peer-assisted learning interventions in enhancing academic performance (Arendale 2000; Longfellow et al. 2008; Lynch, Leo, and Downing 2006; McCarthy, Smuts, and Cosser 1997; Rohrbeck et al. 2003; Schwartz 1992), research into the effects on non-academic outcomes are relatively rare, and those that exist mainly focused on motivation and academic self-concept (e.g. Gillies and Ashman 1995, 2003; Griffin and Griffin 1998; Johnson and Johnson 1991; O'Hara 2007; Topping 1996). Other learning-related factors such as study skills and attitude have received little attention.

The present study focuses on the relationship between academic achievement and the more transferable aspects of learning competence, as measured by the Learning and Study Strategies Inventory (LASSI: Weinstein and Palmer 2002). The intention was to explore whether supplemental instruction, a peer-assisted learning instructional approach based on out-of-classroom sessions facilitated by senior students, could impact not only on students' academic performance, but also on their general learning competence (e.g. attitude towards learning, use of study skills, etc.) as mediators of academic performance.

The role of peer-assisted learning in stimulating academic interest

From a pedagogical point of view, peer-assisted learning can be regarded as active learning which demands involvement on the part of participants. Social constructivist educators (see Downing 2001) view learning as an active process where learners should learn to discover principles, concepts and facts for themselves (Roscoe and Chi 2007; Vickerman 2009). Educators such as Piaget (1935) and Lewin (1948, 1951) regard active learning as a key element for academic success. Peer-assisted learning provides opportunities for learner involvement, with the benefits of immediate responses and feedback through which students can also improve their problem-solving skills in collaborative tasks (Cowie and van der Aalsvoort 2000; Mevarech, Zion, and Michalsky 2007; O'Donnell and King 1999). As the learner is involved in shaping both the learning environment and the content of learning by posing and pursuing questions, they become more able to solve problems (Anderson, Boud, and Sampson 1996), which in turn contributes greatly to learner interest, motivation and metacognitive development (Downing et al. 2007; Shamir, Mevarech, and Gida 2009). Since learning is socially and culturally constructed (Anderson, Boud, and Sampson 1996), involvement of peers in reflecting upon and making sense of information and experience is a powerful stimulus to learning. By working as a group on solving problematic issues, students tend to develop a sense of relatedness, and this can benefit new students within the sometimes alienating environment of a university.

The supplemental instruction model

Supplemental instruction is an intervention program developed by Deanna Martin of the University of Missouri – Kansas City in the mid 1970s to improve the performance and retention of low-achieving students (Martin and Arendale 1993). Supplemental instruction is a peer-assisted learning model for enhancing students' understanding of course material, and for improving students' overall learning skills. Out-of-class supplemental instruction sessions are facilitated by senior students (peers) who have successfully completed the target course, and students are encouraged to work cooperatively on materials that supplement and enrich course material. These are complemented by training on study skills, embedded into the context of the supported course (Peterfreund et al. 2008). All supplemental instruction facilitators undergo thorough training prior to the facilitation of supplemental instruction sessions.

Theoretical framework of supplemental instruction

Previous studies have shown that peer-assisted learning enables students to take more responsibility for their own learning, promotes creative problem-solving and develops group working skills (Boud, Cohen, and Sampson 1999; Mevarech, Zion, and Michalsky 2007; Rowland 2002). The philosophy behind the supplemental instruction model stems from a collection of theoretical principles (Hurley and Gilbert 2008; Rubin and Hebert 1998; Zerger 2008), including Vygotsky's (1978) theory of socially mediated learning, various social interdependence principles (Vygotsky 1986) and cognitive developmental principles (Bruner 1968; Flower and Hayes 1981; Piaget 1935, 1977). Since supplemental instruction sessions are proactive and participatory rather than reactive and passive (Hurley, Jacobs, and Gilbert 2006), students take more responsibility for their educational experience than they would in a conventional learning environment where they depend on an authority figure (the instructor or tutor) for learning. Supplemental instruction borrows from social interdependence principles (Vygotsky 1986) because, by voluntarily attending supplemental instruction sessions, which provide opportunities for shaping their own learning process, students necessarily become independent and active learners.

The cognitive aspect of supplemental instruction focuses on the promotion of creative problem-solving and information-processing strategies, where knowledge is constructed when students organise and process information by connecting it with their own experience and applying it to the new context. In addition, many theorists (Foot and Howe 1998; Piaget 1977; Sullivan 1953; Vygotsky 1978, 1986) argue that peer interaction is conducive to cognitive development due to the promotion of critical cognitive conflicts. For example, when a learner becomes aware of contradictions in his/her knowledge base through peer discussions, this triggers a lapse in equilibrium which will cause the learner to initiate an inquiry-oriented problem solving process to arrive at a solution. This reconstruction of knowledge to propagate understanding is characteristic of constructivist learning, where the notion is that knowledge is more thorough when it is constructed and reconstructed, and not simply distributed (Biehler and Snowman 1997). Since peers are at an equal or similar level, the tutoring/teaching discourse is far less threatening and learners can be more open and inquisitive with one another, thus stimulating critical cognitive conflict (Ladyshewsky and Ryan 2006). Moreover, by working in a cooperative manner within a peer group to reach common goals, students are more engaged and are more socially and educationally motivated to learn when they can contribute their own knowledge and benefit from one another (Dion, Fuchs, and Fuchs 2007).

Finally, the development of student study skills is a vital aspect of supplemental instruction because students can apply the study strategies gained in supplemental instruction in other classes and in different future settings. Consequently, students become more confident learners by adopting a consistent and self-regulative approach to processing information. The flexible use of this internalised and more strategic approach to information processing facilitates learning whenever the student encounters problems or tasks that are challenging (Bandura 1971, 1977; Summers, Bergin, and Cole 2009; Whitebread et al. 2007).

Evidence of the effectiveness of supplemental instruction

There is a wealth of existing research which provides evidence that supplemental instruction is effective in improving student performance and retention. Results usually indicate that supplemental instruction participants have higher average course grades and lower attrition rates than non-participants (Arendale 1994; Congos and Schoeps 2003; Jacobs and Stone 2008; Martin and Arendale 1994; Martin and Blanc 1981). Studies have also demonstrated the effectiveness of supplemental instruction in enhancing undergraduate academic performance (e.g. McGuire 2006), and in a wide selection of undergraduate courses, including biology, chemistry, economics, engineering, history, mathematics and statistics (see, for example, Congos and Schoeps 2003; Kochenour et al. 1997; Loviscek and Cloutier 1997; Lundberg 1990; Magin and Churches 1995; Peterfreund et al. 2008; Rath et al. 2007; Webster and Dee 1998). Qualitative analyses show that participants have indicated the structure of supplemental instruction sessions allows more time for individual feedback, and that they felt less inhibition in approaching tutors for help rather than established faculty members. Since tutors were at the same learning stage not so long ago, students felt that there was greater acceptance by these senior students who can relate to their problems and have greater understanding of their typical struggles (Glynn et al. 2006; Lockspeiser et al. 2008; Weidner and Popp 2007; Weyrich et al. 2008). This aspect of the peer-assisted learning structure has been shown to enhance students' social and educational motivation (Pascarella and Terenzini 2005; Wentzel 1999). See Topping (2006) for a thorough review of the effectiveness of peer-assisted learning in the higher education setting.

Aims of the present study

These previous studies supply empirical evidence which supports the view that peer-assisted learning can improve students' motivation, academic self-concept and academic performance. However, there are other aspects of learning which can also be positively influenced by peer-assisted learning, and have not been previously examined. The Learning and Study Strategies Inventory (LASSI; Weinstein and Palmer 2002) incorporates many of the cognitive and motivational aspects examined in previous studies (e.g. motivation and information processing). It also consists of items which measure students' study skills and learning behaviour, including their use of self-testing strategies, study aids, test strategies, competence in selecting main ideas from notes, test anxiety and learning attitude. Given the nature of the peer-assisted learning supplemental instruction approach, there are grounds for thinking that supplemental instruction can also positively influence many of these aspects, which are known to influence academic performance (see, for example, Albaili 1997; Diseth and Martinsen 2003; Downing et al. 2009; Entwistle 1998; Yip 2007; Yip and Chung 2005).

The contribution of this study is, therefore, to (a) investigate the precise relationship between learning competence and academic performance; (b) examine the argument that peer-assisted learning leads to gains in motivation and information processing skill, alongside academic performance gains; and (c) establish whether supplemental instruction has a positive influence on students' general learning competence and use of study skills, mediating academic performance. In order to do this, data from a supplemental instruction intervention scheme implemented at a university in Hong Kong was examined for effects in these contexts. This intervention involved first-year undergraduate students from the business discipline, in which a year-long supplemental instruction scheme was implemented for four compulsory core courses.

Since supplemental instruction participation is completely voluntary, in that the treatment (supplemental instruction) and control (non-supplemental instruction) groups were not chosen based on random assignment, this study utilised a simple pre- and post-intervention design to control for possible differences in pre-intervention learning competence between the two groups. Measurements of students' learning competence (as measured by the 10 LASSI scales) were taken before and after intervention. These data, along with prior academic achievement and average GPA for the four courses, were used to examine the influences from supplemental instruction on pre- to post-intervention change in learning competence and academic performance.

Hypotheses

A thorough examination of the literature revealed that peer-assisted learning generally has a positive influence on students' motivation, study strategies and academic achievement. These findings provide the basis for a simple theoretical model for the testing of direct and indirect effects of supplemental instruction on academic performance, via influence on other aspects of learning competence. On the basis of previous findings, we hypothesise that, after controlling for previous academic achievement: (1) learning competence (a latent construct as measured by the 10 LASSI scales) has a significant positive relationship with academic performance as measured by average GPA; (2) supplemental instruction intervention has a direct effect on learning competence and academic performance; and (3) learning competence partially mediates the effect of supplemental instruction intervention on average GPA.

Methods

The context of the study

The supplemental instruction scheme is an academic support program that provides regularly scheduled, out-of-class, peer-facilitated sessions that are open to all first-year undergraduate students undertaking particular courses. The aim is to help them develop effective study skills and become more independent, proactive learners. With supplemental instruction, senior students with outstanding academic results and personal qualities are selected to serve as student leaders for groups of four to five students twice a week (two 1-hour sessions). Together, the leaders review course materials and share their learning strategies with the students. Prior to leading supplemental instruction sessions, leaders are required to take part in an intensive two-day training session on proper facilitation techniques and guiding students in learning appropriate study strategies (including selecting main ideas from notes, test preparation, information processing, reviewing course material, etc.). A faculty member serves as the supervisor to select and train student leaders, and monitor and evaluate the quality of supplemental instruction sessions.

Participants

Four hundred and thirty first-year undergraduates (n = 430) from the business discipline at a Hong Kong university form the sample for this study. All students were enrolled in the same degree program, in which a non-compulsory supplemental instruction intervention was incorporated into the curriculum of the four compulsory core courses. Group A (n = 109) consisted of those students who signed up for the supplemental instruction scheme, and Group B (n = 321) those who did not attend any sessions at all. All students who signed up for the scheme attended over 63% of the available supplemental instruction sessions.

Measures

Study skills and learning competence

We assessed students' learning competence by means of the Learning and Study Strategies Inventory (LASSI) (Weinstein and Palmer 2002). The LASSI consists of 80 items divided into 10 scales measuring different aspects of study strategies. Each of the 10 LASSI scales consists of 8 items, and students gave a response to each of the 80 items on a Likert-type scale, from 1 (not at all like me) to 5 (very much like me). The resulting scores are then rescaled to percentiles. The reliability and a sample item for the 10 LASSI scales are presented in Table 1.

Prior academic achievement (pre-intervention academic performance)

All students were first-year undergraduates and, in order to control for prior academic achievement which may influence their learning competence and GPA, we were able to obtain their entry A-level scores from institutional records. In Hong Kong, students' academic ability for university admission is assessed by their A-level examination, taken just prior to university in the final year of secondary education. A-level scores are calculated on a 'point' basis, with two A-level subjects or one A-level subject plus two Advanced-supplementary (AS) level subjects being counted. For A-level subjects, grade A = 10 points, B = 8 points, C = 6 points, D = 4 points, E = 2 points; whilst for AS-level subjects, grade A = 5 points, B = 4 points, C = 3 points, D = 2 points, E = 1 point. Thus, the maximum score for each student is 20 points. We consider that, for

Table 1. Reliability and sample items for the 10 LASSI scales.

	Cronbach's alpha		
Variable	Time 1	Time 2	Sample Item
Concentration (CON)	.74	.75	I concentrate fully when studying.
Time Management (TMT)	.72	.71	I find it hard to stick to a study schedule.
Self-Testing (SFT)	.74	.78	I review my notes before the next class.
Study Aids (STA)	.75	.75	My underlining is helpful when I review text material.
Information Processing (INP)	.77	.81	I translate what I am studying into my own words.
Selecting Main Ideas (SMI)	.80	.81	I have difficulty identifying the important points in my reading.
Test Strategies (TST)	.76	.78	I have trouble understanding exactly what a test question is asking.
Anxiety (ANX)	.78	.81	I get discouraged because of low grades.
Attitude (ATT)	.75	.77	I would rather not be in school.
Motivation (MOT)	.78	.82	I set high standards for myself in school.

the purposes of this study, the A-level score is a reasonable measure of students' prior academic achievement.

Academic performance (post-intervention academic performance)

The measure of each student's post-intervention academic performance is based on their average GPA computed for the four business courses. This is a justifiable measure as all students in the sample undertook the four compulsory courses, and supplemental instruction sessions were only available for these four first-year courses for students enrolled in this particular business programme.

Procedure

Approximately three weeks prior to the start of the first semester students completed the LASSI questionnaire immediately after their enrollment session. Students were briefed on the nature of the questionnaire and confidentiality was confirmed. They were allowed as much time as they needed to complete the questionnaire, typically requiring 25–35 minutes. After the first year of undergraduate study, students were asked to complete the same questionnaire, which was administered in a similar manner to the first setting. Only for the purpose of this study, students' A-level scores and GPA for the four courses were obtained from institutional records.

Statistical analysis

Structural equation modeling procedures were used, (a) to evaluate a latent variable measurement model of the LASSI for assessing learning competence, (b) to determine if learning competence and academic performance differed as a function of the intervention condition, and (c) to evaluate whether any intervention-induced effects on learning competence mediated the intervention's impact on academic performance. One of the strengths of structural equation modeling is that it allows one to simultaneously investigate several independent and dependent variables in the same model.

A confirmatory factor analysis was used to test the validity of the measurement model (i.e. observed LASSI scales in measuring learning competence) on the current sample. This was done before assessing the relationships between the latent variables (i.e. full structural model) in order to detect any potential measurement problems, as recommended by Marsh, Byrne, and Yeung (1999) (see Anderson and Gerbing [1988] for a detailed discussion of the conceptual advantages of first assessing the fit of the measurement model involving latent constructs of the observed variables before testing hypotheses concerning the causal or structural model).

After the validity of the measurement model had been established, the effect of the intervention in learning competence and academic performance was examined by including the intervention condition as a dummy-coded predictor (Supplemental Instruction = 1, Non-Supplemental Instruction = 0). The A-level score variable was included in the model to control for possible differences in previous academic achievement between the supplemental instruction and non-supplemental instruction groups. Figure 1 depicts the full structural model we used for the analysis. A point to note is that there were correlations between the error terms for the LASSI scales measured pre-intervention and post-intervention, and correlations between the residuals across time have been omitted from Figure 1 for clarity of presentation. A

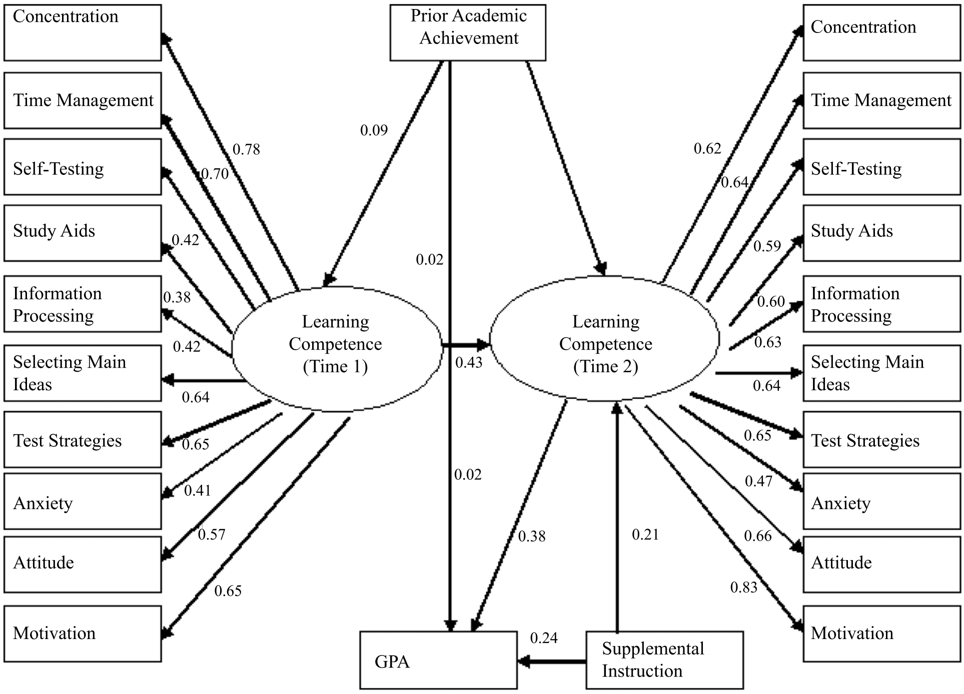

Figure 1. Structural model with standardised coefficients.
Note: All paths $\beta \geq .1$ were significant at $p < .05$. Paths $\beta \geq .14$ were significant at $p \leq .001$.

statistically significant effect of the intervention on learning competence is necessary, but not sufficient, for it to provide a statistically significant mediation effect on academic performance (Baron and Kenny 1986; Shrout and Bolger 2002).

All structural equation modeling analyses presented in this article were performed with Amos 5.0 (Arbuckle 2003). Models that fit the data well are associated with small, insignificant chi-square statistics. As the significance of the chi-square goodness-of-fit test is sensitive to the sample size (often significant for large sample size; see Bentler and Bonett 1980), several model fit indices were considered in addition to the chi-square test. The four indices reported here are the Tucker Lewis index (TLI; > .90 acceptable fit, > .95 excellent fit; Tucker and Lewis 1973), the comparative fit index (CFI: > .90 acceptable fit, > .95 excellent fit; Bentler 1990; Bentler and Bonett 1980), the root mean square error of approximation (RMSEA; < .08 acceptable fit, < .05 excellent fit; Brown and Cudeck 1992), and the standardised root mean square residual (SRMR; < .08 acceptable fit, < .05 excellent fit; Bollen 1989).

Results

Descriptive statistics

Descriptive statistics of the LASSI scales, A-level score and average GPA for the supplemental instruction and non-supplemental instruction groups pre- and post-intervention are shown in Table 2, whilst correlations of these variables are reported in Table 3, with means, standard deviations, skewness and kurtosis presented at the bottom. Since none of the variables have skewness or kurtosis greater than the

Table 2. Descriptive statistics of the variables by group.

	Time 1				Time 2			
	Supplemental Instruction		Non-Supplemental Instruction		Supplemental Instruction		Non-Supplemental Instruction	
Variable	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Concentration	59.17	23.16	55.27	20.83	61.76	24.69	55.54	22.83
Time Management	58.67	19.22	53.86	19.33	63.35	20.72	57.99	20.56
Self-Testing	57.11	23.36	50.01	24.70	62.80	24.59	54.13	24.48
Study Aids	62.64	21.44	54.91	25.62	66.36	25.06	55.34	24.83
Information Processing	55.84	23.94	55.26	24.05	66.55	26.45	58.68	26.83
Selecting Main Ideas	56.87	22.40	55.17	21.15	62.57	24.55	58.60	23.45
Test Strategies	51.86	25.59	52.88	22.85	56.74	25.90	55.96	26.79
Anxiety	51.74	24.03	55.58	22.84	61.63	26.07	66.36	22.97
Attitude	25.97	24.39	21.62	20.39	31.29	23.61	25.90	20.94
Motivation	38.85	26.76	36.45	23.35	49.28	26.46	38.90	25.40
A-level Score	13.09	2.02	12.98	2.20				
GPA					3.12	0.41	2.87	0.54

Table 3. Correlation matrix among the variables included in the study.

	CON	TMT	SFT	STA	INP	SMI	TST	ANX	ATT	MOT	CON 2
CON		0.58 ***	0.30 ***	0.26 ***	0.32 ***	0.52 ***	0.53 ***	0.42 ***	0.41 ***	0.46 ***	0.44 ***
TMT			0.40 ***	0.29 ***	0.29 ***	0.33 ***	0.41 ***	0.24 ***	0.40 ***	0.48 ***	0.30 ***
SFT				0.63 ***	0.57 ***	0.26 ***	0.18 ***	–0.07	0.26 ***	0.44 ***	0.09
STA					0.49 ***	0.22 ***	0.15 ***	0.10 *	0.33 ***	0.44 ***	0.09
INP						0.35 ***	0.25 ***	0.02	0.29 ***	0.44 ***	0.08
SMI							0.65 ***	0.44 ***	0.36 ***	0.39 ***	0.20 ***
TST								0.48 ***	0.40 ***	0.42 ***	0.25 ***
ANX									0.25 ***	0.09	0.22 ***
ATT										0.50 ***	0.21 ***
MOT											0.18 ***
CON 2											
TMT 2											
SFT 2											
STA 2											
INP 2											
SMI 2											
TST 2											
ANX 2											
ATT 2											
MOT 2											
A-level											
Mean	56.3	55.1	51.8	56.9	55.4	55.6	52.6	54.6	22.7	37.1	57.1
SD	21.5	19.4	24.5	24.8	24.0	21.5	23.5	23.2	21.5	24.3	23.4
Skewness	–0.29	–0.25	–0.31	–0.29	–0.39	–0.28	–0.16	–0.26	1.49	0.55	0.17
Kurtosis	–0.52	–0.50	–0.87	–0.94	–0.65	–0.51	–0.85	–0.70	1.79	–0.50	–0.69

(*Continued.*)

Table 3. (*Continued.*)

	TMT 2	SFT 2	STA 2	INP 2	SMI 2	TST 2	ANX 2	ATT 2	MOT 2	A-level	GPA
CON	0.35 ***	0.22 ***	0.19 ***	0.28 ***	0.24 ***	0.27 ***	0.16 ***	0.24 ***	0.22 ***	0.11 *	0.11 *
TMT	0.34 ***	0.24 ***	0.20 ***	0.18 ***	0.11 *	0.12 *	–0.04	0.16 ***	0.22 ***	0.08	0.12*
SFT	0.14 ***	0.31 ***	0.24 ***	0.21 ***	–0.01	0.04	0.17 ***	0.10 *	0.19 ***	0.05	0.10 *
STA	0.12 *	0.22 ***	0.28 ***	0.17 ***	0.09	0.08	0.13 ***	0.15 ***	0.15 ***	0.04	0.03
INP	0.04	0.20 ***	0.18 ***	0.36 ***	0.07	0.10 *	–0.05	0.11 *	0.14 ***	0.01	0.09
SMI	0.12 *	0.13 ***	0.10 *	0.23 ***	0.23 ***	0.23 ***	0.14 ***	0.10 *	0.16 ***	0.03	0.06
TST	0.16 ***	0.10 *	0.05	0.20 ***	0.27 ***	0.27 ***	0.20 ***	0.19 ***	0.18 ***	0.06	0.10 *
ANX	0.09	0.00	0.01 ***	0.06	0.20 ***	0.18 ***	0.40 ***	0.09	–0.01	0.13 **	0.07
ATT	0.14 ***	0.12 *	0.16 ***	0.19 ***	0.20 ***	0.21 ***	0.15 ***	0.29 ***	0.21 ***	0.03	0.12 *
MOT	0.16 ***	0.22 ***	0.25 ***	0.24 ***	0.11 *	0.12 *	0.07	0.17 ***	0.33 ***	0.00	0.15 ***
CON 2	0.59 ***	0.27 ***	0.37 ***	0.33 ***	0.58 ***	0.59 ***	0.39 ***	0.51 ***	0.45 ***	0.07	0.20 ***
TMT 2		0.42 ***	0.39 ***	0.36 ***	0.47 ***	0.48 ***	0.20 ***	0.39 ***	0.48 ***	0.03	0.19 ***
SFT 2			0.61 ***	0.54 ***	0.19 ***	0.18 ***	0.12 *	0.28 ***	0.44 ***	0.04	0.20 ***
STA 2				0.47 ***	0.28 ***	0.27 ***	0.00	0.34 ***	0.55 ***	0.05	0.21 ***
INP 2					0.38 ***	0.36 ***	0.06	0.34 ***	0.55 ***	0.09	0.27 ***
SMI 2						0.75 ***	0.53 ***	0.53 ***	0.50 ***	0.03	0.22 ***
TST 2							0.54 ***	0.49 ***	0.50 ***	0.00	0.27 ***
ANX 2								0.35 ***	0.14 ***	0.04	0.13 ***
ATT 2									0.56 ***	0.01	0.24 ***
MOT 2										0.01	0.36 ***
A-level											0.04
Mean	59.3	56.3	58.1	60.7	59.6	56.2	65.2	27.3	41.5	13.0	2.93
SD	20.7	24.8	25.3	26.9	23.8	26.5	23.9	21.7	26.0	2.16	0.52
Skewness	0.04	–0.02	0.05	–0.18	0.00	0.08	–0.02	1.72	0.66	–0.48	–1.01
Kurtosis	–0.56	–0.93	–0.90	–1.08	–0.97	–1.15	–0.87	2.29	–0.46	1.79	1.58

*Level of significance p <.05, **p <.01; ***p <.001.

respective cut-offs of |3| or |8| recommended by Kline (2005), univariate normality is supported in these items. Using confirmatory factor analysis with maximum likelihood estimation, the assumption of normality must be adhered to. From Table 3 we can see that all LASSI scales are positively correlated with GPA, particularly post-intervention LASSI scores which were all significantly correlated with GPA.

Measurement model

There is much debate about the validity of the LASSI in measuring the three latent constructs proposed by the original LASSI developers, namely self-regulation (CON, TMT, SFT, STA), skills (INP, SMI, SFT) and will (ANX, ATT, MOT). Previous research on the latent constructs of the LASSI revealed different compositions of three-factor structure, with various scales loading onto more than one factor (Olejnik and Nist 1992; Olivarez and Tallent-Runnels 1994; Stevens and Tallent-Runnels 2004). We have tested the original three-factor structure of the LASSI using confirmatory factor analysis, and the model fit was inadequate ($\chi^2(30) = 389.83$, $p < .001$, TLI = 0.68, CFI = 0.79, RMSEA = 0.167, SRMR = 0.109). In regard to this controversial construct structure of the LASSI, it was decided that the 10 LASSI scales would be used in a single-factor model. Confirmatory factor analysis of the single-factor measurement model revealed that the fit was acceptable ($\chi^2(13) = 19.26$, $p > .05$, TLI = 0.99, CFI = 0.99, RMSEA = 0.034, SRMR = 0.019) and all measured variables loaded significantly onto the latent construct we termed learning competence (β range = .36 to .80).

Univariate analyses

Univariate analyses with each group separately on the 10 LASSI scales showed that the intervention group achieved statistically significant increases after the one-year supplemental instruction intervention on 7 of the 10 LASSI scales. The aspects that did not show significant improvements for the supplemental instruction group were concentration, study aids, and test strategies. Although the non-supplemental instruction group reported significant improvement on 6 of the 10 LASSI scales, however, significant improvement was not detected in the motivation scale, which was the variable most correlated with GPA (see Table 3). Moreover, whilst no significant difference was detected between the two groups in terms of A-level score, the difference in the two groups' post-intervention average GPA was statistically significant ($p < .001$). Comparison of pre- and post-intervention LASSI scores also indicated that the improvements observed in the information processing ($p < .05$) and motivation ($p < .05$) scales were significantly different between the groups, with significantly larger magnitude of improvement detected for the supplemental instruction group.

Structural equation modeling

The structural equation model shown in Figure 1 has an acceptable fit ($\chi^2(172) = 393.95$, $p < .001$, TLI = 0.92, CFI = 0.95, RMSEA = 0.055, SRMR = 0.055). The standardised parameter estimates are also shown in Figure 1. The only insignificant causal paths in the model are the three which connect prior academic achievement to pre- and post-intervention learning competence and GPA. Most importantly, since the primary aim of the analysis was to determine whether improvements in learning competence mediated the beneficial impact of supplemental instruction on academic performance after one year of intervention, we inspected the path coefficients in Figure 1 to identify the effect of supplemental instruction on mediator variables. While the intervention had statistically significant, but moderate, direct effects on learning competence ($\beta = .21, p < .001$) and academic performance ($\beta = .24, p < .001$), the post-intervention learning competence construct had a direct and reasonable size effect on academic performance ($\beta = .38, p < .001$). Thus, the effect of the supplemental instruction intervention on academic performance was partially mediated by learning competence. Sobel's (1982) test results (using the interactive tool from http://people.ku.edu/~preacher/sobel/sobel.htm) also supported the statistical significance of this mediation effect ($z = 5.75$, $p < .001$). The positive valence of these effects indicates that the supplemental instruction group had a higher level of learning competence and academic performance, and as learning competence increased academic performance also increased.

With the removal of the intervention condition from the model, the path coefficient between learning competence and academic performance was still significantly large ($\beta = 0.34$, $p < .001$). Separate analyses for supplemental instruction and non-supplemental instruction students both indicated that the learning competence construct was positively related to academic performance (Supplemental Instruction: $\beta = 0.37$, $p < .001$; Non-Supplemental Instruction: $\beta = 0.39$, $p < .001$). These results thus indicate a positive causal relationship between students' learning competence and academic performance.

Discussion

The main objectives of this study were to examine the effectiveness of the supplemental instruction intervention on students' self-perceived learning competence, and its direct and indirect influence on academic performance. Since many studies have shown that motivation and academic self-concept are mediators of peer-assisted learning in influencing academic performance (Gillies and Ashman 1995, 2003; Griffin and Griffin 1998; Johnson and Johnson 1991; Summers, Bergin, and Cole 2009; Topping 1996), we hypothesise that other aspects of student learning competence (e.g. use of transferable study skills as measured by the LASSI) could also mediate the effect of supplemental instruction on academic performance. Our first research question (Hypothesis 1) examined whether students' learning competence influences academic performance after controlling for prior academic achievement. Indeed, this hypothesis found support from correlation and structural equation modeling analyses, which indicated that student learning competence is significantly correlated with their academic performance. As shown in Figure 1, all post-intervention LASSI measures have significantly large loadings on the learning competence construct. Motivation, not surprisingly, contributed the most to this construct. The effect of learning competence was found to be a significant predictor of academic performance ($\beta = 0.38$, $p < .001$); and even with the removal of the intervention condition the path coefficients were still significantly large (Supplemental Instruction: $\beta = 0.37$, $p < .001$; Non-Supplemental Instruction: $\beta = 0.39$, $p < .001$). Consequently, our results provide evidence for a positive causal relationship between students' learning competence and academic performance.

As far as the second hypothesis is concerned, our results echo those of other studies where the effectiveness of supplemental instruction in enhancing student learning has been shown (e.g. McGuire 2006; Peterfreund et al. 2008; Rohrbeck et al. 2003). Univariate analyses revealed that supplemental instruction participants have significantly larger improvements than non-participants in the comparison of pre- and post-intervention information processing and motivation scores. This supports the general view that supplemental instruction leads to greater gains in information processing skill and motivation (Gillies and Ashman 1995, 2003; Griffin and Griffin 1998; Johnson and Johnson 1991; McGuire 2006; Topping 1996). Structural equation modeling also supported the hypothesis that supplemental instruction intervention has significant direct effects on both learning competence (β = 0.21, $p < .001$) and academic performance (β = 0.24, $p < .001$). In terms of the meditational effect (Hypothesis 3), the intervention condition significantly predicted post-intervention learning competence, and learning competence in turn significantly predicted average course GPA. Consequently, the structural equation model demonstrated that a substantial proportion of the total intervention effect on academic performance could be attributed to intervention-induced increases in students' learning competence.

From a theoretical standpoint these findings are particularly relevant to advancing research and implementation of peer-assisted learning. Since learners tend to think differently about a concept as they assimilate knowledge via discussion, strategic processing of information is stimulated. As our results indicated that the improvements detected in the information processing and motivation scores were significantly larger for the supplemental instruction group, this study reconfirms the cognitive developmental principles underlying the supplemental instruction framework.

The traditional view of achievement in education is that success is a function of academic competence and motivation. In this study we offer a third factor in success, which we termed learning competence. In support of the argument that study skills and knowledge construction can be learned and developed (Hanley 1995; King 1991; Letteri 1992; Piaget 1977; Seligman 1998; Sullivan 1953; Vygotsky 1978, 1986; Weinstein 1994a, b), we have demonstrated that a peer-assisted learning intervention which draws on different theories and principles (socially mediated learning, social interdependence principles, cognitive developmental principles) can indeed be beneficial to students' general learning competence, which in turn leads to academic gains. The educational implications of this study are clear. At the most basic level, if peer-assisted learning can generate gains in students' learning competence alongside academic performance, then it is doubly worth teachers investing time and energy in such activities. We recommend that, for future design of supplemental instruction intervention programmes, teachers should focus on identifying how different aspects of learning competence can be optimally incorporated into the supplemental instruction context to further enhance student performance, possibly via the use of qualitative focus group analysis.

Conclusion and limitations of the study

There are some limitations to this study that should be noted. As the current sample is based on students enrolled in a single business programme at a university in Hong Kong, it cannot be ruled out that the present sample was in some sense self-selecting or unrepresentative. Since disciplinary-related differences in use of study skills have been observed (e.g. Aagaard-Hansen 2007; Moje 2007), more supplemental instruction research in a variety of disciplinary settings is necessary to build a comprehensive picture in relation to which aspects of learning are 'general' or '(domain) disciplinary-specific' in influencing academic performance. In addition, one possible mediator is the attendance rate of the supplemental instruction participants. Although currently all students attended at least 63% of the supplemental instruction sessions, it might be worthwhile to assess the potential influence of supplemental instruction attendance rate in mediating learning competence and academic performance.

Due to the controversial latent structure of the LASSI instrument, we utilised a single-factor measurement model for the 10 LASSI scales. One possible extension of this study is to use exploratory factor analysis to identify groupings of related scales, which we have currently used collectively as a general measure of learning competence. This should avoid the potentially biasing effects of any unreliability that might result from using a single mediating latent dimension in a small sample study (Hoyle and Kenny 1999; Shrout and Bolger 2002).

Despite these limitations, the results of our study corroborate the view that supplemental instruction is a feasible tool for enhancing students' learning competence and academic performance. Although it may be challenging for supplemental instruction to be incorporated into the curriculum of every programme, efforts should be made to try because the benefits are apparent from the results across the numerous studies previously discussed. In conclusion, this study has shown that after a one-year implementation, supplemental instruction participants had become stronger proactive learners compared to the non-supplemental instruction group. Our results provide supporting evidence that supplemental instruction can contribute to successful learning and should be considered as a crucial aspect of curriculum design.

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