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Cluster Analysis of Attitudes towards Feedback and Their Mathematics Achievement: A Study of Hong Kong Primary Students

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Abstract

This study aimed to identify clusters of primary students based on their mathematics achievement, and their perceived usefulness of and expectation of feedback from teachers, and second, to examine profiles of self-regulated learning of the students in these clusters. The sample consisted of 4,570 students at Primary 3 to Primary 5 in Hong Kong. Two-step cluster analysis identified three clusters of students in each year level, namely, low achievers with negative feedback attitudes, high achievers with moderately positive feedback attitudes, and moderate achievers with strong positive feedback attitudes. Further, the clusters of moderate and high achievers shared similar mathematics self-efficacy, but moderate achievers had higher achievement goals and stronger self-regulated learning practices than either high or low achievers. Further, low achievers had the lowest, and moderate achievers the highest, self-regulated learning in mathematics. These results were consistent across year levels.

Keywords: mathematics achievement, feedback usefulness, feedback expectation, self-regulated learning, primary student

1 Introduction

Feedback is conceptualized as an action taken by an agent, such as a teacher, a peer, a parent or the learner himself/herself, to provide information about a performed task in order to narrow the gap between the actual level and the targeted level of the performance (Kluger & DeNisi, 1996; Shute, 2008). Several recent reviews identified feedback as one of the most important factors contributing to student learning (Gabelica, Van den Bossche, Segers, & Gijselaers, 2012; Harks, Rakoczy, Hattie, Besser, & Klieme, 2014; Hattie, 2009; Parr & Timperley, 2010). Nevertheless, research has been equivocal with regard to whether the effect was positive or negative to the learning and the learner (Hattie & Timperley, 2007). Recent research showed that effects of feedback on learning could be moderated by individual students' attitudes toward feedback utility (Karakaş, 2011; Rakoczy, Harks, Klieme, Blum, & Hochweber, 2013; Yoshida, 2010), their understanding of feedback (Carless, 2006; Havnes, Smith, Dysthe, & Ludvigsen, 2012; Lee, 2008), their perceptions on the quality of feedback, the way feedback was delivered (Harks et al., 2014), and the students' level of subject knowledge (Fyfe, Rittle-Johnson, & DeCaro, 2012). In other words, the combination of the intrapersonal feedback attitudes and achievement level may affect students' action orientation toward feedback, and hence its effect on learning. As such, an alternative research strategy to the common variable-centred approach, is to use a person-centred approach in order to identify the groups of students with similar configurations of feedback attitude and achievement level. This constituted the first aim of the study.

Several researchers (Butler & Winne, 1995; du Toit, 2012; Labuhn, Zimmerman, & Hasselhorn, 2010; Nicol & MacFarlane-Dick, 2006; Robinson, Pope, & Holyoak, 2013; Zimmerman, 2000) highlighted the inseparable relations between feedback and self-regulated learning. Some of them (Nicol & MacFarlane-Dick, 2006; Robinson et al., 2013) even asserted that if feedback were to be effective, it should support students' self-regulated learning. Nevertheless, research into the combined effect of feedback and achievement on self-regulated learning, particularly for primary students, had been rare. The second aim of this study is to examine the self-regulated learning profiles of clusters formed in the first step of the study.

2 Situational Factors for the Effect of Feedback on Learning

2.1 Inconsistent Effects of Feedback on Learning

Feedback was described as a "double-edged sword" as it could have positive or negative effects on subsequent learning, depending on the process by which the feedback was given and received (Black & Wiliam, 1998; Hattie & Timperley, 2007). On the one hand, feedback was found to enhance students' motivation and confidence toward mathematics (Everingham et al., 2013), and increase the

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accuracy of self-evaluation regarding their own mathematics achievement (Labuhn et al., 2010). Further, at-risk students who tended to be overconfident benefited, albeit marginally, in performance from performance feedback (Labuhn et al., 2010). On the other hand, meta-analysis by Kluger and DeNisi (1996) showed that over 38% of the effects of feedback interventions were negative, although on average, feedback was found to have a moderately positive effect. A more recent review by Gabelica et al. (2012) found only half of the studies involving performance feedback showed positive effects while the remaining studies had no significant effect, although their research did not find any negative effects of feedback. Hattie and Timperley (2007) found conflicting results with regard to the effect of feedback on performance. Thus, feedback may be beneficial, have no effect, or even be debilitating to learning.

2.2 Attitudes toward Feedback as Moderators of Feedback Effects

A number of reasons might have accounted for inconsistencies in the effects of feedback across studies, including the quality of feedback, the process of feedback delivery, and the perception of the feedback by the receiver (Harks et al., 2014). In parallel with personnel research (e.g., Baker, Perreault, Reid, & Blanchard, 2013) which found feedback to be counterproductive and aroused negative perceptions in the receivers if managers overlooked smaller accomplishments of employees and focused only on deficiencies, in the context of schools, if the feedback was perceived negatively by students (Karakaş, 2011; Yoshida, 2010), or if students did not understand the meaning of the feedback from their teachers (Carless, 2006; Havnes et al., 2012), the feedback would be counterproductive. Several studies (Carless, 2006; Lee, 2008) highlighted the dissonance between teachers and students in their perceptions of the values, meanings, frequency, and utility of feedback. In particular, Carless's (2006) survey of 460 faculty staff and 1,740 students from eight universities in Hong Kong found teachers and students held rather different perspectives about the usefulness of feedback. Teachers perceived more quality and usefulness in the feedback they provided than their students did.

An individual's belief in feedback utility has been highlighted in the literature (Handley, Price, & Millar, 2011; Jonsson, 2013; London & Smither, 2002) as critical in determining the recipient's ultimate engagement with the feedback. In the field of management, London and Smither (2002) coined the term feedback orientation to describe "an individual's overall receptivity to feedback. (p. 81)" Feedback orientation included the perceived feedback efficacy, liking feedback, and feedback expectancy. In higher education, Jonsson (2013) identified students' attitudes toward feedback utility to be crucial to their use of feedback, but other factors, such as students' capacity for understanding the academic messages embedded in the feedback also affected feedback use. Research on the association between feedback orientation and achievement of primary students had been relatively sparse. With an aim to fill this research gap, primary students' perceived feedback efficacy and their expectations on feedback were used in this study as indicators for their feedback orientation, and clusters of students were formed based on students' feedback orientation and their mathematics achievement.

2.3 Prior Knowledge as Moderator of Feedback Effects

The extent to which a piece of feedback was used to improve learning depended on the student's capacity to understand the message contained in the feedback (Jonsson, 2003), and the student's prior knowledge played a part in that understanding. Fyfe et al. (2012) found, in experiments involving 115 Grade 2 and Grade 3 students, that effect of feedback on learning was moderated by students' prior knowledge. In their experiments, students were provided with no feedback, feedback on their answers, or feedback on domain-specific problem solving strategies during their exploratory problem solving. The results showed that feedback was beneficial to gains in procedural knowledge at a second stage of the study for students with low prior knowledge of strategies during exploratory problem solving, but students with some prior knowledge of strategies actually learned less with feedback than without feedback during exploration. In the current study, students' achievement in mathematics was taken as a proxy of their prior knowledge in mathematics.

3 Feedback and Self-Regulated Learning Processes

Ample research provided evidence in support of the beneficial effect of quality feedback on academic performance (Black & Wiliam, 1998; Butler & Winne, 1995; Hattie, 2009; Hattie & Timperley, 2007; Labuhn et al., 2010), and several theoretical models, including including Boekaerts' (1992) adaptable learning model, Borkowski's (1996) metacognition model, Winne and Hadwin's (1998) four-stage model, and Zimmerman's (2000) social cognitive model, were put forward to explain the mechanism through which this took place. In this study, our point of departure was the cyclical model of self-regulation explicated by Zimmerman (1989, 2000). Zimmerman (1989) defined self-regulated learning as self-directed processes through which the learner proactively modulated his/her thoughts, feelings and activities during learning in order to attain the desired learning goal.

In Zimmerman's (1989) model, feedback from previous performance was conscientiously used by the learner to regulate behaviour in the current learning endeavour (hence cyclical). Three processes -- personal, behavioural, and environmental -- were depicted in the model to have reciprocal influences on each other, and feedback served as the connective among them (Zimmerman, 1989, p. 330).

In this study, self-efficacy in mathematics and goal orientation were included as personal process variables, and self-regulation as behavioural process variable. Cluster membership defined by the combination of students' previous mathematics achievement and feedback orientation was used as a proxy for environment process variable. Self-efficacy, or belief in one's own capacity to conduct organised actions for a task, is domain specific and context bound (Bandura, 1997). It has been highlighted as essential for self-regulated learning because of its effect on goal setting, committed effort, and perseverance of the learner (Zimmerman, 2000).

Self-regulation in the context of education refers to processes that learners change their learning behaviours in order to achieve their learning targets (Sitzmann & Ely, 2011). In this study, it referred to processes the learners used to "strategically regulate behaviour and the immediate learning environment (Zimmerman, 1989, p. 330)" on the evidence of feedback (e.g., "I modify my learning methods according to teachers' comments").

Goal orientation is students' beliefs about the purposes of learning and this construct is explicitly incorporated in Zimmerman's (2000) model. The notion of personal best goal orientation was proposed by Martin (2006, 2011) and referred to goal orientation with the purpose of going beyond one's own best learning performance achieved earlier. Four dimensions, namely, specific goals, challenging goals, self-referenced goals, and self-improvement goals, were the cornerstones for personal best goals (Martin, 2006). The current study focused on the dimensions of self-referenced (e.g., "I do not compare myself with others but just do my best") and self-improvement (e.g., "I keep striving for breakthroughs in my learning") goals, given governmental policy emphasis on self-initiated improvement and development both at the school- (Education Bureau, 2013) and student-levels (Education and Manpower Bureau, 2005) in Hong Kong where this study was conducted. The self-referenced orientation in personal best goals is in line with the distinguishing feature, the self-oriented feedback loop, proposed in Zimmerman's (1989) model.

Research by Martin and associates (Liem, Ginns, Martin, Stone, & Herrett, 2012; Martin, 2011) showed that by using one's previous best performance as benchmark, the learner was sheltered from comparisons against an absolute standard, or comparisons with other students, both could be too demanding for an individual learner; thus, personal best goals tended to be more meaningful and aligned with the individual learner's current status. Further, personal best goal serves as a constructive intermediary between the dichotomy between mastery- and performance-goal orientations by emphasizing on both self-improvement and comparison (Martin, 2006, 2011). Personal best goal orientation was used in this study for these reasons.

4 Person-Centered Approach to Studying Feedback and Achievement

4.1 Understanding Feedback from Students' Perspectives

Despite numerous studies on the effect of teacher feedback on student learning, most of these were from the teachers' perspectives rather than the students,' and few studies had explored the students' affective and cognitive responses toward feedback (Hargreaves, 2013; Havnes et al., 2012). One important exception was a study by Beaumont, O'Doherty and Shannon (2011) who used semi-structured focus group interviews of 37 undergraduate students and 13 university teachers from three disciplines across nine institutions. The study found that students considered quality feedback to be dialogic exchanges, which might be written or verbal exchanges, between the student and tutor for guidance and reassurance of the students' learning (p. 674). Based on the data, a model titled Dialogic Feedback Cycle was developed on processes of quality feedback, which comprised guidance in preparation for an assignment, in-task guidance given to support work on the assignment, and performance feedback after the submission and feed-forward for subsequent learning (Beaumont et al., 2011). Nicol (2010) also highlighted the importance of engaging students in dialogistic feedback for it to be effective to the students' learning in higher education. Similar studies at the primary school level were rare.

To date, little is known about how students engage with the information contained in the feedback and regulate their thinking or behaviour accordingly to enhance their learning. How feedback is taken up and used by the student for the improvement of strategies and efforts toward reaching the learning goal has been largely neglected by previous research. This research gap is unfortunate because feedback by itself would not automatically have any impact; until and unless the meaning of the given feedback is understood and acted upon by the receiver, it loses its function as feedback (Carless, 2006; Jonsson, 2013). Yet, individual students react differently to the same piece of feedback, depending on their background, discipline, own competency beliefs, nature of student-teacher relationship, the context within which the feedback is given, the student's interpretation, emotional acceptance of the feedback, perceived usefulness of feedback, and the student's epistemological beliefs about feedback (Dennis, Masthoff, & Mellish, 2012; Hyland, 2013).

4.2 Intra-Personal Variables for Feedback Effect

The above review showed that responses to feedback were elicited by a combination of intrapersonal correlates of achievement (e.g., the student's belief about the utility of feedback; his/her expectations on feedback), inter-personal correlates of achievement (e.g., student-teacher relations), and contextual variables (e.g., context in which the feedback was given), rather than by the feedback itself. The same piece of feedback might provoke very different response from students because of the combination of these variables with feedback.

This study focussed attention on intrapersonal correlates of achievement and examined the association between feedback attitude and mathematics achievement from the perspective of students. Whereas previous studies typically used a variable-centred approach (e.g., by using regression or structural equation modelling) in investigating the relationship between feedback and achievement, this study adopted a person-centred, or in the context of this study, a student-centred approach, whereby clusters of students were formed using three indicators, namely, students' mathematics achievement, their attitudes toward feedback usefulness and their expectations for feedback. A person-centred (i.e., centred on students) approach was considered appropriate here because the same piece of feedback might elicit very different response from different students (Dennis et al., 2012; Hyland, 2013). The study then examined characteristics of the clusters and cluster profile on students' self-regulated learning six months later.

Specifically, two research questions were addressed:

1. Could students be identified in distinct clusters on the basis of their perceived feedback efficacy, expectations of teacher feedback, and mathematics achievement?
2. What was the profile of self-regulated learning in mathematics for students in the clusters?

5 Methods

The current study was part of a larger longitudinal study on feedback, self-directed learning and mathematics achievement of primary students in Hong Kong. The present study used data collected at the baseline, and focused attention on students' perceived usefulness of feedback from teachers, expectations of feedback from teachers, and students' mathematics achievement. Then clusters profiles on self-regulated learning six months later were examined.

5.1 Sample

All primary schools in Hong Kong were invited to take part in the project and 26 expressed an interest to voluntarily participate. The sample for the larger study comprised 4,687 students currently enrolled in 165 classes at Primary 3 (P3; median age 8 years), Primary 4 (P4; median age 9 years) and Primary 5 (P5; median age 10 years) from these 26 primary schools. Although not randomly selected, the schools were representative of all schools in Hong Kong in terms of geographic location (Hong Kong Island/Kowloon/New Territories North and East/New Territories West), gender of school population (co-education/single sex schools), religious background of school (with/without religious affiliation), and averaged achievement level (i.e., band 1/2/3 school). The sample for the current study comprised 4,570 students with complete data on the selected variables; 117 students were excluded because of missing data. There was no statistically significant difference between students with complete and incomplete data in their mathematics achievement at baseline. There were 2,414 (52.8%) female students and 2,156 (47.2%) male students in the sample. Table 1 presents the sample distribution by gender and year level.

5.2 Instruments

The instruments used in the present study included a self-report questionnaire and multiple choice academic achievement tests for students in different grades. The mathematics tests were developed according to the Hong Kong mathematics curriculum. The test for P3 contained 29 curriculum-based achievement items and the tests for P4 and P5 each contained 35 items.

In order to address research question 1, clusters of students were formed using cluster analysis on three latent variables comprising students' perceived effectiveness of teachers' feedback in support of their learning as measured by the Feedback Efficacy Scale, students' expectations of feedback from teachers as measured by the Feedback Expectation Scale, and students' mathematics competencies as measured by the mathematics test.

Table 1 Sample Distribution by Gender and Year Level

Year Level	Female	Male	Total
P3	741 (48.1%)	800 (51.9%)	1,541
P4	910 (58.3%)	651 (41.7%)	1,561
P5	763 (52.0%)	705 (48.0%)	1,468
All	2,414 (52.8%)	2,156 (47.2%)	4,570

Note: Within-year-level percentages are presented after the sample size and in parentheses.

The Feedback Efficacy Scale was designed to measure students' perceived usefulness of feedback from teachers. It was made up of four Likert-type items with four response options, namely, 'Useless,' 'Not Too Useful,' 'Quite Useful' and 'Very Useful.' The items had a common item stem stating, 'How useful are the following forms of feedback in supporting your learning?' An example item is 'Conversations on learning between teachers and me.' Psychometric properties of scales are discussed in later sections.

The Feedback Expectation Scale was also designed to measure students' expectation of teachers' feedback in support of their learning. It was made up of four Likert-type items with four response options, namely, 'Strongly Disagree,' 'Disagree,' 'Agree' and 'Strongly Agree.' The items had a common item stem stating, 'I hope to get the following forms of feedback from my teachers...' An example item is 'Point-out the specific mistakes (e.g., say "You forgot to simplify the fraction, so the answer is still wrong.").'

After forming the clusters using the students' responses to the two feedback attitude scales in conjunction with their mathematics achievements, profiles of self-regulated learning in mathematics of students in the clusters were explored in order to address research question 2.

The Personal Best Goal Orientation Scale was adapted from Martin's (2006, 2011) conception and measurement scale of personal best goals. It comprised seven Likert-type items. An example item was, 'My target is to achieve beyond my existing performance' and the response options were 'Strongly Disagree,' 'Disagree,' 'Agree' and 'Strongly Agree.'

The Self-Efficacy Scale was designed to measure students' self confidence in doing well in mathematics. A student's mathematics self-efficacy, or the student's self-beliefs about his/her own capability to learn and do well in mathematics, was found to be an important factor both contributed to and affected by the student's achievement in the subject, and the effect was mediated by the student's self-motivation about the subject (Labuhn et al., 2010; Ramdass & Zimmerman, 2008). The Self-Efficacy Scale comprised four Likert-type items. An example item was, 'I learn things quickly in mathematics' and the response options were 'Strongly disagree,' 'Disagree,' 'Agree' and 'Strongly agree.'

The Self-Regulation Scale was constructed to measure primary students' modulation on their learning approaches on the basis of feedback. It was made up of seven Likert-type items. An example item was, 'When I find that I am doing less well in my study, I change my learning methods,' and the response options were 'Strongly disagree,' 'Disagree,' 'Agree' and 'Strongly agree.'

5.3 Procedures

The students completed a self-report questionnaire during one class session of 40 minutes and the mathematics test in another class session under the teachers' supervision at school. Data collection for all schools was completed within two weeks. Response sheets of the questionnaires and of the mathematical tests were scanned with verification, and the data were captured electronically. About one-fifth of the questionnaire and mathematical test response sheets were randomly selected for cross-examination by another team of the scanning company to ensure that the data were correctly captured. All procedures of the study were approved by the Ethics Review Committee of the university where the authors worked, and ethical guidelines were strictly followed throughout the study.

Scale internal consistency in terms of Cronbach's alpha was reported for each scale. Using Winsteps® (version 3.81.0) (Linacre, 2014), Principal Components Analysis of Rasch residuals (Linacre, 2014; Raîche, 2005) was used to determine the unidimensionality of each scale. Psychometric properties of the scales were examined. Using the Rasch rating scale model (Wright & Masters, 1982), Rasch measurements of the latent variables were estimated for each student.

Next, the calibrated Rasch measurements of the students' latent trait of perceived effectiveness of teachers' feedback in support of their learning, expectations of feedback from teachers and mathematic achievement were used as three indicators in the subsequent Two-Step Cluster Analyses using SPSS (Version 21) in order to find the pattern of the latent trait among the students within each year level. The number of clusters was identified using the distance measure of log-likelihood, maximum branches (per leaf node) of six and maximum tree depth (levels) of six. The number of clusters was then determined on the basis of the clustering criterion of Akaike's Information Criterion (AIC), Schwarz's Bayesian Criterion (BIC), interpretability of the clusters, and pattern of clusters across year levels. For each year level, multivariate analysis of variance (MANOVA) was conducted to ascertain statistically significant difference between the cluster mean Rasch measures of the clusters. Last, profiles of self-regulated learning of the students in different clusters were presented.

It should be noted that although the same set of attitude scales were used across year levels, P3, P4 and P5 students completed different mathematics tests which were designed according to the respective curriculum. Thus, both the validation of the mathematics tests and the subsequent cluster analyses were conducted separately for each year level. Further, although multilevel analysis should have been used because of the nested nature of the data, preliminary analysis found only low intra-class correlations (ranging from 0.006 to 0.030) and small design effects (ranging from 1.156 to 1.831) at either school or class levels for all variables in this study. Single level analyses were conducted instead.

6 Results

6.1 Psychometric Properties of the Instruments

Analysis showed that all scales in this study had good psychometric properties. All measurement scales were internally consistent with Cronbach's alphas between 0.66 and 0.91 (Table 2, column 3). Rasch item reliabilities were greater than 0.65 for all scales (Table 2, column 4) and item separations of all scales were greater than 2 (Table 2, column 5). Principal Components Analysis of Rasch residuals found that the Principal Component eigenvalues in the first contrast were between 1.3 and 2.0 (Table 2, column 6), which were within the acceptable threshold range of values from 1.4 to 2.1 for random noise reported by Raîche (2005), suggesting that there should be only one variance component underpinning the structure of the data.

Further, the percentage of variance in the data explained by the Rasch measures ranged from 25.1% to 61.2% (Table 2, column 7). Point-measure correlation ranged from 0.69 to 0.89 (Table 2, column 8), which was reasonable. These results support that each scale is likely to be underpinned by a single dimension. In addition, the data fit the Rasch model well: the Rasch Model Infit, i.e. weighted, Mean Squares (MNSQ) statistics were within the acceptable range of 0.5 to 1.5. There were only four items with the Rasch Model Outfit, i.e., un-weighted, MNSQ statistics outside the acceptable range (Linacre, 2014) (Table 2, columns 9 to 11).

6.2 Cluster Characteristics

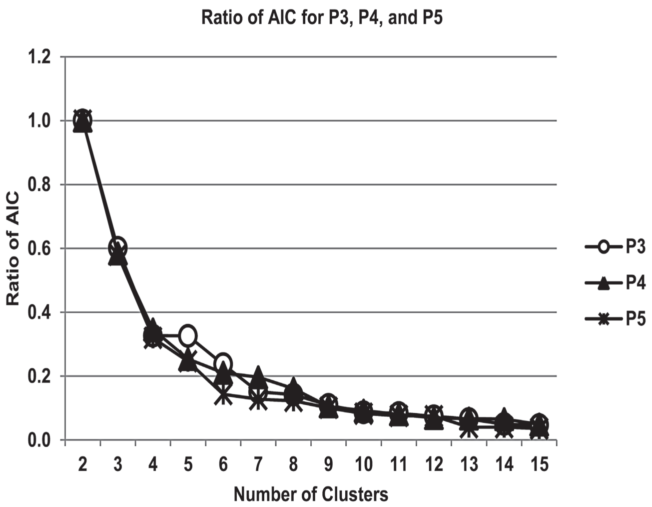
Cluster analyses using the SPSS (version 21) software identified four clusters as mathematically optimal according to the AIC index, and five clusters according to the BIC index (Figure 1). Nevertheless, a three-cluster solution offered the best interpretation of the clusters as well as consistency across year levels. Thus, a three-cluster solution was selected for this study.

The SPSS (version 21) software generates a silhouette measure of cluster cohesion and separation, which in theory can range from -1 to 1. A silhouette measure of -1 means that all cases of the cluster under examination are located

Table 2 Psychometric Properties of Scales

Subscale Name	No. of Items	Cronbach's Alpha	Rasch Item Reliability	Item Separation	Eigenvalue of First Contrast
(1)	(2)	(3)	(4)	(5)	(6)
Math Achievement (P3)	29	0.66	0.65	1.36	2.0
Math Achievement (P4)	35	0.74	0.74	1.67	1.8
Math Achievement (P5)	35	0.81	0.80	2.02	1.7
Feedback Efficacy	4	0.78	0.93	3.72	1.6
Feedback Expectation	4	0.77	0.96	4.93	1.5
Personal Best Goal	7	0.84	0.99	13.30	1.8
Math Self-Efficacy	4	0.91	0.98	7.66	1.4
Self-Regulation	6	0.87	0.98	7.86	1.3

Subscale Name	Observed % of Var Explained by Rasch Measure	Range of Point-Measure Correlation	Range of Item Infit MNSQ	Range of Item Outfit MNSQ	No. of Outfit Outside (0.5 ~ 1.5)
(1)	(7)	(8)	(9)	(10)	(11)
Math Achievement (P3)	25.1	0.16 ~ 0.48	0.87 ~ 1.10	0.69 ~ 1.82	1
Math Achievement (P4)	29.1	0.21 ~ 0.48	0.83 ~ 1.32	0.54 ~ 1.89	2
Math Achievement (P5)	31.3	0.08 ~ 0.52	0.82 ~ 1.19	0.55 ~ 1.98	1
Feedback Efficacy	49.1	0.74 ~ 0.81	0.76 ~ 1.14	0.76 ~ 1.09	0
Feedback Expectation	43.0	0.69 ~ 0.76	0.88 ~ 1.20	0.93 ~ 1.16	0
Personal Best Goal	42.2	0.62 ~ 0.73	0.76 ~ 1.41	0.72 ~ 1.48	0
Math Self-Efficacy	61.2	0.87 ~ 0.89	0.89 ~ 1.06	0.89 ~ 1.07	0
Self-Regulation	47.1	0.74 ~ 0.79	0.79 ~ 1.15	0.80 ~ 1.16	0



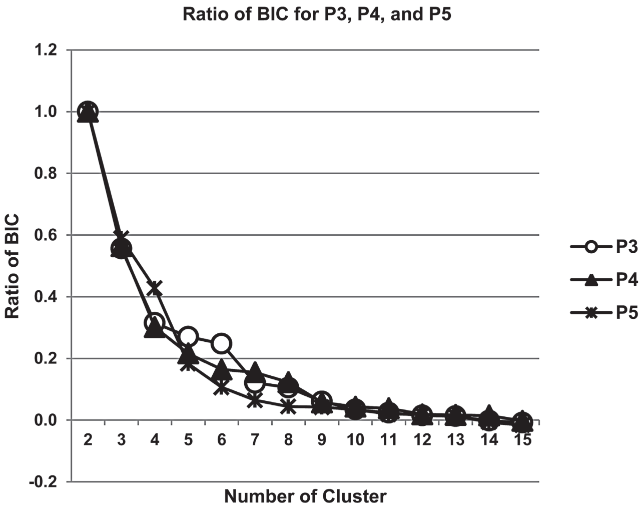


Figure 1 Ratio of AIC and BIC for P3, P4, P5

on the centre of another cluster, which represents the worst possible cluster quality. At the other extreme, a silhouette measure of 1 means that all cases for the cluster under examination are located at its centre and this represents the best possible cluster quality (Kaufman & Rousseeuw, 2005). In between these two extremes, clusters with silhouette measures less than 0.2 are considered as having poor cluster quality. Clusters with silhouette measures between 0.2 and 0.5 are of fair quality, and those with measures between 0.5 and 1 are of good quality.

The results of the cluster analysis are presented in Table 3. The results show that three clusters of students were identified at each year level. The clusters had silhouette measures ranging from 0.3 to 0.4, meaning that they were only of fair quality. The clusters at P3 and P5 were of similar sizes within their year levels. The ratios of largest to smallest clusters for P3 and P5 were 1.26 and 1.20, respectively, and each cluster accounted for about one-third of the students within the year level. At P4, cluster 2 had slightly more students (42.3%); cluster 1 had slightly less than one-third, and about one in four students were in cluster 3. The ratio of largest to smallest clusters for P4 was 1.59 (Table 3).

Cluster characteristics in terms of mean values of the cluster indicators on which the clusters were built were examined within and across year levels in order to determine unique and common characteristics. Presented in Figure 2 are the means of the three indicators, namely, mathematics achievement, feedback efficacy and feedback expectation of the three clusters within each year level. The numerical values of the mean values are presented in Table 4. It can be seen from these displays that cluster characteristics were rather consistent across the three year levels. Cluster 1 comprised students who had low mathematics performance, low feedback efficacy and low feedback expectations. Cluster 2 comprised students who had moderate mathematics performance, but high feedback efficacy and high feedback expectations. Cluster 3 comprised students who had high mathematics performance, moderate feedback efficacy and moderate feedback expectations.

Results of MANOVA showed significant differences between clusters in students' mean scores of each indicator in each grade, and the adjusted R-squared ranged from 0.301 to 0.645, which supports the uniqueness of the clusters within each grade (Table 4).

Table 3 Cluster Quality and Distribution of Students in Clusters

Year Level	No. of Clusters	Average Silhouette	Cluster Quality	Cluster 1 Frequency (row %)	Cluster 2 Frequency (row %)	Cluster 3 Frequency (row %)	Ratio of Largest to Smallest Cluster
P3	3	0.4	Fair	429 (28.80%)	521 (35.00%)	539 (36.20%)	1.26
P4	3	0.4	Fair	473 (31.10%)	642 (42.30%)	404 (26.60%)	1.59
P5	3	0.3	Fair	517 (36.60%)	463 (32.80%)	431 (30.50%)	1.20

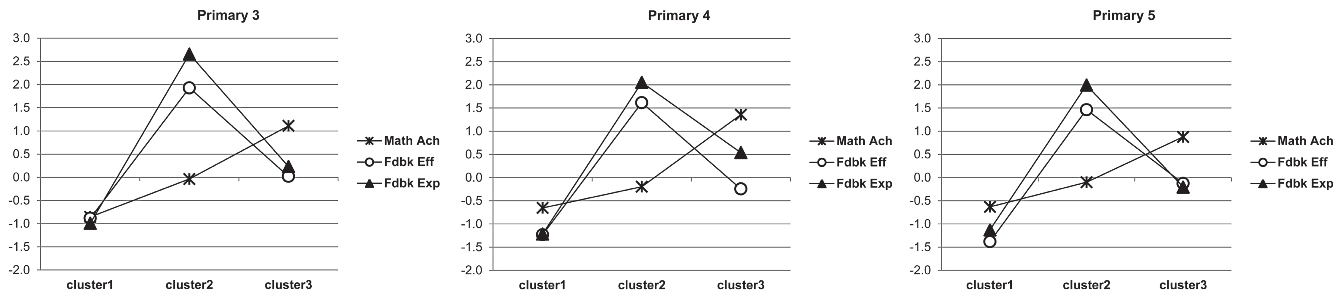


Figure 2 Characteristics of Clusters Defined by the Three Indicators: Mathematics Achievement (Math Ach), Feedback Efficacy (Fdbk Eff) and Feedback Expectation (Fdbk Exp)

Table 4 Cluster Characteristics

Year Level	Indicators	Mean			*F* Value (df1, df2)	*P* Value	Adjusted R-Squared
		Cluster 1	Cluster 2	Cluster 3			
P3	Math Achievement	-0.853	-0.037	1.109	320.203 (2, 1,486)	0.000	0.301
	Feedback Efficacy	-0.883	1.930	0.019	690.540 (2, 1,486)	0.000	0.481
	Feedback Expectation	-0.992	2.658	0.233	839.416 (2, 1,486)	0.000	0.530
P4	Math Achievement	-0.654	-0.196	1.358	642.992 (2, 1,516)	0.000	0.458
	Feedback Efficacy	-1.232	1.617	-0.244	428.024 (2, 1,516)	0.000	0.360
	Feedback Expectation	-1.217	2.053	0.538	775.186 (2, 1,516)	0.000	0.505
P5	Math Achievement	-0.631	-0.100	0.879	318.214 (2, 1,407)	0.000	0.403
	Feedback Efficacy	-1.383	1.466	-0.125	573.721 (2, 1,407)	0.000	0.549
	Feedback Expectation	-1.130	1.995	-0.205	855.825 (2, 1,407)	0.000	0.645

6.3 Self-Regulated Learning of Students in the Clusters

As presented in the previous section, three clusters of students were identified in each year level from P3 to P5. Within each year level, the three clusters were each unique in mathematics achievements and in two attitudes, namely efficacy and expectation, toward feedback from teachers, and the results were stable across the different year levels. In order to further explore the characteristics of the clusters, i.e., research question 2, the clusters within each year level were compared on three aspects of self-regulated learning, namely achievement goal, self-efficacy in mathematics, and self-regulation using MANOVA (Tabachnick & Fidell, 2007), followed by Analysis of Variance (ANOVA) to locate cluster differences with SPSS (Version 21) computer software. Student gender was used as a covariate in these analyses. Results of MANOVA followed by ANOVA after controlling for student gender showed that the three clusters within each year level differed significantly in all the self-regulation scales. That is, the clusters differed significantly in their mathematics self-efficacy, achievement goal, and self-regulation behaviours, and the results were consistent across year levels. Effect sizes in terms of partial eta-squared were moderate and ranged from 0.102 to 0.233 (Table 5).

The mean values and standard deviations of the three components of self-regulated learning, i.e., mathematics self-efficacy, achievement goal and self-regulation practices, of student clusters are presented in Table 6, and illustrated graphically in Figure 3. It can be seen that students in cluster 1, which consisted of students with low mathematics achievement and low feedback attitudes, had low mathematics self-efficacy, low achievement goals

Table 5 Cluster Comparison on Self-Regulation Scale with MANOVA and ANOVA

Year Level	MANOVA			Follow-up ANOVA			
	F (df1, df2)	prob	Partial Eta-Sq	Self-Regulation Scale	F (df1, df2)	prob	Partial Eta-Sq
P3	93.986 (6, 2,944)	< 0.001	0.161	Math Self-Efficacy	103.853 (2, 1,474)	< 0.001	0.124
				Achievement Goal	223.632 (2, 1,474)	< 0.001	0.233
				Self-Regulation	174.262 (2, 1,474)	< 0.001	0.191
P4	85.412 (6, 3,008)	< 0.001	0.146	Math Self-Efficacy	85.474 (2, 1,506)	< 0.001	0.102
				Achievement Goal	208.894 (2, 1,506)	< 0.001	0.217
				Self-Regulation	148.320 (2, 1,506)	< 0.001	0.165
P5	81.259 (6, 2,772)	< 0.001	0.150	Math Self-Efficacy	81.125 (2, 1,388)	< 0.001	0.105
				Achievement Goal	146.752 (2, 1,388)	< 0.001	0.175
				Self-regulation	157.711 (2, 1,388)	< 0.001	0.185

Table 6 Mean and Standard Deviation of Clusters of Self-Regulated Learning

Year Level	Self-Regulated Learning	Cluster 1	Cluster 2	Cluster 3
P3	Math Self-Efficacy	-0.110 (2.916)	2.293 (3.004)	1.887 (2.773)
	Achievement Goal	-0.110 (2.916)	3.083 (1.548)	1.864 (1.539)
	Self-Regulation	0.636 (2.368)	3.185 (2.030)	1.839 (1.818)
P4	Math Self-Efficacy	-0.789 (3.124)	1.103 (3.138)	1.432 (3.013)
	Achievement Goal	0.823 (1.712)	2.838 (1.568)	1.947 (1.475)
	Self-Regulation	0.593 (2.197)	2.756 (1.990)	1.805 (1.817)
P5	Math Self-Efficacy	-0.538 (3.044)	0.939 (3.175)	1.710 (2.841)
	Achievement Goal	0.926 (1.540)	2.579 (1.542)	1.619 (1.345)
	Self-Regulation	0.575 (1.965)	2.709 (1.850)	1.469 (1.714)

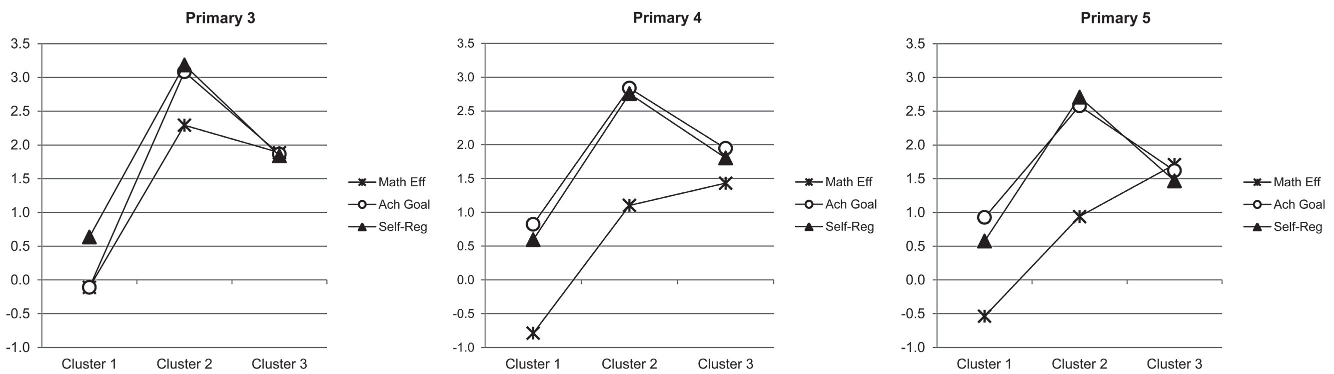


Figure 3 Profile of Mathematics Self-Efficacy, Achievement Goal and Self-Regulation for Clusters 1, 2, and 3 at Year Levels Primary 3, 4, and 5

and low self-regulation practices. Students in cluster 2, which consisted of students with moderate mathematics achievement and high feedback attitudes, had moderate mathematics self-efficacy, but high achievement goals and high self-regulation practices. Students in cluster 3, those with high mathematics achievement and moderate feedback attitudes, had moderate (for P3 and P4) or high (for P5) mathematics self-efficacy, moderate achievement goals and moderate self-regulation practices. In other words, cluster 2 and cluster 3 were similar in their mathematics self-efficacy (except P5), but differed in their achievement goals and self-regulation practices.

7 Conclusion and Direction for Future Research

This study aimed to explore the relationship between feedback attitude and mathematics achievement from the perspective of students. Using a person-centred approach, the study cluster analysed primary students' mathematics achievement and attitudes toward feedback, and examined the profiles of self-regulated learning of students in the clusters. Three clusters of students with distinct characteristics of mathematics achievement and feedback attitudes were identified at each year level. The first cluster comprised students who were low achievers in mathematics, who did not consider feedback to be useful, and who had low expectations of feedback from teachers. The second cluster comprised students who were intermediate in their achievement, had high efficacy of feedback and high expectations of feedback from teachers. The third cluster comprised high achievers; students who had moderate efficacy of feedback and moderate expectations of teacher feedback. The three clusters were roughly the same size at P3 and P5. At P4, cluster 3 was smaller and cluster 2 larger than cluster 1. Consistently across year levels, however, were the cluster profiles of self-regulated learning. At all year levels, students in cluster 1 had low self-efficacy in mathematics, set low achievement goals and had low practice of self-regulation. Students in cluster 2 and cluster 3 both had moderate mathematics self-efficacy. They differed in terms of their achievement goals and self-regulation practices, being high for cluster 2 and only moderate for cluster 3.

These results showed a clear tendency that low achieving students were associated with the lowest feedback attitude, and high achieving students were associated with moderate feedback attitude, but the most striking finding was that students of intermediate achievement expressed the strongest desire for teachers to help them. Hence, this last group of students were those learners who refused to give up hope. They recognised the usefulness of feedback in helping them and they expected the teachers to provide them with feedback support. They were also the ones who believed in their own ability to do well in mathematics -- at P3 these students even had slightly higher mathematics self-efficacy than the high achievers, set high achievement goals and exercised strong self-regulation in their learning. The message from this intermediate group was very clear: "We want to excel. Please help us!"

Our results extended findings of recent research (Baker et al., 2013; Harks et al., 2014; Karakaş, 2011; Yoshida, 2010) that highlighted the importance of perceived usefulness of feedback by the receiver in that this study identified the associations among perceived feedback usefulness, feedback expectation, students' current achievement, and their self-regulated behaviours. Feedback alone might not be the panacea. Rather, the dynamic interaction among a number of factors, including perceived feedback usefulness, expressed hope for teacher support, identifying achievement targets, self-belief in ability to succeed, and willingness to invest effort for improvement, contribute to academic achievement. Future research should explore how these factors interact to affect outcomes.

In line with previous research (e.g., Gabelica et al., 2012; Hattie & Timperley, 2007; Kluger & DeNisi, 1996), this study found that feedback did not automatically lead to positive effects on learning, not unless students held beliefs in the usefulness of feedback and in their own capability to learn. Causal relations between feedback efficacy, self-efficacy and achievement should be further investigated using longitudinal studies.

Further, although the cross-sectional design of this study precluded us from drawing any conclusions on trend, it is worrying that the group size of cluster 2, those students yearning for help, 'shrunk' from 42% at P4 to 33% at P5, with a corresponding 'increase' from 31% to 37% in the size of cluster 1, those who had no expectations of feedback. Developmental studies should be conducted in the future to chart the longitudinal change of students in their expectations of feedback in association with changes in their academic achievement.

The results of this study have noteworthy implications for teachers. Student engagement including their attention to feedback, the understanding of the meaning of feedback, and using feedback to regulate subsequent learning efforts (Carless, 2006; Dennis et al., 2012; Hyland, 2013) are of great importance for feedback to be effective in improving performance (Handley et al., 2011; Price et al., 2011; Quinton & Smallbone, 2010). Teachers should develop competencies in providing feedback as a guidance process, as advocated by Beaumont et al. (2011), in which guidance is given at the assignment preparatory stage, during the in-task phase, as well as providing performance feedback and feed-forward guidance, in order to enhance perceived usefulness of feedback by students. Further, the uptake and utilisation of feedback should be monitored by both students and teachers.

Finally, in addition to the longitudinal studies mentioned above, the current study can be extended in at least three ways. First, the reasons underpinnings students' perceived low feedback efficacy and their low feedback expectations, particularly for students of low mathematics achievement and, to a lesser extent, students of high achievement, should be further examined. Second, one size might not fit all. It is important for researchers to investigate the content and delivery strategies of feedback in order to suit the different needs of students at various achievement levels and with different self-efficacies in learning the subjects. Third, the participants of this study were students at primary levels 3 to 5 studying mathematics in Hong Kong where examination pressure was well-documented. The extent to which findings of this study could be generalised to other subjects at different year levels, cultural backgrounds and geographical locations could be explored. Understanding the feedback process for students of different aspirations and backgrounds should make important contributions to educational and psychological fields. It is hoped that this study has made it possible to follow up on these issues in the future.

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