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Regulating approaches to learning: Testing learning strategy convergences across a year at university

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Background. Contemporary models of student learning within higher education are often inclusive of processing and regulation strategies. Considerable research has examined their use over time and their (person-centred) convergence. The longitudinal stability/variability of learning strategy use, however, is poorly understood, but essential to supporting student learning across university experiences.

Aims. Develop and test a person-centred longitudinal model of learning strategies across the first-year university experience.

Methods. Japanese university students (n = 933) completed surveys (deep and surface approaches to learning; self, external, and lack of regulation) at the beginning and end of their first year. Following invariance and cross-sectional tests, latent profile transition analysis (LPTA) was undertaken.

Results. Initial difference testing supported small but significant differences for self-/external regulation. Fit indices supported a four-group model, consistent across both measurement points. These subgroups were labelled Low Quality (low deep approaches and self-regulation), Low Quantity (low strategy use generally), Average (moderate strategy use), and High Quantity (intense use of all strategies) strategies. The stability of these groups ranged from stable to variable: Average (93% stayers), Low Quality (90% stayers), High Quantity (72% stayers), and Low Quantity (40% stayers). The three largest transitions presented joint shifts in processing/regulation strategy preference across the year, from adaptive to maladaptive and vice versa.

Conclusions. Person-centred longitudinal findings presented patterns of learning transitions that different students experience during their first year at university. Stability/variability of students' strategy use was linked to the nature of initial subgroup membership. Findings also indicated strong connections between processing and regulation strategy changes across first-year university experiences. Implications for theory and practice are discussed.

Learning within formal education involves persistent, adaptive effort over years of academia. From the students' perspective, this consists of applying at least two essential strategies: the organization and management of learning (regulation) and the acquisition/

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assimilation of information from lectures, tutorials/laboratories and text (processing). The nexus of behavioural regulation and processing is an essential pairing if students' individual learning experience is to be effectively understood.

While learning strategies are recognized as important parts of the formal academic experience and essential skills – particularly in an age inundated with information and necessitating lifelong learning (McKeachie, Pintrich, & Lin, 1985) – their stability/variability and necessary strategic application are still poorly understood. Few contexts are more demanding of this question than first year at university. Students are expected to quickly mature as learners and develop new strategies to address the new demands presented by higher education. Research to this point has been unclear about learning strategy changes during this crucial period. Longitudinal research has often indicated either small improvement over tertiary entry level but little development in the transition to (Coertjens, Donche, De Maeyer, van Daal, & Van Petegem, 2017) and during tertiary experiences (i.e., Coertjens, Donche, De Maeyer, Vanthournout, & Van Petegem, 2013). Early research utilizing difference testing over time generally suggested a decline in the quality of student learning (e.g., Volet, Renshaw, & Tietzel, 1994; Watkins & Hattie, 1985). Researchers have hypothesized many reasons for the conflicting results. A practical hypothesis is that many university learning environments are not conducive to adaptive (deep approach) strategy increases (e.g., Zeegers, 2001). Specifically, that some tertiary education environments often fail to demand deep learning for students to be successful; and as a result, many students do not pursue such strategies.

A more methodologically oriented reason for the conflicting results could be the apparent mixture of stability/variability across strategy use and subgroups, an issue which might be addressed through the use of a longitudinal person-centred analytical framework. Employing such a framework (LPTA; latent profile transition analysis), the current study sought to address these questions in the context of first-year learning at a Japanese University, which itself is an under researched tertiary learning environment. In addition to general mean-based and broad profile analysis, this study will provide insight into stability and variability at the subgroup level and add a unique perspective on students' transitions between subgroups across the first year at university.

Strategies

The current study relied on the broad definition presented by McKeachie *et al.* (1985) for learning strategies 'cognitions or behaviours that influence the encoding process and facilitate acquisition and retrieval of new knowledge.' In the current study, we focus on two aspects of the students' learning strategies: (1) the ways in which students manage or organize their learning behaviours (i.e., regulation of behaviour); (2) the processing which students undertake to acquire new knowledge (i.e., approaches to learning).

When discussing behavioural regulation and processing strategies, it is important to be clear about the level of specificity being referred to. Both processing and regulation can be examined at the scale of a single task (e.g., Artino & Stephens, 2009; Peverly, Brobst, Graham, & Shaw, 2003), a single course (e.g., Vermetten, Lodewijks, & Vermunt, 1999; Wolters & Pintrich, 1998) or as a pattern of learning undertaken across a set of departmental courses (e.g., Clercq, Galand, & Frenay, 2013; Coertjens *et al.*, 2013). In the current study, we are concerned with the pattern of students' experiences across their departmental courses and will therefore restrict our discussion to research in this area.

Learning strategies

Throughout the 1970s and 1980s, research into how individuals acquired new knowledge, chiefly from text, grew rapidly. North American research generally focused on the different types of cognitive processing strategies (for an important review of the foundational literature, see Weinstein & Mayer, 1986). In contrast, many European researchers pursued a model, which while beginning with processing (Marton, 1975) grew to include the intentions behind processing (Marton & Säljö, 1984). This model came to be known as approaches to learning (Richardson, 2015) and has seen broad use across Europe and Pacific Asia. Constructs in this field are modelled as deep approaches, which describe an intention to understand with processing that is elaborative, connecting, and integrating new with past knowledge. Surface approaches are a match between an intention to remember new information to meet assessment demands with processing focused on memorization. The regulation of study behaviours has its origin in early work about metacognition (e.g., Baker & Brown, 1984). These metacognitive principles were building block for many self-regulation theorists (e.g., Boekaerts & Cascallar, 2006; Pintrich, 2000; Winne, 2005). In contrast to research focusing exclusively on the individual as the regulating force within students' studies, Vermunt conceived of a tripartite model of regulation based on extensive qualitative research with Dutch university students as a part of the Inventory of Learning Styles (ILS; Vermunt, 1996, 1998). Vermunt's model of regulation includes self-, external, and lack of regulation. Self-regulation describes study behaviours wherein the individual directs his or her own effort and sets his or her own study objectives. When students are externally regulated, they follow the teacher or study materials when setting objectives and structuring their learning. Lack of regulation describes the absence of both external and self-related sources of regulation (Vermunt, 1996, 1998).

Stability, variability, and change in strategy use

An apparent lack of consistency across studies examining learning strategies longitudinally has led to an unclear direction for research in this area. An early cross-sectional study across multiple years of study at university (Watkins & Hattie, 1985) observed no significant increase in deep approaches to studying. Across a single semester, Volet *et al.* (1994) observed significant declines in deep approaches to learning. Early (Newble & Jaeger, 1983) and more recent (Baeten, Struyven, & Dochy, 2013; Struyven, Dochy, Janssens, & Gielen, 2006) efforts to improve approaches have met with similar frustration, as students' surface rather than deep approaches increased. With regard to approaches to learning specifically, Asikainen and Gijbels' (2017) review of the current literature has indicated similar findings.

The evidence that exists regarding the development of students' regulation strategy use points in the same direction. Longitudinal research with the ILS (Severiens, Ten Dam, & Van Hout-Wolters, 2001) has pointed towards a decline in self-regulation relative to external regulation. Based on the studies reviewed to this point and given the correlation between adaptive (i.e., deep approaches and self-regulation) and maladaptive (i.e., surface approaches and external/lack of regulation) aspects of processing and regulation (e.g., Heikkilä & Lonka, 2006), the potential synergistic decline of processing and regulation strategies is a reasonable hypothesis.

Past research has also examined questions of stability/variability in strategy use by comparing the same students' strategies across multiple courses. This research has indicated that students' strategies exhibit both stability and variability across course contexts (Vermetten *et al.*, 1999). Specifically, self- and external regulation were found to be stable, while lack of regulation exhibited substantial variance, attributed to its strong connection with the learning difficulties students experienced. In the current research, we were interested in the broader question of strategy stability/variability: that is, are students' paired regulation and processing strategies stable across a year of departmental studies?

While considerable longitudinal research has been undertaken in the area of strategies, questions have been raised regarding the mean-based difference testing approaches generally utilized (e.g., Coertjens *et al.*, 2013). Traditional ANOVA and regression-based approaches might mask trajectories of development, due to measurement error inherent within mean scoring (Coertjens *et al.*, 2013). There is also the reality that traditional variable-centred approaches fail to account for distinct subgroups existing within a population. These subgroups might exhibit differential strategy use and stability/variability for these strategies over time. Some of these issues can be overcome through intra-individual analyses (e.g., latent growth curve modelling) or a longitudinal person-centred approach.

Person-centred research

Past research has noted that student populations are not a uniform group in their strategy use (Lindblom-Ylänne & Lonka, 1998; Meyer, 1998). Meyer *et al.* were perhaps the first to begin discussing the positive and negative nature of multiple strategy use called orchestrations (e.g., Meyer, Parsons, & Dunne, 1990). Meyer *et al.* referred to dissonant orchestrations of learning strategies as linkages between strategies and the learning environment, which were both unexpected and uninterpretable. Contributing to this discussion from a person-centred perspective, Lindblom-Ylänne and Lonka (2000) observed two clusters, presenting dissonant and normal clusters of students' study orchestrations (i.e., uninterpretable linked strategy use and interpretable linked strategy use). Later, person-centred research with approaches to learning and learning beliefs (Rodríguez & Cano, 2006) presented four groups: High (quantity), Low (quantity), Surface (quality) and Deep (quality). These results were also consistent with findings from Vanthournout, Coertjens, Gijbels, Donche, and Van Petegem (2013). Consistent with considerable prior research, they observed no significant general mean increases in deep approaches. Vanthournout *et al.* suggested, however, that the lack of sample-level changes might be masking changes in the unseen (latent) subgroups we often fail to examine. They suggested a more fine-grained analysis of approaches to learning.

Research to this point indicates that the variable-centred analysis of sample means might be confounding our understanding of changes in students' strategies. Past cross-sectional person-centred research has worked to address this issue (e.g., Heikkilä, Niemivirta, Nieminen, & Lonka, 2010; Vanthournout *et al.*, 2013), with analyses presenting three and four subgroups, respectively, but these studies only provide snapshots of strategy use and were therefore limited in their ability to contribute to our understanding of strategy stability/variability. A person-centred longitudinal design might support continued development of our understanding of this crucial issue.

Fryer (2017a) aimed to address this gap by applying latent profile transition analysis (LPTA) to an examination of students' approaches to learning, perceptions of teaching quality, and achievement. The cross-sectional version, latent profile analysis (LPA), generally refers to the use of continuous cluster indicators in latent variable mixture analysis (Magidson & Vermunt, 2004). Latent profile transition analysis (LPTA) is an extension to LPA, which integrates autoregressive modelling to test longitudinal group membership (Nylund, Asparouhov, & Muthén, 2007). Thereby, LPTA provides profile information at multiple time points and indicates the stability/variability of these subgroups and the transitions of each student between measurements. Using LPTA, Fryer (2017a) observed three subgroups at two time points. Substantial stability was noted for two subgroups (80% and 85%) but substantial variability (37%) for the third. These results were consistent with past theorizing about the potentially confounding effect of latent subgroups for questions of stability/variability. Further research in this area, building on these preliminary findings, might be a way forward for these theoretical issues, while also supporting the enhancement of student learning within Japanese higher education.

Strategy use east and west

As described to this point, strategy research has its origins in North America and Europe. During the past three decades, however, a considerable number of investigations have been undertaken with Pacific Asian student populations, expanding our intercultural understanding of what it means to learn at university. Arising chiefly from research undertaken in Hong Kong (e.g., Kember, Biggs, & Leung, 2004; Kember, Wong, & Leung, 1999; Watkins & Biggs, 2001), but supplemented by work in Mainland China (e.g., Marton, Wen, & Wong, 2005) and more recently in Japan (Fryer, 2013, 2017a; Fryer, Ginns, & Walker, 2014, 2016; Fryer, Ginns, Walker, & Nakao, 2012), the idea of the 'Asian' learner has become widely accepted. This is a learner who employs both surface and deep strategies, together or in series. While the Inventory of Learning Styles (ILS; Vermunt, 1994) has been significantly used in Asian contexts during the past decade (e.g., Ajisuksmo & Vermunt, 1999; Law & Meyer, 2011; Marambe, Vermunt, & Boshuizen, 2012,), the potential of distinctly Asian patterns of regulation strategies has not to our knowledge been observed.

While questions regarding the paired use of processing and regulation strategies in the Asian educational context have not received much attention, research in Western contexts, particularly Western Europe, has grown substantially during the past two decades (see Vermunt & Donche, 2017). A considerable portion of this European research has focused on the stability of students' strategies and concerns regarding strategy use across the higher education experience.

Japanese higher education

Japanese primary education has been the subject of considerable research for decades (e.g., House, 2009; Stigler, Lee, Lucker, & Stevenson, 1982) and has many aspects which are internationally respected (e.g., lesson study; Fernandez, Cannon, & Chokshi, 2003). In contrast, very little empirical research has examined teaching and learning within Japanese universities. The largely anecdotal literature published internationally has generally presented a negative picture of Japanese higher education. Issues raised range from the constrictive system of entrance examinations (Takeuchi, 1997) to the low expectations for students in many contexts (Doyon, 2001). Amano and Poole (2005) even go so far as to refer to it as the Achilles' heel of the Japanese state.

Perhaps the chief issue related to the quality of students' learning within Japanese higher education is the curriculum crowding common to many degree programs. Across many of the country's institutions, students often work to complete four years of course credits in just three years. This feat is often undertaken to enable students to maximize the crucial 'job hunting' window, which only exists prior to graduation. As a result, students can end up taking upwards of 10–15 courses simultaneously, and often each just once a week. This situation is a quintessential example of 'curriculum crowding'. Curriculum crowding is a potential impediment to deep learning and the self-regulated management of one's studies. Students overwhelmed by the variety and quantity of topics are more likely to rely on external regulation in well-structured contexts and might lack regulation if they do not feel they can rely on instructors for direction. Similarly, crowding might lead to increased surface approaches as students seek to grapple with the large amount of assessment, which accompanies 10 or more simultaneous courses each once a week.

The current study

In the current study, we aimed to build on past strategy research seeking to understand potential subgroup stability and variability dynamics over time. This study focuses on the longitudinal pairing of regulation (self-, external, and lack of regulation) and processing (deep and surface approaches to learning) strategies. Latent profile transition analysis provides a new perspective on both stability/variability questions – that is, which subgroups are stable and which are not – and on the transitions 'mover' groups make. These transitions have the potential to further our understanding of how students' strategies change and may suggest pathways towards supporting deep learning and self-regulation.

Aims

The current study aimed to develop and test the person-centred changes in students' joint processing and regulation strategy use across their first year at university. Based on past research with some of the same scales (i.e., Heikkilä *et al.*, 2010), we expected two to four groups. We predicted that two of the groups would replicate past studies High and Low Quantity subgroups, presenting profiles with high and low overall strategy use (e.g., Rodríguez & Cano, 2006; Vanthournout *et al.*, 2013). Other potential subgroups were expected to reflect specifically adaptive and maladaptive strategy pursuit, presenting profiles with high deep approaches and self-regulation versus high surface and external/lack of regulation, respectively. Overall, substantial stability in students' reported strategy use was expected across the year of study. Specifically, groups pursuing adaptive strategies were expected to be particularly stable (Wilson & Fowler, 2005). Based on potential issues arising from curriculum crowding, we expected a pattern of students moving towards groups with predominantly surface approaches and external or lack of regulation.

Methods

First-year students (n = 933; female = 241) studying in seven departments at one private university in Japan participated in the full study. After reading a description of the study and its aims, students voluntarily completed a survey in Japanese at the beginning (Time-1 in the fourth week of classes) and end (Time-2 the second to final class) of the year. The academic year was made up of two 15-week semesters with assessment 2–3 weeks following the final class of each semester. Surveys were completed following course lectures in the classroom. From Time one to Time two, there was a sample attrition of 54 students (5%). Follow-up with course records indicated that the majority of the attrition was due to course dropout, with 12 students being absent on the day. Follow-up with absent students was not within purview of the research project.

Part of the current sample (the regulation variables) overlaps with a study examining the interrelationship between deficits in motivation and regulatory strategies (Fryer *et al.*, 2016).

Measures

The current study utilized five scales from two different inventories and was a part of larger multicohort, longitudinal study examining motivated strategies (Fryer, 2013). For the current research, two scales were adapted from Trigwell and Ashwin (2006) study: five items measuring students' deep approaches to learning (e.g., I often find myself thinking about ideas from my course when I'm doing other things.) and five items measuring students' surface approaches to learning (e.g., I concentrate on learning just those bits of information I have to know to pass.). To compliment these processing strategies, three regulation strategy scales were adapted from the Inventory of Learning Styles (Vermunt, 1994). Each scale was shortened to four items following piloting and exploratory/confirmatory factor analysis: self-regulation (e.g., To test my learning progress, I try to answer questions about the subject matter which I make up myself.), external regulation (e.g., I study according to the instructions given in the study materials or provided by the teacher.) and lack of regulation (e.g., When I run into trouble with my studies I don't know when and/or who I should seek help or advice from.). All Likert-type items were on a scale of one to six, from totally unlike me, to totally like me. Students' year-end GPA (0–4.33) was also included in the current study, provided by the university's registrar office.

Analyses

For the current study, all latent analyses were undertaken with M*plus* 7.0 (Muthén & Muthén, 1998-2013). For all other analyses, JMP 9.01 (SAS, 2007–2011) was employed. The data set had <3% missing data. Missing data in the study were found to be consistent with MCAR (Little's MCAR test chi-square = 218.109, *df* = 197, Sig = .134) which supported imputation. Prior to analyses, the data were imputed employing LISREL 8.80 (Joreskog & Sorbom, 2006). LISREL employs the EM algorithm, which generates random draws from the probability distribution via Markov chains (see Schafer, 1997). Reliability analysis was conducted by calculating Raykov's rho (Raykov, 1997). Raykov's rho is an accurate estimate for the reliability of scales that have demonstrated unidimensionality and are made of diverse items.

Initially, a joint confirmatory factor analysis was undertaken to estimate the convergent and divergent validity of all variables modelled. This was followed by invariance testing between Time-1 and Time-2 data points. Following confirmation of invariance, LPA was conducted for Time-1 and Time-2 separately. For each time point, one through six groups were each assessed separately to find the most appropriate subgroup model. Finally, latent profile transition analysis was undertaken, examining two through six subgroup models.

Fit for the structural equation models was based on multiple fit indices. One incremental (comparative fit index; CFI) and one absolute (root-mean-square error of approximation; RMSEA) were use to measure model fit. Acceptable/good fit was indexed with CFI values above .90/.95 (McDonald & Marsh, 1990) and RMSEA values below .05/ .08 (Browne & Cudeck, 1992). Invariance testing of Time-1 and Time-2 regulation and approach constructs relied on CFI and RMSEA comparisons to assess the adequacy of the invariance between time points. The assumption of invariance is tenable if CFI does not change more than .01 and the RMSEA increases by <.015 for the invariant model (Chen, 2007).

Model fit for cross-sectional latent profile analyses was assessed with multiple fit indices. For each LPA, two likelihood ratio tests and three information criterion indexes were utilized. For the likelihood ratio tests, the Vuong–Lo–Mendell–Rubin likelihood ratio test (Vuong, 1989) and Lo–Mendell–Rubin likelihood ratio test criterion (Lo, Mendell, & Rubin, 2001), both provide a test of whether the identified set of latent groups was less statistically significant than a solution with one group less, that is whether the solution with one group less was a better fit for the data. For the information criterion, Akaikes's information criterion (AIC; Akaike, 1987), the Bayesian information criterion (BIC; Schwartz, 1978), and the sample size-adjusted BIC model are each information criterion, wherein lower values indicate the preferred model. BIC is generally seen as being the most useful information criterion guide for LCAs (Nylund *et al.*, 2007). Where no lowest BIC results from reasonable subgroup arrangements, the last relatively large BIC decrease, or an elbow, can be interpreted as indicating best fit (Nylund *et al.*, 2007).

Following classes being finalized, MANOVA was conducted to test the finalized models (subgroups resolved through LPAs modelled as explaining variance in the reported learning strategies) for Time-1 and Time-2. ANOVA followed by Turkey–Kramer HSD was then conducted to examine the difference across classes at Time-1 and Time-2. Difference testing was followed by an examination of the overall 'mover–stayer' model and finally the transitions of the three largest 'mover' subgroups.

Results

Correlations, descriptive statistics, and reliabilities are presented in Table 1. Correlational results were consistent with past research and theory in this field. Scale reliability was generally acceptable, with relatively low Raykov's rho for surface approaches. Reliability consistent with the current results has been observed across many studies in this field. Experts in this area (Richardson, 1994) have suggested that the low reliability of surface approaches is due to its relationships with assessment structures, which vary widely across cultures and teaching-learning contexts.

Structural equation modelling

Joint confirmatory factor analysis of all variables resulted in acceptable fit: CFI = .91, RMSEA = .04 (CI 90% .037–.042), chi-square = 1662.323 (185). Invariance testing indicated that the assumption of invariance was tenable (Chen, 2007): CFI = 91, RMSEA = .04 (CI 90% .037–.042), chi-square = 1685.921 (170).

Mean differences

As a first step, an ANOVA was conducted to test the sample-mean differences between the five strategies at Time-1 and Time-2 (Table 2). While self and external regulation did not exhibit significant differences ($p < .05$), the remaining three strategies demonstrated

Table 1. Observed Correlations, Means, Standard Deviations, and Raykov's rho

	DA_T1	SA_T1	SRL_T1	ERL_T1	LRL_T1	DA_T2	SA_T2	SRL_T2	ERL_T2	LRL_T2	YEAR_GPA
DA_T1											
SA_T1	.14**										
SRL_T1	.56**	.00									
ERL_T1	.20**	.18**	.23**								
LRL_T1	.05	.49**	.03	.32**							
DA_T2	.43**	.11**	.30**	.15**	.03						
SA_T2	.04	.41**	−.08*	.09	.31**	.27**					
SRL_T2	.33**	−.01	.46**	.09	−.06	.51**	.00				
ERL_T2	.13**	.12**	.04	.33**	.09	.22**	.14**	.16**			
LRL_T2	−.02	.32**	−.08*	.14**	.46**	.11**	.54**	.04	.24**		
YEAR_GPA	.09**	.02	.05	.14**	.09**	.03	−.04	.01	.18**	.00	
Mean	3.2	3.7	2.8	3.75	3.7	3.8	3.5	2.8	3.6	3.6	2.4
SD	.68	.59	.77	.61	.81	.67	.68	.76	.74	.84	.69
Raykov's rho	.82	.62	.85	.66	.81	.82	.69	.82	.64	.79	

Note:. LRL = lack of regulation; SRL = self-regulation; ERL = external regulation; SA = surface approaches; DA = deep approaches; T1 = Time-1; T2 = Time-2.
$^{*}p < .05$, $^{**}p < .01$.

Table 2. ANOVAs for Time-1 and Time-2 means

	TIME-1	TIME-2	*P*	*F*	R^2
SRL	2.91 (.72)	2.81 (.76)	.056	7.68	.00
ERL	3.76 (.60)	3.76 (.66)	.84	.04	.00
LRL	3.74 (.83)	3.57 (.84)	.0001	19.08	.01
DA	3.24 (.68)	3.46 (.68)	.0001	47.34	.03
SA	3.72 (.59)	3.80 (.67)	.005	7.9	.00

Note:. SRL = Self-regulated learning; ERL = externally regulated learning; LRL = lack of regulation; DA = deep approaches to learning; SA = surface approaches to learning.

significant, but very small differences ($p < .01$): lack of regulation ($R^2 = .01$), deep approaches ($R^2 = .03$), and surface approaches ($R^2 = .00$).

Latent profile analyses

Following construct validation and invariance testing, latent profile analysis was conducted at each time point. For each of the Time-1 and Time-2 samples, one through six subgroup models was tested. For both series of tests, the information criteria and likelihood ratio tests confirmed four subgroups as the model for the data. Table 3 presents the results for the tested number of subgroups. The subgroups were labelled Low Quality (specifically low deep approaches and self-regulation), Low Quantity (low strategy use generally), Average (overall average use of strategies), and High Quantity (high use of all strategies) strategies. Figures 1 and 2 present the Time-1 and Time-2 profiles graphed as Z-scores.

Model difference tests: MANOVA and ANOVA

Two MANOVAs testing the explanatory power of the four subgroups found at Time-1 and Time-2 showed consistent amounts of variance explained (e.g., 48%/41%): Time-1 (Wilks' lambda = .52, $p < .001$, $df = 12$, $F = 56.69$) and Time-2 (Wilks' lambda = .59, $p < .001$, $df = 12$, $F = 44.33$).

ANOVAs were conducted for each strategy at Time-1 and Time-2; for analysis, the groups were independent variables and strategies the dependent (Table 4). All ANOVAs at Time-1 were significant ($p < .0001$), with variance explained ranging between 16% and 46%. At Time-2, all ANOVAs were significant except for GPA, with variance explained ranging between 1% and 37%. ANOVAs were followed by Tukey–Kramer HSD significant difference testing across classes for most variables measured (Table 4).

Latent Profile Transition Analyses (LPTA)

LPTA was undertaken to finalize the best fitting mover–stayer model. Confirming the cross-sectional modelling, all three information criteria again supported four subgroups as best representing the sample. All four subgroups were theoretically interpretable and met the minimum size requirements. The smallest group (Low Quantity) while borderline in size (4.8%) was distinctive enough to be an important part of the overall model. Information criteria statistics for the two through six subgroups are presented in Table 5. Finally, BIC presented a clear elbow at four subgroups confirming the organization as the best fit to the data.

Table 3. Fit for time-1 and time-2 latent profile analyses

	Time-1						Time-2					
	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5	C6
Akaike	9518.33	9275.37	9032.18	8807.57	8752.86	8707.80	10,073.94	9831.95	9659.10	9503.23	9438.39	9379.29
Bayesian	9566.72	9352.78	9138.62	8943.05	8917.37	8901.33	10,122.31	9909.34	9765.52	9638.67	9602.86	9572.79
Adjusted Bayesian	9534.96	9301.97	9068.75	8854.12	8809.39	8774.29	10,090.55	9858.53	9695.65	9549.75	9494.88	9445.75
Vuong–Lo–Mendell–Rubin likelihood ratio test		0.14	0.00	0.00	0.36	0.23		0.01	0.05	0.06	0.39	0.43
Lo–Mendell–Rubin adjusted lrt test		0.14	0.00	0.01	0.37	0.23		0.02	0.06	0.06	0.40	0.46
Bootstrapped likelihood ratio test		0.00	0.00	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00

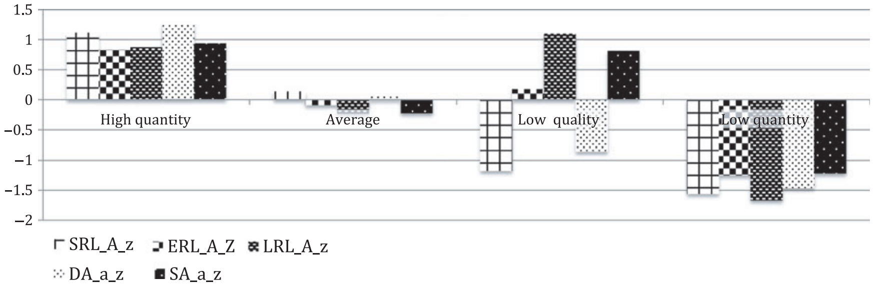

Figure 1. Latent profile analysis Time-1. *Note*: SRL = self-regulation, ERL = external regulation, LRL = lack of regulation, DA = deep approaches to learning, SA = surface approaches to learning, a = Time-1, z = *z*-scored.

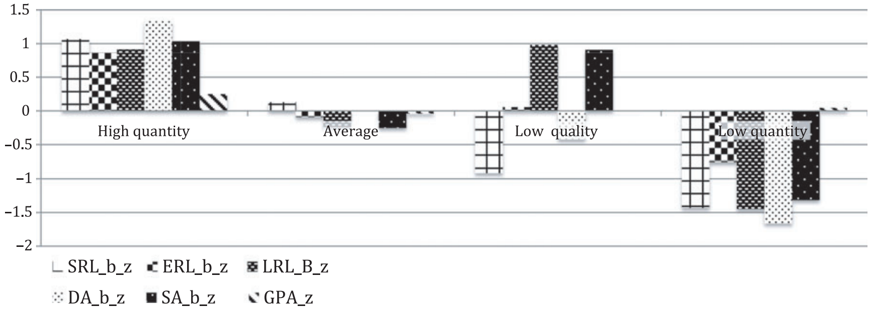

Figure 2. Latent profile analysis Time-2.

Table 4. ANOVAs for time-1 and time-2 subgroups

	Low quantity	Low quality	High quantity	Average	*p*	*F*	R^2
SRL_1	1.79 (.63) a	2.06 (.64) ab	3.70 (.58) bc	3.00 (.49) d	.0001	257.88	.46
ERL_1	3.01 (.75) a	3.87 (.81) b	4.26 (.63) c	3.71 (.46) cd	.0001	59.57	.16
LRL_1	2.35 (.93) a	4.65 (.61) b	4.46 (.76) bc	3.54 (.59) d	.0001	222.94	.42
DA_1	2.25 (.80) a	2.66 (.68) b	4.09 (.51) c	3.28 (.47) d	.0001	198.42	.39
SA_1	3.00 (.66) a	4.20 (.54) b	4.27 (.53) c	3.59 (.46) d	.0001	132.52	.30
SRL_2	1.73 (.62) a	2.12 (.63) b	3.62 (.81) c	2.91 (.56) d	.0001	171.43	.36
ERL_2	3.26 (.95) a	3.79 (.69) bd	4.32 (.70) c	3.70 (.56) d	.0001	39.46	.11
LRL_2	2.35 (.93) a	4.39 (.68) bc	4.33 (.75) c	3.37 (.62) d	.0001	183.07	.37
DA_2	2.32 (.75) a	3.17 (.64) b	4.36 (.57) c	3.46 (.50) d	.0001	171.41	.36
SA_2	2.92 (.78) a	4.41 (.59) bc	4.50 (.66) c	3.63 (.48) d	.0001	179.50	.37
GPA	2.44 (.61) a	2.40 (.68) ab	2.57 (.65) abc	2.38 (.70) abd	.06	2.46	.01

Notes:
SRL = self-regulated learning; ERL = externally regulated learning; lack of regulation = LRL; DA = deep approaches to learning; SA = surface approaches to learning. _1 = Time-1; _2 = Time-2.
All scales are from 1 to 6. GPA = Grade Point Average 0–4.33. Means are different where the letter nomenclatures (a, b, c, d) are different ($p < .05$).

Table 5. Fit for two through five groups for the longitudinal latent profile transition

	c2	c3	c4	c5	c6
Akaike information criterion	18,924.091	18,508.457	18,053.204	17,884.721	17,767.458
Bayesian information criterion	19,083.759	18,740.7	18,367.701	18,291.147	18,275.49
Adjusted Bayesian information criterion	18,978.954	18,588.256	18,161.266	18,024.37	17,942.02

The final mover–stayer model is presented as Figure 3. Broad stability was observed in group size being maintained, with the largest number of transitions being from the Low Quantity (60%) and High Quantity (28%) groups. Transitions to and from all groups were observed except for from Low Quality to Average. Overall small increases in subgroup size were observed, except for the High Quantity group.

Key transitions

Figure 4 presents the profiles of the three largest mover–stayer subgroups. Across Low Quantity to Average and Average to Low Quantity mover groups, a reversed pattern of changes can be seen in students' preference for surface/deep approaches to learning and self/external regulation, which was reflective of the nature their final subgroup. The transition from the High Quantity to Average subgroups, however, presents a substantial decrease in strategy use and a relative growth in external regulation – preferred over lack of regulation.

Discussion

The current study examined a longitudinal, person-centred model of students' self-reported approaches to learning and regulation strategy use across students' first year at

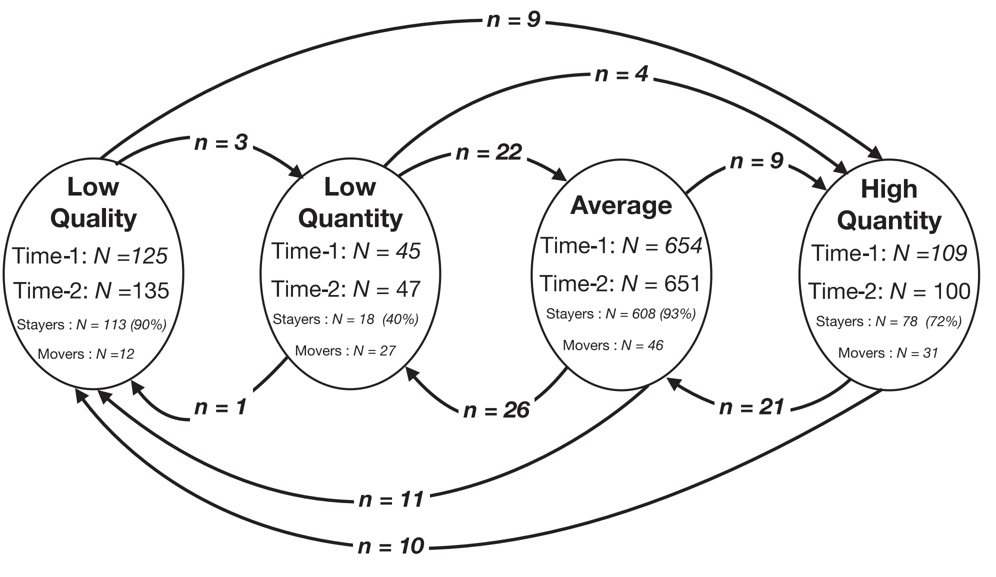

Figure 3. Mover and stayer transition Model.

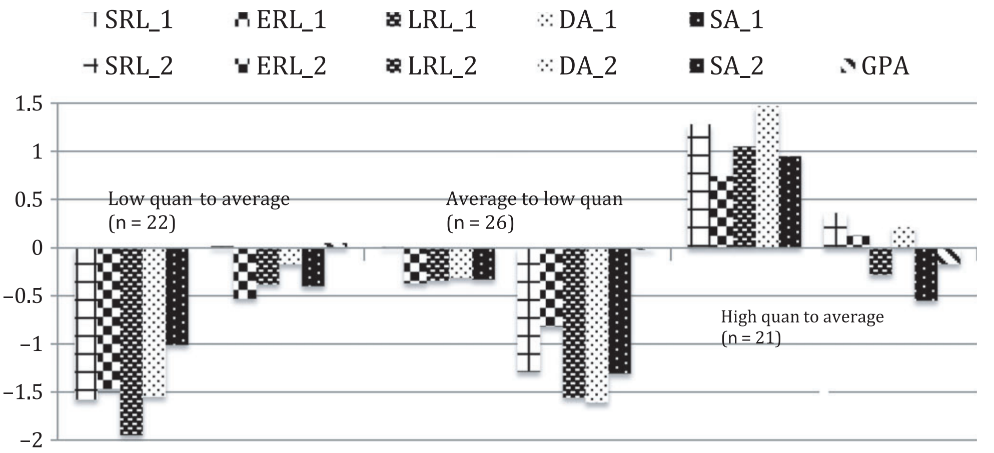

Figure 4. Three mover–stayer profiles at time-1 and time-2.

university. Sample-mean difference testing presented a very small decrease in lack of regulation, while small increases in both surface and deep approaches were observed. Cross-sectional and then longitudinal latent profile (transition) analysis indicated that four subgroups fit the sample best. Based on the subgroup's profiles, they were labelled High Quantity, Average, Low Quantity, and Low Quality. The resulting 'mover–stayer model' (Figure 4) presented a spectrum of subgroup stability to variability. The subgroups from most stable to least were Average, Low Quality, High Quantity and Low Quantity. From general subgroups to transition groups, an examination of the three largest 'mover'; groups depicted the joint processing and regulation strategy changes that students reported experiencing when transitioning between more and less adaptive groups. While students pursuing more adaptive strategies were expected to exhibit greater stability over time, the most stable subgroups were found to be students exhibiting Average and Low Quality strategy profiles at the beginning of the academic year. Finally, a pattern of movement towards the Low Quality group supported our prediction that the learning environment might not be supporting deep approaches and self-regulation strategies.

Theoretical implications

Number and nature of student subgroups

Consistent with past research (Rodríguez & Cano, 2006; Vanthournout *et al.*, 2013) High Quantity and Low Quantity groups were present and were replicable at Time-2. The remaining subgroups, however, were not in clear alignment with past findings. The Average subgroup represents students who apply a moderate amount of all strategies, and while they preferred self-regulation and deep approaches, it was not enough to substantially stand out. The remaining subgroup not clearly represented by the previous literature was the Low Quality subgroup. This group was marked by a very high lack of regulation and surface approaches relative to self-regulation and deep approaches to learning. The opposite of this subgroup failed to emerge from the current study's analysis: a High Quality subgroup with high deep approaches, low surface approaches, high self and low external regulation. While not employing the same set of variables, recent studies (Heikkilä *et al.*, 2010; Vanthournout *et al.*, 2013) have observed a subgroup utilizing a set of adaptive learning strategies. The lack of such a subgroup in the current study might be due to the cultural or institutional context, or perhaps the set of variables included in the current profiling.

Multiple strategy use

The only subgroup to display clear contrasts in strategy use (low adaptive and high maladaptive strategy profile) was the Low Quality group. The remaining three groups presented relatively consistent within-group use of all five strategies. Past studies have presented two of the three subgroups (e.g., Heikkilä *et al.*, 2010; Vanthournout *et al.*, 2013), but unlike the current study did not find the majority of their sample pursuing a broadly undefined orchestration of strategies (Average). It is possible that this might be reflective of the nature of the exclusively first-year students within the sample, who might not have had sufficient time to develop differentiated strategy use. Future research with students further in their university studies might reveal profiles with greater differentiation in strategy use. It is also possible that this is a product of the cultural context. Past studies with students of Confucian heritage have demonstrated that the pairing of seemingly contradictory strategies is both common and potentially adaptive (e.g., Marton *et al.*, 2005). To our knowledge, however, this discussion has focused on the nature of students' processing and has not included regulation.

Stability and variability

In the current study, stability might be assessed a number of ways. The first has been employed by other studies (e.g., Vermetten *et al.*, 1999), the correlation of scales across time, and suggests low stability as the autocorrelations were relatively low. It is important, however, to keep in mind that the temporal distance between measurements is substantial (8 months) and across an intense year of transition (first year at university). The second means of examining stability/variability are the percentage of stayers in each subgroup (Figure 4); here, we see considerable differences across groups. As suggested by past longitudinal studies (e.g., Vermetten *et al.*, 1999), it is not a question of stability or variability, but instead a mixture. Findings from the current study suggest that this 'mixture' might be directly related to the relative stability of different subgroups. The strategy makeup of the most and least stable groups provides some perspective on this issue. The Average is the most stable and largest subgroup that in addition to exhibiting average strategies, these students are also the most prevalent students. Being a part of this large group might mean that their strategy use is at least sufficient and therefore not necessarily in need of change. In contrast, the Low Quantity subgroup was the least stable, suggesting, along with its profile, that it is a flexible subgroup. Students in this subgroup might for a short period of time simply be uncertain where to put their energy and be searching for the right direction.

A story of three transitions

The three transitions presented in Figure 4 indicate what happens to students' strategies in the transition to new subgroups. The two transitions between the Low Quantity and Average subgroups present the mirror reflection we would expect. In these transitions, students' preference for external/self-regulation and surface/deep was reversed in pairs. The paired flipping of preferences for these strategies suggests that students' pursuits of their processing and regulation strategies are not just significantly correlated but also linked at a fundamental level. One potential reason for this linking (drawing separately from the SRL and approaches to learning literature) might be a shared cause. Long-standing sociocognitive research (SRL; e.g., Zimmerman, 1989) and recent evidence in the area of approaches to learning (e.g., Trigwell, Ashwin, & Millan, 2012) have emphasized the importance of ability perceptions for both strategies types.

The third transition from High Quantity to Average is mostly just a diminishing in the intensity of strategy use, with one exception. The resulting Average group students reported a shifting preference for external regulation over lack of regulation. It is almost as though the High Quantity students in coming down to the Average subgroup level give up any lingering uncertainties in favour of attending to the explicit demands of the course.

Practical implications

Our results demonstrate that both cross-sectionally and longitudinally at least four subgroups of strategies users exist in the current sample. These findings contribute to growing evidence of these subgroups in HE learning contexts internationally. What the current study adds to past research is the clear sense of the variance amongst subgroups with regard to stability and variability. Our results suggest that perhaps the least adaptive strategy use (high surface approaches and lack of regulation combined with low deep approaches and self-regulation) is very stable. It seems clear that if students from a subgroup such as the Low Quality subgroup are left to their own devices, they are unlikely to naturally improve. Past research (Vermetten *et al.*, 1999) has, however, suggested that the lack of regulation preferred by this subgroup is particularly susceptible to the learning environment. Interventions targeting students exhibiting a lack of regulation might therefore meet with some success. In comparison, the transitory nature of the Low Quantity group suggests that the fate of students in this group might be in the hands of students' natural development as much as instruction and curricula.

After the two least adaptive subgroups (Low Quantity and Low Quality), the question that remains is what instructors might do to nudge the very stable centre upward and protect the high-performing students from decline during the transition to university. Our results suggest that a hallmark of the largest groups of students transitioning down from the High Quantity subgroup is, along with the overall diminishing of strategies, the comparative increase in external regulation. It seems possible that the decline in High strategy use students could be due to negative friction between their strategy use and the expectations of the environment: that is, deep approaches and self-regulation on the part of students not being supported by the learning environment, while the environment at the same time presents abundant external regulation and encourages surface approaches to learning.

The reality is instructors of first-year classes at university are regularly faced with enormous classes making issues related to subgroups seemingly moot. However, effective measurement of the strategies students come to university with might be a place to start. With knowledge of students starting points, targeted support might be organized for significant subgroups. McKeachie *et al.* (1985), in addition to noting the difficulty of intervening in students' strategy use, demonstrated that such interventions were far more effective with less adaptive student subgroups (e.g., high-anxiety students).

Potential contextual and cultural implications

The lack of a clear pattern of students' moving to subgroups employing increasingly adaptive strategies in the current study suggests that the teaching-learning environment might not be sufficiently supporting learner development. The reality, however, is that this is not an issue specific to Japan or this institution, but is instead a significant problem across higher education. From the earliest (e.g., Watkins & Hattie, 1985) to later longitudinal and intervention findings (Baeten *et al.*, 2013; Zeegers, 2001), researchers have noted that many of the outcomes of higher education are not in alignment with best learning practices. We suggest that this issue is a source of interference with adaptive learner strategy change in the current context. The current study was not designed to test whether Japanese university-specific teaching-learning issues such as curriculum crowding were having any effect on strategy change. The current study, however, does raise the question of the potential role of curriculum crowding on students' strategies, which presented a pattern of decline in quality in the current context. A quasi-experimental design, however, would be necessary to effectively address this question.

Without cross-cultural comparisons, the implications for the role of students' culture within profiles and subgroups observed are limited. However, students' reported pursuit of multiple, often counterintuitive, strategies is consistent with past research and theorizing in other Pacific Asian contexts (e.g., Marton *et al.*, 2005). It is also possible that the large Average subgroup could be related to the cultural context, where there is a strong preference to be consistent with the broader group (Triandis, Bontempo, Villareal, Asai, & Lucca, 1988). These and many other related issues can only be meaningfully addressed in future studies.

Limitations, future directions, and conclusions

Future studies should compliment self-reported survey data with additional data sources such as think-aloud-protocols (e.g., Deekins, Green, & Lobczowski, 2017; Dinsmore & Zoellner, 2017) and eye-tracking (e.g., Catrysse *et al.*, 2016; Scheiter, Schubert, & Schüler, 2017). Furthermore, the current research needs to be replicated in a wider variety of institutional and cultural contexts to check the conclusions from our findings.

Future studies might examine a wider variety of processing theories (see Dinsmore, 2017; for a recent review). Research in this area should also continue to seek connections between strategy models less often researched together as a continued path towards a better understanding of how students adapt to and achieve during higher education (for recent integrative reviews mapping this, see Fryer, 2017b; Zusho, 2017).

Consistent with past research and theorizing (i.e., Vermetten *et al.*, 1999), a mixture of stability and consistency was observed within students' strategy use during their first year at university. Across the year of study, students transitioning to different subgroups were found to reverse their preferences for approach and regulation strategies. Our findings indicate a fundamental connection between students' joint processing and regulation strategies and the academic journey they take through their final formal education experience.

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