Changes in Achievement Goal Profiles of students in a Highly Active Design Thinking Classroom

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Introduction

This is a complete research paper.Design thinking is a process that promotes teaching and learning of different skills that are required for the twenty-first century [1]. It has proven in engaging students in problem solving skills and in helping them to pursue more of STEM based careers [2].Design thinking has gained immense popularity in the past decade as it is often associated with innovation [3]. With the gaining popularity, many universities are offering design thinking courses not only to engineering and design departments but also to other departments like management, medicine etc.

According to a recent article titled "Towards Bringing Human-Centered Design to K-12 and Post-Secondary Education" by Shehab et al., it is mentioned that

> While there has been increasing research into how we can best engage students in Human Centered Design in K-16 classrooms, we still lack a general consensus on the terms, practices, scaffolds, and assessments that are needed for us to effectively implement and scale HCD integration [4, p. 859].

The main reason for more research into teaching and learning of design thinking is because "design thinking typically addressed challenges that are open-ended and ambiguous, with no clear direction or deliverable" [5, p. 52]. Other Challenges of design thinking pedagogy that have a direct effect on teacher and student motivation in those courses include.

- *Audience*-Students in these design courses include many non-designers
- *Team*- design projects are collaborative in nature, including students from different disciplines
- *Creativity*- the purpose of design thinking is to enhance student creativity (which, according to many students' beliefs or epistemologies, are not malleable in nature) and make them capable of 21st-century skills.
- *Practice*- Sudden shift from traditional class structure to an active class structure by following a set of complex processes and principles [6].

The importance of motivating students academically has always been an interest in educational research. According to [7], a strong area in the domain of achievement motivation is achievement goal theory. According to [8], [9], the main focus of achievement goal theory is to identify the underlying purpose with which individuals engage in an academic task. The two main achievement goals that individuals pursue are mastery goals and performance goals [10]. A mastery goal focuses the learner when engaged in an activity with the desire to learn and understand materials/content/skills and to develop competence. A performance goal focused student engages in an activity to show competence to others and outperform others. Goal theorists later on categorized achievement goals based on approach and avoidance [11], [12]. The four different achievement goals and their definitions can be seen from Table 1. In the

beginning of achievement goal theory, the theory mainly emphasized the difference between mastery goals and performance goals. According to [8], mastery goals had higher educational benefits compared to performance goals. In 1990's a few researchers bought a new perspective to the goal theory, where they emphasized the importance of both mastery and performance goals [13]. This change in perspective led to the start of a debate in the field related goal theory. But group of researchers still believed that performance-avoidance goal was related to negative effects.

<div align="center">Relevant Literatures</div>

Debate: Multiple Goal Theory

Multiple goal theory is considered as the new perspective of achievement goal theory, where researchers argued about the benefits of performance goals in certain contexts. According to [13], through their findings, mentioned that the mastery goals, coupled with performance goal, bring out "unique benefits" in achievement outcomes. According to [14], multiple goal perspective assumes that students can pursue both mastery and performance goals in some educational settings and reap the benefits of each goal. The mastery- goal perspective theorists argue that only mastery goals should be endorsed, and there are high costs involved in endorsing both mastery and performance goals together. Whereas in the multiple goal perspective, theorists suggest that endorsing high mastery and low-performance goals are considered most adaptive [15].

Table 1. Four achievement goals and their characteristics

#	Achievement Goal	Characteristic
1	Mastery- approach goal	Improving competence
2	Mastery-avoidance	Avoid losing competence
3	Performance- approach goal	Demonstrating competence
4	Performance-avoidance goal	Avoid demonstrating incompetence

Variable-Centered and Person-Centered Approach

Both variable-centered and person-centered approach are both used to contribute to the existing debate in achievement goal theory. Variable-centered statistical techniques examine how one type of goal relates to an outcome of interest across all individuals in a given sample and partition out overlapping variance explained by two or more predictor variables [16]. Variable-centered research on achievement goals provides critical information but does not fully explore how all achievement goals combine and which combinations are beneficial.

In a person-centered approach, the analysis is done at the individual level compared to the sample level in a variable-centered approach [15]. Within any community of learners, there probably exist subgroups that share similar motivational patterns. Uncovering such subgroups within the same college classroom and understanding what characterize them with respect to other aspects of learning may give us knowledge that is important not only for theory building but also for educational practice [17]. In a person-centered approach, individuals with the same combinations of motivations are grouped together to identify common patterns of goal

endorsement. The main advantage of a person-centered approach is that it is easier to compare different goal profiles with each other in terms of different achievement outcomes to identify adaptive and maladaptive combinations of goal endorsement [15].

Research Context

The course under study is a freshman-level design thinking course offered at a mid-western university. The course is a compulsory course for polytechnic students in the university and is being offered all year long. Typically there are around eighteen sections of the course offered in the Fall and Spring semesters and around three sections in the summer semester. The format of the course is flipped and active in nature, where all the course contents are shared with students before the actual class and during the class hours, active discussions and the hands-on project is being done. The course has three projects. Projects 1 and 2 are small-scale projects mainly focused on teaching the students the design thinking process. Project 3 is an 8-week long main project, where students are expected to work on a real-time problem and come up with functional prototypes to solve or minimize the identified problem. All the projects are group-based, and hence students are required to collaborate with their peers in and outside class to successfully complete the course.

Research Question

In the context of the design thinking course over the semester, this study investigated student achievement goal orientation profiles. The first research question in this study is whether students fall into distinct categories based on student achievement goal orientation profiles. The second research question is if clusters show any significant difference in pretests and posttests of goal orientation. The third research question was what effect distinctive categories have on student achievement.

Methods

Participants and Data Collection

A total of 420 students enrolled in the Design Thinking Course at a large Midwestern university in the United States during Fall 2021 participated in this study. This research was approved by the university's institutional research board (IRB). The sociodemographic information of study participants is as below.

Table 2. Socio-demographic characteristics of study participants

Socio-demographic characteristics		Counts (N)	Precent (%)
Grade	Freshman	292	69.52
	Sophomore	88	20.95
	Junior	34	8.1
	Senior	6	1.43
Gender	Female	80	19.05
	Male	339	80.71
	Unknown/Prefer not to say	1	0.24
Ethnicity	Asian	120	28.57
	Black or African American	11	2.62

White or Caucasian	247	58.81
Hispanic or Latinx	19	4.52
Other	19	4.52
Unknown/Prefer not to say	3	0.71

Measure: Patterns of Adaptive Learning Scales (PALS)

The patterns of adaptive learning scales (PALS) have been developed by a group of researchers studying goal orientation theory [18]. PALS is a five-point Likert-type scale. This scale aims to examine the relationship between learning context and students' motivation, affect, and behavior [18], [19]. Original scales include student scales and teacher scales. Student scale is comprised of five subscales: 1) personal achievement and goal orientations, 2) perceptions of teacher's goals, 3) perceptions of the goal structures in the classroom, 4) achievement-related beliefs, attitudes, and 5) strategies, and perceptions of parents and home life. Teacher scale is comprised of three subscales: 1) teacher's perceptions of the goal structure in the school, 2) teachers' goal-related approaches to instruction, and personal teaching efficacy. As mentioned earlier, this study adopted three subscales from students' personal achievement goal orientations (see Appendix. A). Three subscales are: mastery goal orientation (N = 5), performance-approach goal orientation (N = 5), and performance-avoid goal orientation (N = 4). All items of three subscales are anchored at 1 = "Not at all true," 3 = "Somewhat true," and 5 = "Very true."

Data Collection

The data for the research was collected as a part of the end- of- semester course survey. The survey was created in Qualtrics and shared with each instructor of the design thinking course of Fall 2021. On the last day of the class meeting, students were given time in-class to complete the PALS survey. An extra credit of 5 points were given to the students as an incentive to enable maximum number of participants. The survey results were sorted to eliminate empty responses.

Data Analysis

Cluster Analysis

This study adapted cluster analysis [20] to create a typology of students' goal orientation profiles. Cluster analysis allow the researcher to empirically establish cluster of highly similar entities using multivariate statistics [20]. Among the hierarchical and non-hierarchical methods, researchers chose the latter because it aligned with the aim of study. Non-hierarchical methods require a priori number of groups in advance, in contrast to hierarchical methods. K-means cluster analysis method was selected based on its efficiency and statistical stability [21]. As a partitioning clustering method, K-means clusters group objects depending on feature values into K disjoint clusters [22]. Researchers investigated the K numbers of clusters utilizing *NbClust* package [23], [24] in R. This package proposes 26 indices for determining the best clustering numbers. Among all indices, seven proposed two as the best number of clusters, 13 proposed three as the best number of clusters, and 1 proposed four, nine, and ten as the best number of clusters. This package helps researcher to decide the best number of clusters according to the majority rule. Therefore, the researchers decided three as K in advance before the cluster analysis. Considering the shape of the datasets and number of outliers, we used Euclidean

distance measure with K-means algorithm. K-means cluster analysis yielded a meaningful three-cluster solution: Cluster 1 (N = 125), Cluster 2 (N=208), and Cluster 3 (N=171) (see Figure 1).
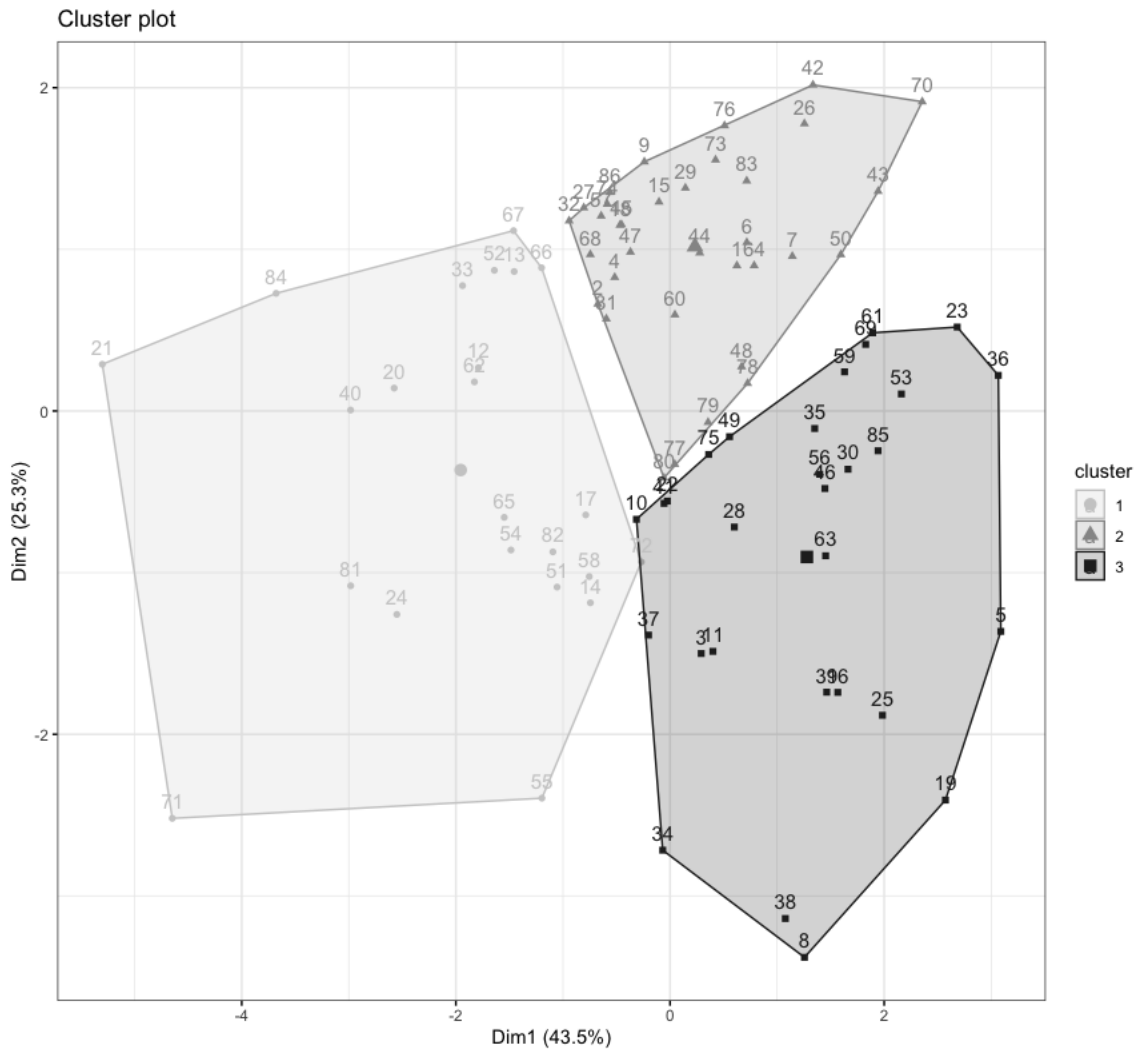

Figure 1. Cluster plot of K-means cluster analysis of student motivation

Descriptive Statistics

Descriptive statistics for the three clusters with the grade variable are in Table 3. Results show that students' goal orientation has not changed dramatically, and clusters were formed based on their profiles and characteristics of goal orientation. As can be seen in Table 3, Cluster 1 and Cluster 2 both had high mastery goal orientation. Compared to other clusters, Cluster 3 had medium mastery goal orientation. In terms of performance approach goal orientation, Cluster 2 show medium level of goal orientation, while Cluster 1 and Cluster 3 showed low level of performance approach goal orientation. In performance avoidance goal orientation, Cluster 2 showed medium level of performance avoidance while Cluster 1 and Cluster 3's level of performance avoidance were comparably lower. Therefore, Cluster 1 had high mastery low performance goals (High mastery/low performance group), Cluster 2 showed high mastery and medium performance goals (High mastery/medium performance group), and Cluster 3 showed

medium mastery and low performance goals (Medium mastery/low performance group). The mastery goal orientation was highest in all three clusters, followed by performance-avoidance goal orientation, and performance-approach goal orientation. Final grade of each cluster show that Cluster 2's grade was the highest, followed by Cluster 1 and Cluster 3.

Table 3. Descriptive statistics by cluster

	Group	High mastery low performance N = 208	High mastery medium performance N = 171	Medium mastery low performance N = 125
Goal Orientation		M (SD)	M (SD)	M (SD)
Mastery goal orientation_Pre		4.79 (0.29)	4.76 (0.31)	3.84 (0.52)
Mastery goal orientation_Post		4.50 (0.49)	4.52 (0.50)	3.64 (0.68)
Performance-approach goal orientation_Pre		1.82 (0.62)	3.09 (0.81)	2.29 (0.67)
Performance-approach goal orientation_Post		1.85 (0.60)	3.15 (0.75)	2.37 (0.64)
Performance-avoidance goal orientation_Pre		2.11 (0.68)	3.55 (0.76)	2.82 (0.74)
Performance-avoidance goal orientation_Post		2.20 (0.70)	3.49 (0.69)	2.80 (0.72)
Final Grade		901.73 (103)	985.46 (78.7)	891.08 (90.4)

Note. Pre: Pretest, Post:Posttest

Pretest-Posttest Comparison

After having established the different groups by cluster analysis, researchers determined whether there were significant group differences. First, we performed multiple paired t-tests to see if there is a difference between pretest and posttest. For High mastery/low performance group the result from mastery goal orientation pretest (M = 4.79, SD = 0.29) and posttest (M = 4.50, SD = 0.49) indicate that the design thinking project experience resulted in a statistically significant decrease, $t(414) = 7.346$, $p < 0.001$. The High mastery/medium performance group also experienced slight decrease of mastery goal orientation, $t(340) = 5.34$, $p < 0.001$. Other test results did not show any statistically significant differences between the pretest and posttest.

Group Comparison

The one-way ANOVA was followed by Tukey post-hoc tests to find out where the significant difference among the groups was located. Results show that the differences of goal orientation between groups were significant, except for High mastery/low performance group and High mastery/medium performance group. The final grades of groups also were significantly different.

Table 4. Fixed-Effects ANOVA results

Predictor	Sum of Squares	df	Mean Square	F	p	partial η2	partial η2 90% CI [LL, UL]
Mastery goal orientation: Pretest							
(Intercept)	2281.62	1	2281.62	12751.32	.000		
Group	60.63	1	60.63	338.86	.000	.40	[.35, .45]
Error	89.82	502	0.18				
Mastery goal orientation: Posttest							
(Intercept)	2002.10	1	2002.10	5856.05	.000		
Group	48.74	1	48.74	142.57	.000	.22	[.17, .27]
Error	171.63	502	0.34				
Performance approach goal orientation: Pretest							
(Intercept)	248.42	1	248.42	339.62	.000		
Group	34.70	1	34.70	47.44	.000	.09	[.05, .13]
Error	367.19	502	0.73				
Performance approach goal orientation: Posttest							
(Intercept)	250.73	1	250.73	370.20	.000		
Group	39.76	1	39.76	58.71	.000	.10	[.07, .15]
Error	339.99	502	0.68				
Performance avoidance goal orientation: Pretest							
(Intercept)	301.54	1	301.54	388.88	.000		
Group	65.44	1	65.44	84.40	.000	.14	[.10, .19]
Error	389.25	502	0.78				
Performance avoidance goal orientation: Posttest							
(Intercept)	344.27	1	344.27	487.46	.000		
Group	47.86	1	47.86	67.77	.000	.12	[.08, .16]
Error	354.55	502	0.71				
Final Grade							
(Intercept)	877851.8	1	877851.8	66.54	.000		
Group	4262338.14	1	4262338.14	51.59	.000	.17	[.12, .22]
Error	5140189.94	502	10219.0655				

Note. LL and UL represent the lower-limit and upper-limit of the partial η^2 confidence interval, respectively.

As results of ANOVA showed significant results, researchers ran Tukey's HSD to figure out which specific group's means are different, when compared with each other. Figure 5 displays the comparison of all possible pairs of mean. Groups with high mastery did not significantly different in terms of their mastery goal orientation, both in pretest and posttest. Except for those cases, goal orientation of three groups were statistically significantly different.

Table 5. Tukey's HSD of all groups: High mastery low performance, High mastery medium performance, and Medium mastery low performance

Tukey's multiple comparisons test	Mean Diff.	p	SE of Diff.	N1	N2	q	DF
Mastery goal orientation: Pretest							
High mastery/low performance group vs. High mastery/medium performance group	0.03	-	3.6	208	171	0.65	3006
High mastery/low performance group vs. Medium mastery/low performance group	0.95	<0.001	3.95	208	125	18.84	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.92	<0.001	4.1	171	125	17.55	3006
Mastery goal orientation: Posttest							
High mastery/low performance group vs. High mastery/medium performance group	-0.02	-	3.6	208	171	0.43	3006
High mastery/low performance group vs. Medium mastery/low performance group	0.86	<0.001	3.95	208	125	17.06	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.88	<0.001	4.1	171	125	16.79	3006
Performance approach goal orientation: Pretest							
High mastery/low performance group vs. High mastery/medium performance group	-1.27	<0.001	3.6	208	171	27.62	3006
High mastery/low performance group vs. Medium mastery/low performance group	-0.47	<0.001	3.95	208	125	9.32	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.8	<0.001	4.1	171	125	15.26	3006
Performance approach goal orientation: Posttest							
High mastery/low performance group vs. High mastery/medium performance group	-1.3	<0.001	3.6	208	171	28.27	3006
High mastery/low performance group vs. Medium mastery/low performance group	-0.52	<0.001	3.95	208	125	10.31	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.78	<0.001	4.1	171	125	14.88	3006
Performance avoidance goal orientation: Pretest							
High mastery/low performance group vs. High mastery/medium performance group	-1.44	<0.001	3.6	208	171	31.32	3006
High mastery/low performance group vs. Medium mastery/low performance group	-0.71	<0.001	3.95	208	125	14.08	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.73	<0.001	4.1	171	125	13.93	3006
Performance avoidance goal orientation: Posttest							
High mastery/low performance group vs. High mastery/medium performance group	-1.29	<0.001	3.6	208	171	28.05	3006
High mastery/low performance group vs. Medium mastery/low performance group	-0.6	<0.001	3.95	208	125	11.9	3006
High mastery/medium performance group vs. Medium mastery/low performance group	0.69	<0.001	4.1	171	125	13.16	3006
Final Grade							
High mastery/low performance group vs. High mastery/medium performance group	-83.73	<0.001	3.6	208	171	12.48	3006
High mastery/low performance group vs. Medium mastery/low performance group	10.65	<0.001	3.95	208	125	1.36	3006
High mastery/medium performance group vs. Medium mastery/low performance group	94.38	<0.001	4.1	171	125	12.25	3006

Result

The first aim of this investigation was to determine if there exists distinctive goal orientation profiles among the students who take design thinking course. Figure 2 shows groups elicited as a result of cluster analysis, and their goal orientation level at two timepoint (pretest and posttest). Results showed that three groups exist: 1) High mastery/low performance group, 2) High mastery/medium performance group, and 3) Medium mastery/low performance group.

When the researchers analyzed goal orientation at the group level, mastery goal orientation was the highest goal orientation among three goal orientation, followed by performance-avoidance goal and performance approach goal. Considering the project-based collaborative nature of design thinking, students might be more afraid of looking incompetent while working with their peers. There were no significant differences between pretest and posttest. Groups were significantly different in the level of goal orientation ($p < .001$), except for mastery orientation of High mastery low performance group and High mastery medium performance group. Those two groups' mastery orientation were not significantly different in both pretest and posttest.

Figure 2. Result of this study
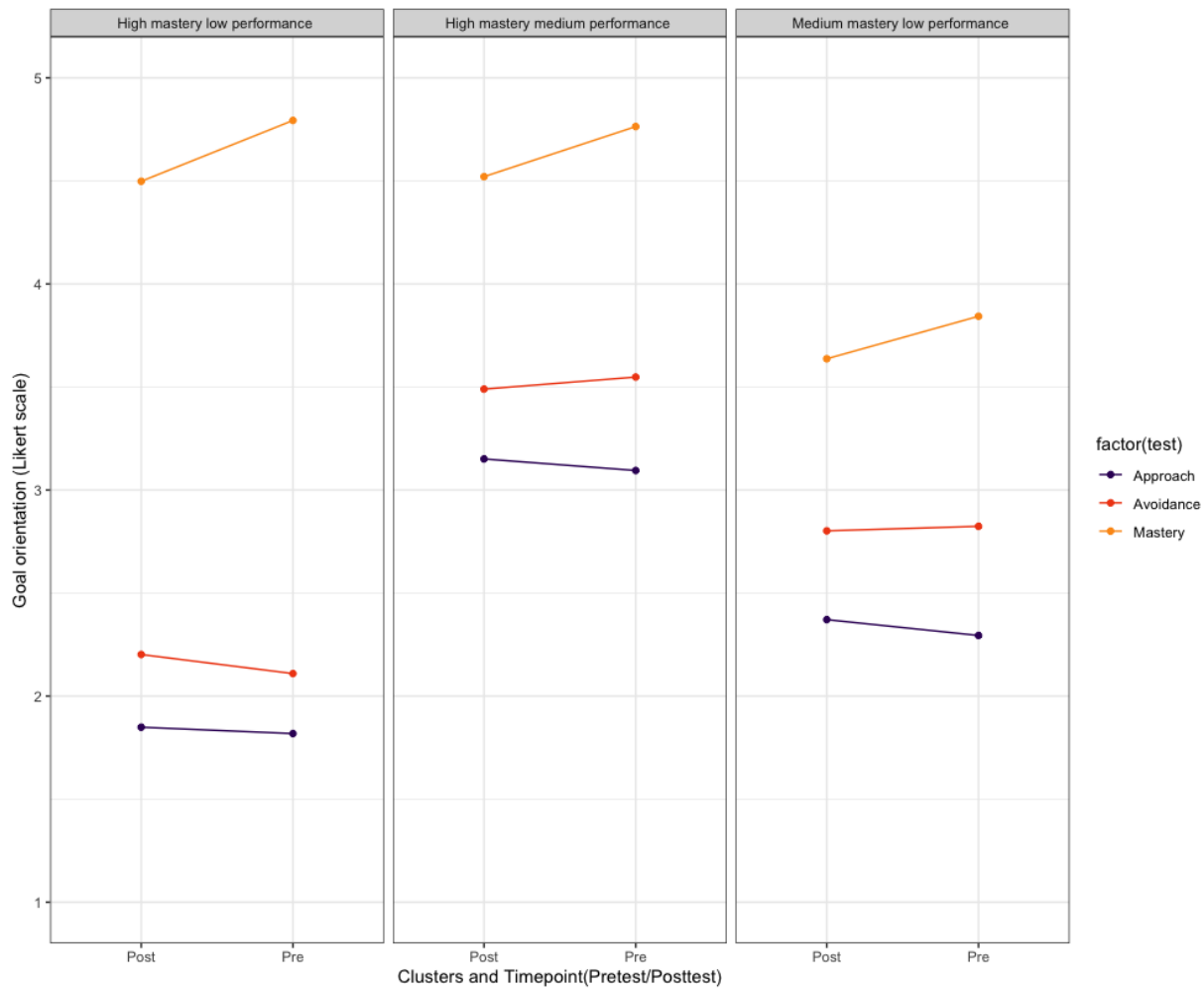
Note. 1: High mastery low performance group, 2: High mastery medium performance group, and 3: Medium mastery low performance group

Finally, there was significant differences of students' achievement between groups. The High mastery medium performance group's final grade was the highest (M = 985.46, SD = 78.7), followed by High mastery/low performance group (M = 901.73, SD = 103), and the Medium mastery/low performance group (M = 891.08, SD = 90.4) showed the lowest grade. This is in accordance with revised goal theory model. While normative goal theory [13] view high mastery/low performance group is the most adaptive pattern in terms of achievement, revised goal theory model asserted that high-mastery/high-performance group can be better on some outcomes [25].

Discussion

The implication of this study is that students should be encouraged to adopt a mastery goal orientation, and design thinking course should be restructured to promote a mastery goal orientation centered on learning new concepts and broaden one's perspectives. With regards to

performance goal orientation, students with high performance goal orientation performed better when the mastery goal orientation is not significantly different. Thus, if managing high mastery goal orientation, performance goal also helps students achieve better. Design thinking process being iterative in nature can make students feel that it is difficult to master the process. The results of the study points to the direction that the instructors teaching design thinking course to find ways of promoting mastery goal orientation in their classrooms. However, considering the importance of performance goal orientation, instructors need a balanced approach to the goal orientation. Also, for the students with low motivation profiles, instructors and teaching assistant can intervene in advance to prevent them from failing. In this way, students can implement strategies that involve successfully coping with their failure, rather than avoiding it [26].

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Appendix A: Achievement Goal Survey Questions

#	Goal Orientation	Item
1	Mastery	It's important to me that I learn a lot of new concepts this year.
2	Goal	One of my goals in class is to learn as much as I can.
3	Orientation	One of my goals is to master a lot of new skills this year.
4		It's important to me that I thoroughly understand my class work.
5		It's important to me that I improve my skills this year.
6	Performance	It's important to me that other students in my class think I am good at my class work.
7	Approach	One of my goals is to show others that I'm good at my class work.
8	Goal	One of my goals is to show others that class work is easy for me.
9	Orientation	One of my goals is to look smart in comparison to the other students in my class.
10		It's important to me that I look smart compared to others in my class.
11	Performance	It's important to me that I don't look stupid in class.
12	Avoidance	One of my goals is to keep others from thinking I'm not smart in class.
13	Goal	It's important to me that my teacher doesn't think that I know less than others in class.
14	Orientation	One of my goals in class is to avoid looking like I have trouble doing the work.