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Differentiated Instruction - Motivation and Academic Achievement Across Distinct Disciplines

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ABSTRACT

Differentiated instruction (DI) is gaining popularity as a pedagogical method/method of teaching, with the move towards inclusion. Research indicates that DI's effects on student performance and engagement are significant and positive, though there are some inconsistencies when it comes to specific findings. This study sought to investigate the extent of the effects of DI on student academic performance and motivation across two courses from distinct disciplines - English and Chemistry - in a chosen international school in Beijing, China. The study adopted a quasi-experimental research design using a sample of 32 high school students. Anonymized data on motivation were collected using a validated researcher-developed Academic Motivation Scale (AMS), while academic achievement was measured by standardized testing scores. Analysis of Variance (ANOVA) was used in analyzing and presenting data collected for the study. Results indicated that the differentiation was effective at increasing motivation to a statistically significant extent, in line with the literature. However, student academic performance as measured by test scores was not shown to have been significantly influenced by DI. It was also found that the effects of DI did not significantly differ between the two chosen courses. The results imply that in this study, DI's superiority in one particular subject/discipline has not yet been established, but future studies can be conducted in a more substantial time frame which may potentially lead to more significant results.

Introduction

Differentiated instruction (DI) is defined as the differentiation of content, process, and product in anticipation of and in response to varying student interests, needs, and readiness. (Tomlinson, 2017). Content, as in teachers modify what students learn, or their instructional content, to better address each learner's needs. Process, as in teachers assign tasks to accommodate how students learn. And the product, as in teachers provide students with a choice of how to demonstrate the information learned (Tomlinson, 2017). As the trend of inclusion gains importance, research regarding the effectiveness of DI is being done from various perspectives as educators test the validity of a pedagogy upon which their ambitions rest. Some studies have shown that differentiation improves motivation and academic performance; while others contradict this view and suggest that DI has no significant influence on either (Pablico, 2017; Zohrabi, 2012). This inconsistency needs to be inspected, however, as a narrowing of focus is needed to improve the quality of instruction.

Studies have discovered many barriers to effective differentiation, from lack of training, efficacy, and time, to increased workload and stress (Onyishi & Sefotho, 2020; Ginja & Chen, 2020). If DI is discovered to be more influential in some subjects/disciplines over others, more focus can be placed on the ones that benefit the most from this strategy, and the scope of teacher training regarding differentiation can also be narrowed. Thus, this research seeks to explore the extent of the impact of DI on student academic outcomes and motivation across two high school courses from different disciplines. In other words, the purpose of this study is to describe whether the impact of DI differs across courses from different disciplines specifically at the high school level, if a significant effect of DI within courses is observed in the first place. And if the difference is significant, this study seeks to raise awareness of the importance of teacher training in that particular subject or discipline with its results.

Literature Review

Theoretical Frameworks & Relevant Studies

Differentiated Instruction

The idea of differentiation was explored and discussed in detail by the pioneer in the field, Carol Ann Tomlinson. According to Tomlinson, differentiation is proactive, qualitative, rooted in assessment, student-centered, and dynamic (2017). For a teacher to differentiate proactively, they need to plan ahead with predictions about which student might be most suited for which types of instruction. With a better understanding of student differences, educators may be more successful at selecting learning options that would be appropriate to most learners. The primary goal of DI is to improve the quality or suitability of materials to match student needs, which may require constant adjustments to pedagogy according to changing student performance (Tomlinson, 2017).

Differentiation is student-centered, i.e. instructors are responsible for designing their materials based on what students find engaging, relevant, and interesting. Additionally, differing prior knowledge must also be addressed to assign appropriate challenges or offer support for students. Differentiation is not a monotonous method, rather, it is dynamic and cyclical. Students may go through group discussions, class work, and individual exploration according to their personal pace (Tomlinson, 2017).

Tomlinson's framework of differentiation would be used to ensure comparability in this study. To summarize, teachers start differentiation by identifying student needs - which can be done by giving pre-tests to evaluate student readiness - and then adjust instructional techniques accordingly. Teachers can match activities and comprehension tasks based on student readiness as measured by pretests to ensure that students effectively process the information taught. To differentiate products, teachers may offer project format options that can all reflect and measure common learning outcomes (Tomlinson, 2014).

Constructivist Theory

The constructivist learning (CL) theory forms a substantial part of the theoretic basis of DI, in line with differentiation by readiness and interest proposed by Tomlinson (Pablico et al. 2017). It is defined as "active construction of new knowledge, based on learners' prior experience" (Koohang et al., 2009). The CL approach emphasizes knowledge construction, cooperative learning, self-regulated learning, and real-world applications. Knowledge construction is the core of the CL theory and is facilitated by students' prior knowledge and experience. CL encourages real-life applications and diversification of ways through which students can demonstrate their understanding, instead of confining them to a set of assessments or product choices (Schreurs et al., 2014; Pablico et al. 2017).

The Self-Determination Theory

The Self-Determination Theory (SDT) of motivation first developed by Deci and Ryan, (1985) aligns with the philosophy of DI regarding ways to enhance motivation. It proposes that motivation comprises several distinct factors which contribute to action induction, including the three psychological needs: autonomy, competence, and relatedness (Ryan & Deci, 2000). The SDT recognizes that motivation is attributed to different factors, and explores different types of motivation, including intrinsic and extrinsic motivation, to understand how it affects action induction (see Figure 1) (Ryan & Deci, 2000).

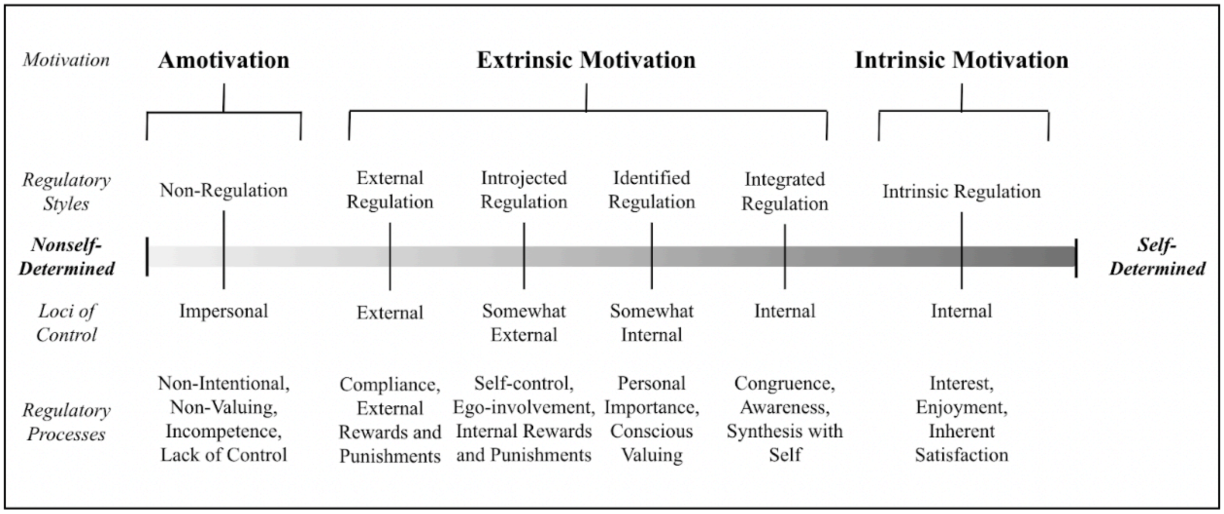


Figure 1. The Motivation Spectrum, adapted from (Ryan & Deci, 2000).

Intrinsic motivation, described as "[the] natural inclination toward assimilation, mastery, spontaneous interest, and exploration" (p. 70), enhances individual potential in a wide variety of situations, including in the classroom (Csikszentmihalyi & Rathunde, 1993; Ryan & Deci, 2000). Studies have shown that individuals who have a sense of competence are more likely to experience enhanced intrinsic motivation (Fisher, 1978; Ryan, 1982; deCharms, 1968). Competence can be enhanced by opportunities for individual exploration, personalized guidance, and choice that align with the principles of DI (Deci & Ryan, 1985, 2000). However, intrinsic motivation is only present when an activity satisfies an individual's intrinsic interest or has characteristics that produce interest, such as novelty or challenge. In cases where intrinsic motivation is unachievable, varying degrees of extrinsic motivation can facilitate autonomy, depending on the extent to which individuals internalize the value of the tasks demanded in the SDT framework (Ryan & Deci, 2000). For instance, when students are motivated by the relevance of their assignments to their chosen careers, they have internalized the value of their tasks and experience more autonomy than those who are externally motivated by deadlines and threats as can be seen in Figure 2.

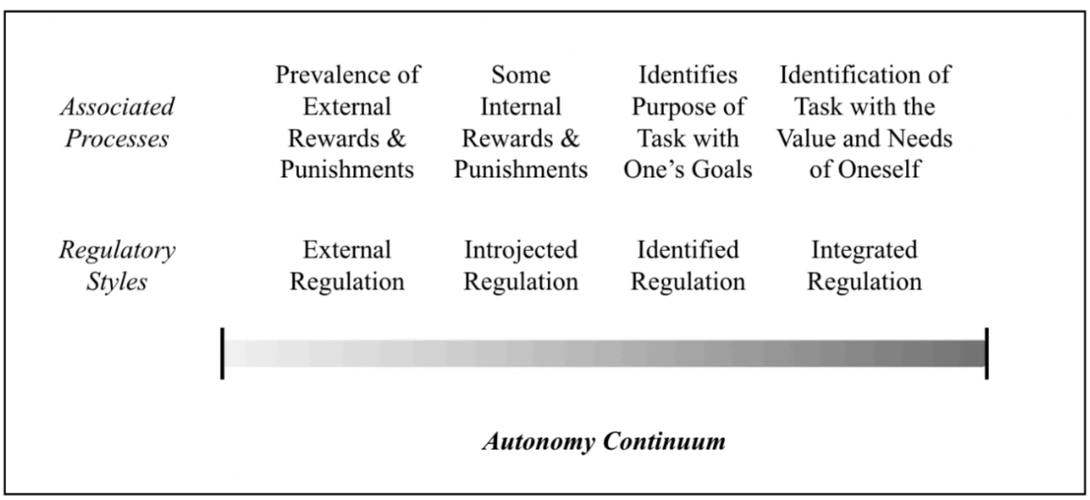


Figure 2. The Internalization Continuum with Respect to Autonomy (Extrinsic Motivation) (Niemiec & Ryan, 2009).

Motivation and Academic Performance

The SDT proposes that motivation is sustained by three psychological constructs: autonomy, competence, and relatedness. Autonomy means behaving voluntarily and being self-endorsing. When students feel autonomous, they are more likely to stay motivated and engaged. However, feelings of competence are also necessary to sustain motivation. Competence is the experience of effective behavior and high self-efficacy. Relatedness, on the other hand, refers to the process of internalization in effective extrinsic motivation. People accept the values of those they feel connected to and exhibit higher motivation and engagement. Studies show that satisfying these three psychological needs enhances academic achievement and promotes motivation (Jang et al., 2009; Guay, Ratelle, Roy, & Litalien, 2010). Highly motivated students tend to be more engaged and driven (Ryan & Niemiec, 2009).

According to the SDT, providing optimal challenges and support is essential for maintaining students' motivation. The concept of differentiation is aligned with this view and is suggested to provide adequate guidance to students at all levels. Research has shown that differentiation, when combined with structured guidance, can promote student motivation and academic achievement, but there is some conflicting data on the topic (Deci, 2009; Guay, Roy, & Valois, 2017).

A study conducted in Quebec, Canada by Guay, Roy, and Valois (2017) aimed to investigate the impact of differentiation on students' academic performance and educational adjustment in French classes. The study used a mediated moderation model, where differentiation was considered as a moderating variable and students' perceived competence as the mediating variable. It was hypothesized that providing explicit goals and guidance through structure provision along with DI would positively influence students' perceived competence and autonomous motivation. The findings of the study supported the hypotheses, suggesting that DI helps in highlighting the positive effects of structure on student autonomy and mitigating the negative effects on controlled motivation.

Furthermore, In Leblebicier's (2020) action research in university English courses, the use of differentiated writing instructions were studied to determine if it could better accommodate student differences and improve academic writing skills. Over a 10-week period, 21 second-year university students attended academic writing classes designed within the DI model. Qualitative data were collected through various questionnaires and interviews, and the study found that students had a positive view of DI as an instructional method that significantly contributed to improving their academic writing skills.

Demir (2021) conducted a mixed-method study to examine the impact of differentiation based on learning styles on student motivation in science learning. The study involved 63 fourth-grade students, with 30 in the experimental group and 33 in the control group. The results indicated that DI had a significant positive effect on student motivation in science learning. Additionally, DI was observed to improve information application in other courses, enhance understanding of the differentiated course, and raise awareness of the surrounding environment. Similarly, Pablico, Diac, and Lawson (2017) investigated the effects of DI on student engagement and academic achievement in Biology classes using a mixed-method approach. While DI did not have a significant impact on academic achievement, the analysis revealed that both students and teachers held positive opinions regarding DI, and it was observed to increase student engagement and motivation.

Pablico, Diac, and Lawson (2017) also focused on the effects of DI in the science (Biology) classroom. In exploring DI’s impact on both student engagement and academic achievement, a mixed-method approach was used, student academic achievement was measured through end-of-course (EOC) performance, and personal surveys were used to determine teacher and student opinions regarding DI. The analysis showed that DI did not have a significant impact on academic achievement measured by EOC, but students and teachers alike held positive opinions regarding DI, and student engagement and motivation increased.

Two studies, one conducted by Sesen and Tarhan (2011) and the other by Zohrabi, Torabi, and Baybourdiani (2012), focused on the effects of student-centered vs. teacher-centered (see Figure 4 ‘Traditional’ column) instructional techniques on academic achievement in Chemistry and non-native English learning. Sesen and Tarhan's study found that high-school students in the experimental group taught using student-centered techniques, had fewer misconceptions and a better understanding of the chemistry topic "acids and bases" compared to the control group taught using teacher-centered instruction. Zohrabi, Torabi, and Baybourdiani (2012), conducted in Iran, found that a teacher-centered process was more effective in improving student learning of English in the long term, although students preferred student-centered processes and a communicative approach. The study affirmed teacher-centered learning through explicit (bottom-up) methods.

The literature reviewed above indicates that the impact of DI on student academic achievement and motivation varies across courses, with some showing significant effects while others did not. Inconsistencies in the results of different studies highlight the need for further research in this area, specifically examining the relationship between academic performance and motivation. Moreover, before implementing DI, it is important to consider whether it is worth the investment of time and resources in a particular subject, and whether training should focus on courses where the effects of DI are most apparent. Although much subject-specific research on DI has been conducted, there is a lack of studies comparing its effects across courses from different disciplines. Therefore, this study aims to fill this gap in the literature by exploring the impact of DI on academic performance and motivation in two distinct subjects.

Research Questions

After an extensive review of the literature, the following research questions were formulated:

1. Does the implementation of DI have a statistically significant impact on the motivation and academic outcomes of high school students in English and Chemistry courses?
2. Is there a significant difference in the impact of DI on high school students' motivation and academic outcomes between English and Chemistry courses?
3. In which course, if any, are the effects of DI most significant?

These research questions aim to investigate the impact of DI on high school students' motivation and academic outcomes across different subject areas and to determine whether the effects of DI are subject-specific.

Methods

Population & Procedure

This study is set in Beijing, China. A quantitative quasi-experimental pre-test−post-test non-equivalent group design was chosen to establish correlations between variables in a naturalistic environment (see Figure 3 for detailed steps) (Cohen et al., 2018). Due to the scarcity of studies conducted among the Chinese student population, particularly that of private international high school students whose Westernized curriculum is vastly different from that of public schools, this study seeks to address a population gap discovered in the literature. Science and English courses were chosen because the two are from distinct disciplines: Humanities, and Natural and Applied Sciences, regarding which many studies have been done exploring these courses specifically (Leblebicier, 2020; Demir, 2021; Pablico et al., 2017; Sesen & Tarhan, 2011; Zohrabi, et al., 2012). During the week of professional development, the purpose and framework of this research were proposed to all teaching staff, and the two teachers whose schedules were most compatible with the designs of this research agreed to collaborate with the principal investigator. Regular, required courses were chosen for variation in student abilities and convenience during random assignment - English (mainstream) and Chemistry - as each course has two blocks.

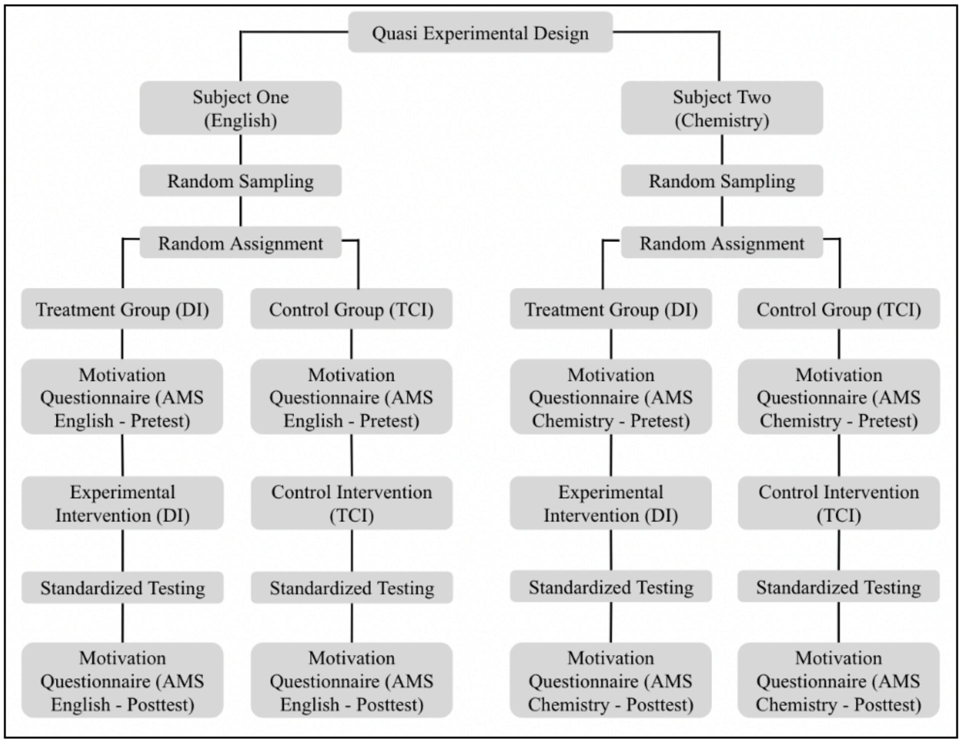


Figure 3. Research Design and Procedures.

All participants of the study were randomly selected from Beijing SMIC private high school from either the English classes taught by Teacher A, or Chemistry classes taught by Teacher B (names were coded to protect confidentiality). Experimental and control conditions were randomly distributed to each block. Because of the small class size of the Chemistry experimental group, the same number of student participants were randomly selected from each of the other three classes. A total of 32 students were selected at the beginning of the study; as one student from the English experimental group withdrew from the study mid-way, a total of 31 students completed the study. All student participants gave informed consent, and all personal information such as motivation and exam scores were anonymized by randomly assigning codes to each student (e.g. Student A = 5A).

Teacher A who taught English used the reading Measures of Academic Progress (MAP) test Lexile scores to determine how he wishes to differentiate his students, while Teacher B of Chemistry administered a Next Generation Science Standards (NGSS) standard pretest to assess readiness. A motivation questionnaire was administered to each student participant during school time as a pretest at the beginning of this research which took about ten minutes to complete. Then the experimental intervention was given in line with the framework of Tomlinson for one month and a half, sufficient time for the complete instruction of one unit, while the control groups were given the control intervention. Throughout the research process, teachers administered standardized tests to all student participants and the scores associated with codes were collected to measure trends of academic achievement. At the end of this study, students were given the posttest questionnaire (same as pretest) for the purpose of measuring and comparing changes in motivation.

Differentiation Techniques

This study places greater emphasis on differentiation by process rather than product, since standardized tests were used as the primary means of establishing comparability of academic performance across the two conditions. In English (mainstream), Teacher A utilized varied text and resource materials to accommodate varying student readiness and interests. Students were given choices with baseline expectations for quality established so that they could select assignments that matched their readiness. For instance, students were allowed to choose the format in which they wished to present their knowledge (such as a narrative, presentation, poster, etc.). This approach may facilitate motivation, as students' interests were taken into account, and autonomy was also encouraged as students could feel independent and in control.

In the laboratory, Teacher B prioritized discovery-based learning and provided minimal instruction to allow students to group flexibly and develop their own methods, learning from their mistakes. Teacher B also gave students a second chance and adjusted the activities according to their interests and weaknesses, promoting critical thinking and collaboration through hands-on activities. Tools were adjusted based on students' abilities and interests to reduce boredom and ensure safety. This approach strengthened student competence by equipping them to meet requirements based on their abilities, as opposed to a predetermined curriculum.

Teacher-Centered Instruction

For the purpose of this study, teacher-centered instruction (TCI) would be used as the instructional method in the non-DI condition. TCI refers to a style of instruction that focuses mainly on the content, where the educator plans ahead the content to be taught, a set of ways to teach the content, and the mode of assessment (Scheurs & Dumbraveanu, 2014). The key difference between TCI and constructivist student-centered learning (on which DI is based) is that TCI emphasizes teacher authority and assessment in terms of how well students, regarded at best as ‘recipients of knowledge’, ‘replicate’ the material taught (Kaymakamoğlu, 2017, p. 30). In contrast, the constructivist approach focuses on what students are expected to demonstrate by the end of instruction, and plans are made in a bottom-up fashion. The framework of TCI naturally guides the modes of delivery; instructors generally provide undifferentiated frontal instruction and are in control of the learning process. As a result of this and other related factors (see Figure 4), students mainly work individually and are mostly extrinsically motivated (Kaymakamoğlu, 2017).

	Traditional	**Constructivist**
View of Learning	Knowledge Transmission	Knowledge Transformation
Authority	Emphasize Teacher Authority	Emphasize Teacher Relatedness
Teacher's Role	Frontal Instruction, Individual Professionalism	Small Group Discussions, Collaborative Professionalism
Learner's Role	Passive Recipient; Individual Work	Active Participant; Group Work
View of Knowledge	Presented as ‘certain’; Focuses on Application	More Flexible Pace and Fluid Learning; Focuses on Problem Identification
View of Curriculum	Fixed and Predefined, Hierarchical Grading	Dynamic and Flexible
Learning Experiences	Focuses on Factual Knowledge; Emphasis on Content and Product	Focuses on Acquisition of Learning, Self-Inquiry, Social, and Communication Skills; Emphasis on Process
Control of Process	Teacher-Structured	Self-Directed
Motivation	Mainly Extrinsic	Mainly Intrinsic
Product	Product Oriented (e.g. Standardized Test); Norm-Referencing	Process Oriented (e.g. Reflection); Criterion-Referencing

Figure 4. Comparison of Traditional and Constructivist Models of Education (adapted from Kaymakamoğlu, 2017, p. 31).

Instruments

The Academic Motivation Scale (AMS)

The Academic Motivation Scale (AMS) was used in this study to measure changes in student motivation in both control and experimental groups in English and Chemistry classes. The AMS is the English version of the Echelle de Motivation en Education (EME), originally developed in French by Vallerand et al. (1992), which is based on SDT by Deci and Ryan (1985). The AMS measures intrinsic motivation (to know, to accomplish, and to experience), extrinsic motivation (external, introjected, and identified), and amotivation. The scale consists of seven subscales, with four items for each type of motivation. Students rated each statement on a Likert scale ranging from 1 (does not correspond at all) to 7 (corresponds exactly). The AMS has been shown to have good internal consistency, temporal stability, and construct validity in previous studies (Vallerand et al., 1992; Vallerand & Bissonnette, 1992; Vallerand et al., 1989; Cheng & Ding, 2019). See Appendix B for the full questionnaires used in this study.

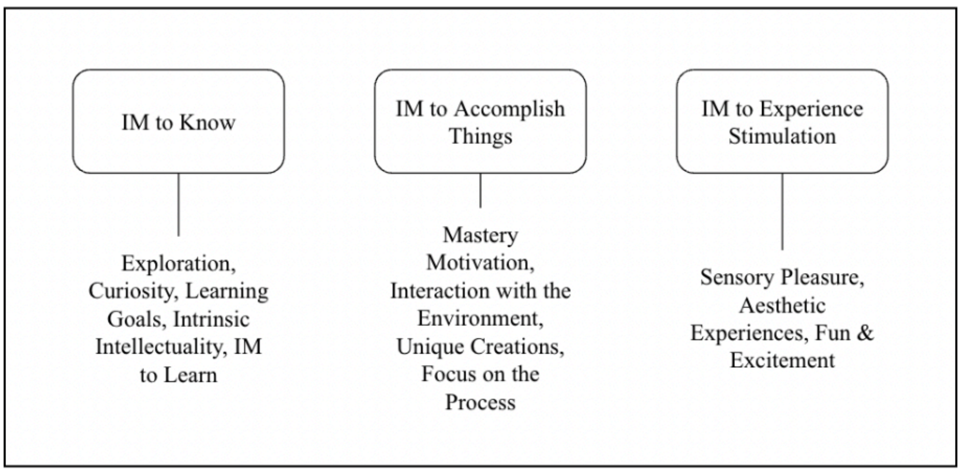


Figure 5. Three Types of Intrinsic Motivation (IM) (Vallerand et al., 1992).

Data Analysis

Analysis of variance (ANOVA) was used to analyze data regarding student motivation and academic performance, as it looks at the significance of differences within and between groups, making it suitable for this quasi-experiment (Cohen et al., 2018, p. 781). There are several kinds of ANOVA; for the purpose of this study, a one-way ANOVA was used. This is because only one independent variable is manipulated - the instructional technique (DI vs. TCI). Cohen and his colleagues in their book *Research Methods in Education* (2018) describe the independent variable involved in ANOVA as 'categorical', while the dependent variables are 'continuous'. DI and TCI fall under the category 'pedagogy', while the continuous variables would be motivation scores and standardized testing scores. As explained by Cohen (2018), ANOVA calculates within-group variation by first calculating the means of all the groups, then comparing individual's scores within each group to the respective mean of the group. To calculate between-group variation, the means of all the groups are first averaged, and then each group's mean is compared to the aggregate mean to discover any statistically significant difference (p. 781). For the purpose of this study, results are considered statistically significant if the p-value is less than 0.05.

Null Hypotheses

This quantitative study will either reject or fail to reject the following null hypotheses (H_0).

(1) There will be no statistically significant effect of DI on student motivation in either selected course, Chemistry or English (mainstream).

  (a) If H_0 no.1 is rejected, further data analysis would be conducted to test the following H_0:

DI's effect on student motivation would not statistically significantly differ between English and Chemistry.

(2) There will be no statistically significant effect of DI on student academic performance in either selected course, Chemistry or English.

  (a) If H_0 no.2 is rejected, further data analysis would be conducted to test the following H_0:

DI's effect on student academic performance would not statistically significantly differ between English and Chemistry.

Results

Summary Statistics

To determine the relationship between DI and student motivation and academic performance, several variables were taken into consideration; namely, intrinsic motivation, extrinsic motivation, total motivation, amotivation, and standardized testing scores. Table 1 shows the correlation coefficients of these variables in relation to each other.

Motivation

In order to identify students' motivation in English and Chemistry prior to and after treatment, pretest and posttest motivation questionnaires were administered to the experimental and control groups in each course (see descriptive statistics in Table 1 & 2). A one-way ANOVA was conducted for each course to compare the mean motivation scores in each category (IMT, EMT, MT, AM).

Table 1. Pearson correlation table (PIMT, PEMT, PMT, PAM, POIMT, POEMT, POMT, POAM, ST1, ST2, ST3, ST4C).

	PIMT	PEMT	PMT	PAM	POIMT	POEMT	POMT
PIMT	1.0000						
PEMT	0.7489*	1.0000					
	0.0000						
PMT	0.9362*	0.9340*	1.0000				
	0.0000	0.0000					
PAM	-0.2345	-0.2468	-0.2573	1.0000			
	0.2041	0.1807	0.1623				
POIMT	0.7569*	0.6052 *	0.7290*	-0.3641*	1.0000		
	0.0000	0.0003	0.0000	0.0440			
POEMT	0.6497*	0.8311*	0.7910*	-0.1030	0.6728*	1.0000	
	0.0001	0.0000	0.0000	0.5812	0.0000		
POMT	0.7699*	0.7834*	0.8305*	-0.2575	0.9172*	0.9118*	1.0000
	0.0000	0.0000	0.0000	0.1619	0.0000	0.0000	
POAM	-0.2687	-0.1665	-0.2331	0.6518*	-0.2451	-0.1088	-0.1946
	0.1438	0.3707	0.2069	0.0001	0.1839	0.5600	0.2941
ST1	0.2158	0.3806*	0.3182	-0.2108	0.2347	0.3307	0.3083
	0.2437	0.0347	0.0811	0.2550	0.2038	0.0692	0.0915
ST2	-0.0635	-0.2553	-0.1696	-0.1255	0.0335	-0.2428	-0.1122
	0.7344	0.1657	0.3616	0.5012	0.8581	0.1881	0.5479
ST3	0.1160	0.1221	0.1273	-0.2766	0.2310	0.2042	0.2382
	0.5343	0.5130	0.4951	0.1319	0.2111	0.2704	0.1969
ST4C	0.3801	0.3240	0.3723	-0.3786	0.5461	0.3684	0.4892
	0.1464	0.2208	0.1556	0.1482	0.0286	0.1604	0.0545

	POAM	ST1	ST2	ST3	ST4C
POAM	1.0000				
ST1	-0.0694	1.0000			
	0.7106				
ST2	-0.0073	-0.0867	1.0000		
	0.9689	0.6427			
ST3	-0.2645	0.5113*	0.0897	1.0000	
	0.1504	0.0033	0.6312		
ST4C	-0.3110	0.6389*	0.3612	0.6268*	1.0000
	0.2410	0.0077	0.1692	0.0094	

Note. *Significant at the 95% confidence level ($p < 0.05$). See Appendix A for key to variables.

Table 2. Means and standard deviations (in parentheses) for motivation scores of experimental and control groups before and after the treatment for English (rounded to the nearest hundredth).

	Experimental Group (E1)			Control Group (E2)		
	n	Pretest	Posttest	n	Pretest	Posttest
IMT	7	56.33 (22.01)	60.67 (13.89)	8	45.57 (17.42)	40.57 (11.33)
EMT	7	52.5 (20.83)	59.5 (12.14)	8	50.57 (13.77)	54.43 (9.47)
MT	7	108.83 (41.07)	120.17 (21.46)	8	96.14 (28.59)	95 (19.07)
AM	7	8.83 (5.88)	7.83 (4.96)	8	6.86 (3.93)	9.43 (6.88)

Note. *Significant at the 95% confidence level ($p < 0.05$). See Appendix A for key to variables.

Table 3. Means and standard deviations (in parentheses) for motivation scores of experimental and control groups before and after the treatment for Chemistry (rounded to the nearest hundredth).

	Experimental Group (CE)			Control Group (CB)		
	n	Pretest	Posttest	n	Pretest	Posttest
IMT	8	33.71 (15.17)	36.57 (19.85)	8	51.29 (13.53)	50.29 (13.89)
EMT	8	27.57 (13.82)	32.71 (18.67)	8	41.14 (10.02)	43.71 (14.40)
MT	8	61.29 (28.55)	69.29 (37.00)	8	92.43 (19.87)	94 (27.24)
AM	8	7.71 (3.64)	10.43 (6.78)	8	8.57 (5.22)	10.71 (5.28)

Note. IMT, EMT out of 84; MT out of 168; AM out of 28. See Appendix A for the key to variables.

To observe and quantify changes in student motivation, one-way ANOVA was first employed separately within each course. Then if changes were found to be significant, the change observed in the two treatment groups would be compared again using ANOVA.

Table 4. ANOVA results of pretest and posttest motivation scores of experimental and control groups in English (change in motivation) (rounded to the nearest hundredth).

	Experimental Group (E1) (Pre vs. Post)				Control Group (E2) (Pre vs. Post)			
	F	*p*	Sum of Squares	Mean of Squares	*F*	*p*	Sum of Squares	Mean of Squares
IMT	6.666	0.0493*	1450	1450.2	41.94	0.000644***	1694.5	1694.5
EMT	5.385	0.068.	1184	1183.8.	1.514	0.265	241.8	241.8
MT	9.26	0.0286*	5776	5776	10.45	0.0178*	3120	3120.5
AM	10.63	0.0224*	117.57	117.57	28.71	0.00173**	82.71	82.71

Note. '.' Significant at the 90% confidence level ($p < 0.1$); *Significant at the 95% confidence level ($p < 0.05$); **Significant at the 99% confidence level ($p < 0.01$); ***Significant at the 99.9% confidence level ($p < 0.001$).
Df = 1 for all variables.
See Appendix A for the key to variables.

As seen in Table 4, the treatment/DI condition English class's intrinsic motivation increased. ANOVA results showed that this increase is statistically significant ($p < 0.05$). Further analysis expressed that the control/TCI condition English class's intrinsic motivation decreased even more statistically significantly ($p < 0.001$). Analysis of pre and posttest extrinsic motivation of the English treatment group found that though there was an increase in extrinsic motivation, the difference is not statistically significant ($p > 0.05$). The control condition was also shown to have an increased extrinsic motivation but it was statistically insignificant ($p > 0.05$). Total motivation of the DI English class was found to have a statistically significant increase ($p < 0.05$). Conversely, a statistically significant decrease in total motivation in the TCI English class was found ($p < 0.05$). According to results by ANOVA, amotivation statistically significantly decreased in the English treatment group ($p < 0.05$) while it statistically significantly increased in the control group ($p < 0.05$).

Table 5. ANOVA results of pretest and posttest motivation scores of experimental and control groups in Chemistry (change in motivation) (rounded to the nearest hundredth).

	Experimental Group (CE) (Pre vs. Post)				Control Group (CB) (Pre vs. Post)			
	F	*p*	Sum of Squares	Mean of Squares	*F*	*p*	Sum of Squares	Mean of Squares
IMT	13.95	0.00968**	979.6	979.6	0.998	0.356	166.3	166.3
EMT	64.46	0.000199***	1050.1	1050.1	16.98	0.00621**	1022	1021.8
MT	31.55	0.00136**	4137	4137	6.746	0.0408*	1942	1942.2
AM	4.523	0.0776*	39.33	39.33	2.215	0.187	45.71	45.71

Note. *Significant at the 95% confidence level ($p < 0.05$); **Significant at the 99% confidence level ($p < 0.01$); ***Significant at the 99.9% confidence level ($p < 0.001$).
Df = 1 for all variables.
See Appendix A for the key to variables.

No statistically significant difference in the level of intrinsic motivation was found in the Chemistry control group ($p > 0.05$). A statistically significant increase was expressed in the data of the experimental group, where intrinsic motivation increased by a high significance ($p < 0.05$). A statistically significant increase in extrinsic motivation was observed both in the DI ($p < 0.05$) and TCI ($p < 0.05$) Chemistry classes; however the TCI Chemistry class's extrinsic motivation increased to a lesser degree. Total motivation increased to a statistically significant degree in both the control ($p < 0.05$) and experimental groups ($p < 0.05$), and again, the experimental group's motivation increased with a larger significance. Finally, the levels of amotivation in the DI and TCI conditions were analyzed, and it was found that the control group had no statistically significant difference between their pretest and posttest amotivation ($p < 0.05$). On the other hand, although a statistically significant increase in amotivation was observed in the data of the experimental group ($p < 0.05$), it was by a small magnitude.

As the results of within-course motivation level changes in experimental groups were mostly statistically significant, further analysis can be done to answer the second and third research questions. To do so, one-way ANOVA were conducted comparing changes in motivation across Chemistry and English courses to observe whether DI's effects on student motivation were more apparent in one course over the other.

Table 6. ANOVA results for motivation scores across courses (treatment groups – E1 vs. CE).

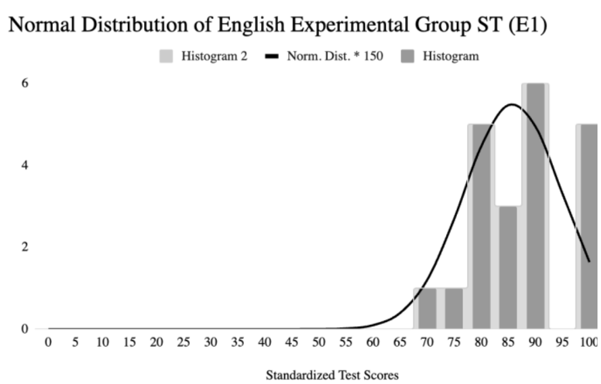
	Df	Sum of Squares	Mean of Squares	*F*-value	*p*-value
IMT	1	41.5	41.48	0.397	0.556
EMT	1	6.63	6.63	0.152	0.713
MT	1	66.4	66.43	0.328	0.591
AM	1	105.38	105.38	6.929	0.0464*

Note. *Significance at the 95% confidence level ($p < 0.05$). See Appendix A for the key to variables.

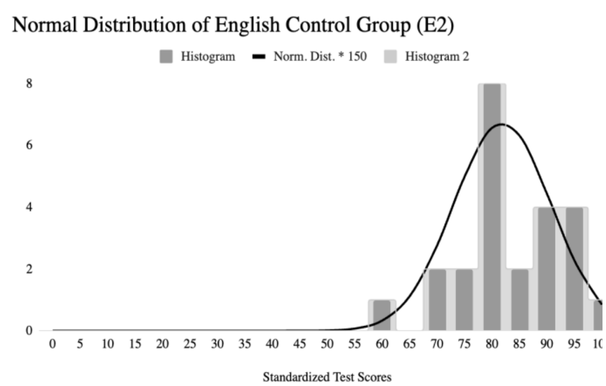
As can be observed in Table 6, the differences in changes in motivation across Chemistry and English were not statistically significant ($p > 0.05$). However, the changes in amotivation were significantly different across the two courses ($p < 0.05$). According to prior data analysis, average amotivation increased in the Chemistry experimental group while it decreased in the English experimental group, thus in this case it can be observed that while DI's effects on motivation was generally the same across the two courses, the instructional technique was more effective at decreasing amotivation in the English course.

Academic Performance

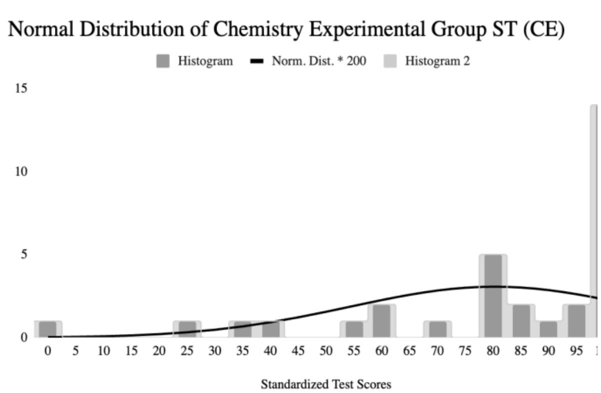
To evaluate students' academic performances, the same standardized tests were administered in the experimental and control groups in each course by their respective instructors. Student scores were plotted on normal distribution curves (see Figures 6-9); as can be observed, students were generally high-performing.



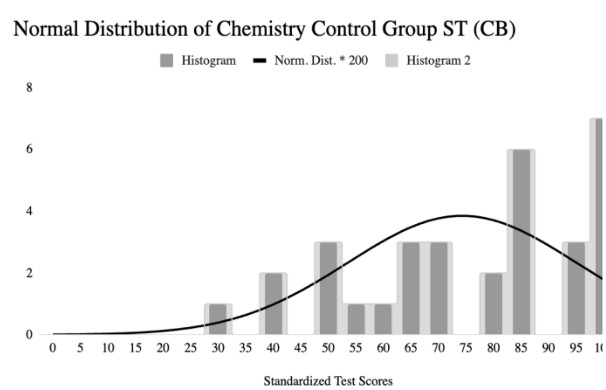
(6a) Experimental Group (English-E1)



(6b) Control Group (English-E2)



(6c) Experimental Group (Chemistry-CE)



(6d) Control Group (Chemistry-CB)

Figure 6. Academic Performance of All Students.

To explore whether DI's effects on student performance are more apparent in either one of the courses, academic achievement comparisons between DI and TCI groups need to first be established within courses. Therefore, a one-way ANOVA was conducted for each course, and the data analyses suggests that DI has no statistically significant effect on academic performance measured by standardized tests ($p > 0.05$; $p > 0.05$; Table 7) in either the control or experimental groups.

Table 7. ANOVA results for standardized testing scores within courses.

Courses (DI vs. TCI)	Df	Sum of Squares	Mean of Squares	*F*-value	*p*-value
English (E1 vs. E2)	1	5.4	5.42	0.06	0.81
Chemistry (CB vs. CE)	1	186	186.2	0.412	0.526

Note. See Appendix A for the key to variables.

Since no statistically significant relationship has been observed within courses, comparisons across courses cannot be made.

Discussion

Effects & Implications of DI

The present study was an investigation of the effectiveness of DI - which includes a variety of specific student-centered strategies and emphasizes adjustment of instruction, content, goals, and opportunities for displaying knowledge, to target each individual student's unique abilities and needs (Onyishi & Sefotho, 2020; Spencer-Waterman, 2014) - on high school English and Chemistry students' motivation and academic achievement.

According to the constructivist theory and the SDT, effective implementation of DI should increase student motivation (intrinsic and extrinsic) and subsequently their academic performance. To explore whether DI is in fact positively correlated with either of these variables, a quasi-experiment was conducted comparing DI's effects in two of the subjects frequently included in the literature. Limited studies have been conducted exploring motivation and academic performance together, and still fewer are conducted across different subjects simultaneously. As classrooms steer towards inclusion and more pressure is put on instructors to ensure optimal student performance, further investigations regarding the effectiveness of certain instructional techniques currently advocated in the field are needed to narrow the focus to enhance quality of chosen implementations (Crowder, 2011).

To address the first inquiry, on whether DI has a statistically significant impact on high school students' motivation or academic outcome in either subject, the data suggested that DI's effects on student motivation was statistically significant in both English and Chemistry. This is in line with existing literature (Pablico, 2017; Taylor, 2017; Demir, 2021; Leblebicier, 2020; Zohrabi et al., 2012). Increases in intrinsic motivation have been observed in experimental groups in both courses, though more statistically significantly so in Chemistry. Extrinsic motivation increased in Chemistry, while it did not change statistically significantly in English at the 95% confidence level ($0.1 > p > 0.05$); however, the change was significant at the 90% confidence level. The results of the data analysis suggests that differentiation is an effective method to increase motivation in the classroom, and thus should be more extensively implemented to enhance student engagement and even academic performance in the long run. Furthermore, it was observed that amotivation - characterized by the state of aimless doing accompanied by the feeling of incompetence and lack of control - was effectively reduced in the English treatment class, linking to DI's influence on general motivation. It can be seen that DI is also effective at reducing amotivation as measured by the Academic Motivation Scale (Ryan, Deci, 2000).

As the first null hypothesis has been rejected, further data analysis was carried out to test the linked null hypothesis under null hypothesis no.1 that DI's effect on student motivation would not statistically significantly differ between English and Chemistry. The results suggest that there is no statistically significant difference in DI's influence across the two courses, and thus the linked null hypothesis cannot be rejected. In the context of classroom practice, this suggests that in this study there currently isn't one course in which the effect of DI on motivation is more apparent. Potentially, more data over a longer period of time is needed if future researchers are interested in drawing further conclusions regarding this aspect. Relevant to the classroom, there are not enough results to narrow the focus of differentiation to one of the two subjects, thus, further investigation is needed.

Regarding academic performance measured by standardized testing scores, the second null hypothesis cannot be rejected based on the results, and no further data analysis is needed to test the null hypothesis under null hypothesis two. According to the results, DI does not have a statistically significant effect on student standardized testing scores in either English or Chemistry. In the context of the classroom, this means that although this study found that increase in motivation was linked to differentiation, such a conclusion cannot be drawn regarding academic performance. This is in line with the conclusion of Jane Pablico and her colleagues in their research conducted in a high school Biology classroom. Pablico found that although students generally held a positive perception of DI and increases in engagement levels were observed, DI had no statistically significant effect on academic performance as measured by the End of Course Exam (E.O.C.) (Pablico et al., 2017). Zohrabi and his colleagues obtained similar results in their study regarding student-centered learning in English - although students preferred the student-centered technique and engaged more actively in class, the pedagogy did not improve learning measured by test scores (Zohrabi et al., 2012).

Limitations & Future Direction

Due to the time limit of this project, the treatment was administered to the experimental groups for a shorter period of time than the original time intended. This may have contributed to the lack of significance in Standardized Testing Scores, though this is not extremely likely according to literature. Motivation scores across courses may potentially begin to differ significantly if the treatment was administered longer however, and future studies should aim to conduct similar experiments for a more substantial period of time. Due to time constraints and practicability, this study focused on only two courses from two distinct disciplines - Chemistry and English from the disciplines Humanities and Natural and Applied Sciences respectively. These two courses have been explored in the literature extensively, which was what inspired this quasi-experiment. However, further research should be done comparing a variety of different courses to each other, including subjects belonging to different disciplines such as Social Sciences and Business, which are not as widely explored as the ones chosen in this study.

Another limitation is that this study only focused on DI’s effects on academic achievement and motivation at the high school level. To further contribute to the literature, cross-sectional studies can be done involving students from different levels of education (e.g. Elementary, Middle, and High School) to explore whether DI’s effects differ in different age groups. The underlying logic for such an observational study would be essentially the same as the one presented in this study, except instead of comparing the effects across courses, future studies can compare the effects across age groups.

Another direction future research can follow is to determine whether the effects of one particular differentiation strategy is superior over others in particular subjects. Extensive studies have looked at obstacles or objections to differentiation specifically from the teachers’ point of view. Increased workload, stress, lack of thorough understanding of pedagogy and student needs have all been identified as barriers to effective implementation of DI in existing literature, and this list is not exhaustive (Onyishi & Sefotho, 2020; Taylor, 2017; Lavania & Nor, 2020; Pozas et al., 2019; Owens-Cunningham, 2021, Ginja & Chen, 2020). By identifying the more effective techniques from the framework, more focus may be placed on training pre-service and in-service teachers to effectively implement those techniques, subsequently increasing teacher efficacy and instructional quality (Crowder, 2011).

Conclusion

Based on the quantitative findings of the study, it can be concluded that DI has a significant and positive effect on student motivation in both English and Chemistry classes. Intrinsic motivation increased statistically significantly in the English treatment group while intrinsic and extrinsic motivation increased in the Chemistry treatment group. While

DI is effective in improving motivation within each course, there is no statistically significant difference in the extent of the improvement between the two courses, suggesting that DI is not more effective in improving motivation in one course over the other. However, it was found that DI was more effective in decreasing amotivation in English class, suggesting a potential future research direction to further validate this result.

On the other hand, quantitative analyses regarding academic performance showed that DI had no statistically significant effect on student academic achievement as measured by standardized testing scores. This terminated further analyses of ST data across courses as the second null hypothesis cannot be rejected. Although data from this study cannot establish a concrete relationship between differentiation and academic achievement, further studies can be done to generate new findings from this angle while addressing the limitations.

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