

# Blended learning source of satisfaction of psychological needs

## An empirical study conducted on O-levels chemistry students in metropolis city of Pakistan

Blended learning program in chemistry

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### Abstract

**Purpose** – In this study, researchers applied blended learning program to investigate the success of a blended learning program on satisfaction of the psychological needs, and academic achievement of chemistry students of O-Levels, following curriculum prescribed by University of Cambridge.

**Design/methodology/approach** – Research pattern is quantitative aligned with the quasi-experimental and pre-post experimental design which aimed at examining the efficiency of a motivational strategies adopted with the use of blended learning program on psychological needs satisfaction (competence, autonomy, and relatedness) and achievement in chemistry O-Levels Syllabus, at the end of the research program.

**Findings** – Hypothesis testing represented that use of blended learning program has significant and positive impact on academic achievements through the mediation of autonomy. Results also revealed the substantial association of blended learning on other psychological needs (i.e., competence and relatedness); however, the competence and relatedness have no effect on academic achievements in this study. Thus, research concludes that providing an autonomous environment in substitution of the controlled environment promotes learning and produces positive outcomes.

**Originality/value** – Blended learning or use of Learning Management Systems is being commonly used mostly in the tertiary level of studies; however, blended learning with secondary classes especially in the field of chemistry is yet not studied in detail. Similarly, the usefulness of the motivational strategies to learn chemistry is observed with university-level students, but very rare data about encouraging students at the secondary level have been gathered. Therefore, the researcher designed this blended learning program to enhance students' motivation towards achievements in secondary chemistry.

**Keywords** Learning Management Systems, Blended learning, Chemistry, Psychological needs satisfaction, Autonomy, Competence, Relatedness, Academic achievement

**Paper type** Research paper

### 1. Introduction

Researchers have reported that students' perception and confidence to score well in the chemistry class usually decreases over time, as the complexity increases and due to lack of counseling about the importance and/or usefulness of the chemistry course. Zusho, Pintrich and Coppola (2003) also reported a decline in motivation, rehearsals, and elaborations practices with the passage of time while studying chemistry courses. Wu and Foss (2010)



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explained that most of the learners studying chemistry are neither motivated nor interested in the subject, whereas [Aregawi and Meressa \(2017\)](#) further elaborated that students take chemistry simply to fulfill the requirement of a degree in fields of their interests. This lack of motivation is alarming as chemistry is one of the important subjects connecting all the sciences together and field of chemistry, science and technology are related to the trade and industry of developed and advanced societies ([Burmeister, et al., 2012](#)). Using approaches such as the use of ICT ([Hashemyolia et al., 2014](#); [Sun et al., 2017](#); [Lee et al., 2016](#); [Ain et al., 2016](#)), PowerPoint presentations, flipped classes ([Seery, 2015](#); [Zainuddin and Perera, 2019](#)), the introduction of novel topics ([Stuckey and Eilks, 2014](#); [Blatti, 2016](#)), adoption of modern teaching strategies ([Gul and Rafique, 2017](#)), cooperative learning ([Shachar and Fischer, 2004](#); [Saad, 2017](#)) are some of the strategies, teachers have adopted to enhance involvement and motivation to learn chemistry but unfortunately these are only effective temporarily and continuous use is not as efficient as it is expected.

[Deci and Ryan \(2000\)](#) concepts based on a quite different metatheory which begins with the assumption that pupils are by nature active and engaged. In a supportive environment, they are naturally inclined toward the attainment of knowledge, and show regulated behavior. Self-determination theory focused on the directing processes through which the outcomes are achieved, rather than directing toward the fulfillment of goals. [Wouters et al. \(2016\)](#) identified enhancements in the medical students' motivation through autonomy, relatedness, and competence during the selection procedure of admission medical schools. [Deci \(1975\)](#) also proposed that people with a higher feeling of inner motivation are better to feel competent and self-determined.

Previous researches showed that successful learning is a result of mutual engagement of learners and teachers in the learning process and learners were found motivated and active in participation in an autonomy-supportive environment provided by teachers ([Ryan and Deci, 2000](#)). A comparative analysis of learners taught by both controlling as well as autonomy-supportive teachers found that learners with teachers of latter category exhibited enhanced motivation ([Ryan and Grolnick, 1986](#)), augmented competence ([Deci et al., 1981](#)), improved conceptual understanding ([Benware and Deci, 1984](#)), and improved performance ([Boggiano et al., 1993](#)). Autonomy-supported teachers' students were higher in learning's investments, high achievements, motivation with intrinsic values, and positive emotions ([Assor et al., 2002](#); [Kaplan et al., 2014](#); [Deci and Ryan, 2000](#)). Thus, outcomes of the previous literature are applied in a new context for improved credentials.

The emphasis of the present study is on improving achievement of students to learn chemistry by satisfying psychological needs (autonomy, competence and relatedness), through the blended learning approach. Blended learning since last 10 years appeared as the most common technology-based instructional approach and applied in different educational contexts ([Henrie et al., 2015](#); [Spanjers et al., 2015](#); [Ain et al., 2016](#)). In fact, it is found that blended learning positively influences the engagement and competency of students. But, unfortunately, despite huge potential, many nations are struggling and are reluctant to adopt this instructional design ([Edward et al., 2018](#)). Pakistan is also among those countries still striving with international standards in the adoption of technology. Thus, the blended approach in secondary education is also unfocused so far and needs attention. The significance of this study is focused on the adoption of technology-based learning as a limited practice of e-learning has observed in the secondary level of studies, especially the field of teaching secondary level chemistry in Pakistan, where the researcher has adopted a blended learning approach to motivate and produce self-determined and satisfied students in schools. It has been suggested that adoption of the technology will not only make abstracts concepts associated with chemistry easy to understand and visualize but also open a gateway for teachers to make complex concepts uncomplicated to explain and elaborate.

Furthermore, outcomes of this study stimulate management and administrators to conduct training courses for teachers for improvement and sustainability of their services and integration of technology in the learning environment which in turn will help them to practice student-centered learning approaches.

### Literature review

Blended learning is defined as an amalgamation of traditional classroom learning and e-learning, where the methodology for blended learning is based on formal or informal, scheduled or self-paced physical class-based or virtual learning environment designed for students (Wang *et al.*, 2007). Blended or hybrid learning is slightly different from traditional online learning in a way that it is a blend of face to face interaction with computer mediated and technologically oriented approach (O'Byrne and Pytash, 2015). Impact of blended learning has been observed by many researchers in different contexts. Henrie *et al.* (2015) found in longitudinal studies during survey that student satisfaction in engagement with the blended learning environment was mainly due to the instruction's clarity and relevance of activities more than the medium of instruction that enhances their motivation and thus achievement.

Review of the related literature has highlighted the fact that the adoption of cooperative learning in line with the blended learning despite some limitations (Wang *et al.*, 2015) and challenges (Lee *et al.*, 2016; Tynan *et al.*, 2015; Kihzoza *et al.*, 2016; O'Byrne and Pytash, 2015; Florian and Zimmerman, 2015) has shown positive impact on educational accomplishments. Saad (2017) compares cooperative learning style with traditional lecture method and concludes that cooperative learning has a positive impact on academic achievements in the area of science and technology. Spanjers *et al.* (2015) collected students' responses and found that blended learning particularly the quiz part is more effective, equally attractive but more demanding than traditional learning. In continuation of the Spanjers *et al.* (2015) statements, Ho *et al.* (2016) highlighted differences in comparative analysis of face to face and blended learning approach and found that group taught through blended learning showed more overall satisfaction, self-efficacy and better knowledge implementation. Similarly, studies conducted in Malaysia by Ain *et al.* (2016) found that use of the Learning Management System has a significant influence on performance expectancy. Supporting Ain *et al.* (2016) findings, Hashemyolia *et al.* (2014) established the importance of blended learning via Learning Management System, as a source of enhancing self-regulated learning strategies, explaining students' performance and engagement in online learning.

Lee *et al.* (2016) studied the impact of the use of Moodle Learning Management System on students of three tertiary level universities in Hong Kong, and manifested positive outcomes for qualities such as conceptual understanding, eagerness and confidence in learning science. Another study conducted in Hong Kong by Cheng and Chau (2016) discovered a significant relationship of online participation in a blended learning course, and learning styles with academic achievement and course satisfaction. In similarity with Far East Asian region, studies in other regions of Asia have also highlighted the positive influences of Learning Management System on academic achievements. Waheed *et al.* (2016) explored effects of Moodle Learning Management System on academic performance, intrinsic and extrinsic motivation in Pakistan, and found that blended learning has a positive impact on the mentioned variables. Importance of Virtual Learning Environment in Malaysian secondary science students was explained by Raub *et al.* (2015) and found robust support to enhance higher order thinking skills. Similarly, Krasnova (2015) also demonstrated that integration of blended learning has contributed to increase quality of education in higher education in Russia.

Self-determination theory (SDT) can also be termed as the theory of motivation as it deals with the supporting tendencies towards the achievement of the goal and toward effective

behavior. Within self-determination, various factors contribute to enhancing natural tendencies towards the achievement of goals. These include intrinsic motivation, extrinsic motivation, and fulfillment of the basic psychological needs (autonomy, competence, and relatedness). [Reeve \(2016\)](#) explained autonomy as the interpersonal feeling or behavior to make students identify, visualize and nurture, develop, and strengthen students' inner motivation. Similarly, competence is termed as a positive and timely feedback provision with students learning whereas relatedness is a feeling of connecting learning context with the real world. Satisfaction of psychological needs in the light of SDT is examined by various researchers not only in the context of academic achievement but also in relation to behavioral changes, improvement of manners ([Britton et al., 2014](#)), social economic status, income inequality, health ([Di Domenico and Fournier, 2014](#)) environmental and financial safety satisfaction ([Chen et al., 2015](#)), controlling coach behavior, narcissism ([Matosic et al., 2017](#)), well-being, life satisfaction and healthy functioning ([Nishimura and Suzuki, 2016](#)), and prosocial behavior ([Martela and Ryan, 2016](#)).

Many researches used SDT to enhance positive influence, participation, and achievement in academic and learning contexts ([Kaplan et al., 2014](#); [Assor et al., 2002](#); [Deci and Ryan, 2000](#); [Datu, 2017](#); [Yasmin et al., 2017](#)). [Kaplan and Madjar's \(2017\)](#) findings demonstrated the utility of SDT within the diversified cultural setting of teacher training and supported the universality of the theoretical framework. Self-reported survey from participants revealed that autonomous motivation, relatedness, and competence were positively contributed by need support. Furthermore, it was found that self-exploration, self-accomplishment and engagement were significantly subsidized by autonomous motivation, engagement was positively influenced by competence, however relatedness was associated with engagement only among the Bedouin students, and with self-accomplishment only among the Jewish students.

Another study highlighted the influences of technology-based learning under the light self-determination theory on learners' motivation by [Noour and Hubbard \(2014\)](#). Data was collected from 616 undergraduate students through face-to-face questionnaire from three colleges of International Transport and Logistics (CILTs) at the Arab Academy for Science, Technology and Maritime Transport (AAST&MT). The study established a robust relationship between learners' motivation and variables of self-determination such as intrinsic motivation and extrinsic rewards. Researchers further stated the challenges and predictions for using the Blended Learning in Logistics Education (LE) in Egyptian Higher Education (HE) system for future researchers.

Similarly, one of the other studies conducted at Indonesian's University by [Zainuddin and Perera \(2019\)](#) compared differences among the pupils of a flipped classroom and traditional classroom settings in terms of fulfillment of basic psychological needs and motivation. Researchers further examined the influence of technology-based classroom setting impacts on students' self-determined motivation in their learning of English as a Foreign Language (EFL). A higher level of competence, relatedness and autonomous learning skills among the students of the flip classroom had successfully established the significant and the positive impact of technology-oriented setting on students' self-determination and motivation.

### 3. Research Methodology

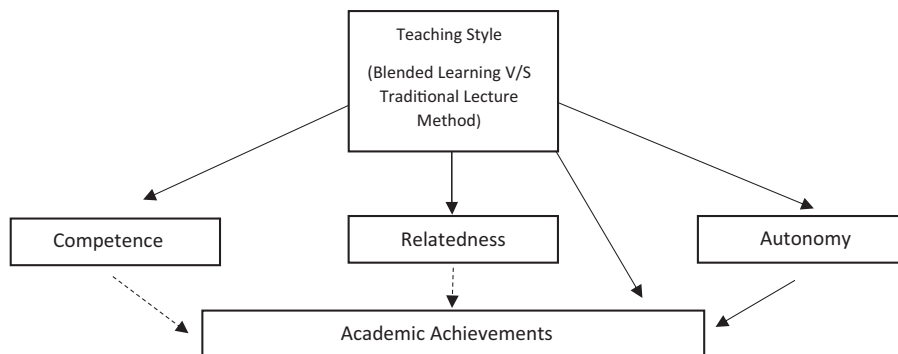
In this study, a quantitative approach has adopted by the researchers for generalization of statistically-computed findings; for computation of variables with the aim of establishing connections between trends and research variables. Research pattern is quantitatively aligned with the quasi-experimental and pre-post experimental design which aimed at examining the efficiency of a motivational strategies adopted with the use of blended learning program on psychological needs satisfaction (competence, autonomy and

relatedness) and achievement in chemistry O-Levels Syllabus, at the end of the research program (Figure 1). Researcher is using strategies with the help of blended approach, not only to develop skills regarding comprehension and calculations required to get expertise with Cambridge O-Levels Chemistry syllabi but also to enhance the satisfaction of psychological needs.

*Study sample*

Researcher herself is the teacher and designer of the study program. At the time of the experiment, she was taking two sections of grade IX (section A with 24 students and section B with 30 students). In both of these sections, chemistry was offered as a mandatory subject. Researcher only selected these two sections to maintain uniformity of teaching content. The researcher offered students to be part of the EDMODO portal by inviting them on their emails. Out of 54 students, 38 students started participating in activities on online program; however, 16 students did not become part of it. Students participated in the experimental group attempted a quiz before engagement in online activities. Scores from that quiz used as pre-test score to check the efficiency of the blended program at the end of the research experiment.

54 students (19 girls and 35 boys) participated in the study program. Traditional lecture teaching method was applied to the control group; however, involving students in motivational strategies for the achievement of satisfaction of psychological needs through blended program was intended in teaching of the experimental group for 10 weeks. No age variation was found and all the students' birth was between the years 2004–2005. Demographic information is given in Table 1.



Source(s): Developed by the Author

**Figure 1.** Research model indicating impact of blended learning on academic achievements through satisfaction of psychological needs (autonomy, relatedness, competence)

Experimental group (N = 38) and controlled group (N = 16)

Female (N = 19)  
Experimental  
N = 15

Control  
N = 4

Male (N = 35)  
Experimental  
N = 23

Control  
N = 12

**Table 1.** Demographics of the participants

*Research environment and strategies*

The setting for traditional classroom activities where the lecture method was most frequently used was a Convent School offering Cambridge O-Levels Syllabus in science and commerce. Other than teaching students via lecture method, teacher also sometimes adopted other teaching tactics such as discussion, peer work, and demonstrations to resolve possible confusions student showed during class lessons. However, teacher couldn't use these strategies frequently due to time constraints, as limited time was given for completion of the prescribed syllabus. Virtual learning classes conducted using the EDMODO portal. Students from the experimental group not only attended traditional classes with lecture method but also involved in activities in an online portal. Demographic information of the experimental group showed that the most common activity students engaged during blended learning environment were attempting practices quiz at the end of each topic. Other common activities are shown in Table 2. Another important information assembled from the demographic part of the questionnaire clearly displayed that 33 students (87 percent) were satisfied with the pace and content of the activities; however, five students (13 percent) were unable to manage and found portal burdensome and tiring. Researcher's main purpose to involve students was to not only provide resources but also create an environment to flourish their psychological needs. Competence satisfaction was achieved through involving students in online quizzes and discussions and by providing them feedback along with the comments and badges for active learners and performers. These encouraging badges are built in and available on the EDMODO portal. This strategy was adopted to make students feel competent and encouraged when they were performing well and to enhance their confidence regarding achievements in chemistry. Though researcher was trying to involve students in classroom discussion, many of the students were hardly participative and were not involving in discussions frequently. Surprisingly, the same timid students were active online and were also communicating their issues in personal messages. So, the use of blended learning was used to create an autonomous environment to help students build their confidence and to conquer their shyness. For enhancing students' satisfaction of relatedness, researcher often uploaded interesting videos related not only with the content but also relating course and its application in real life situations. Other than that, some poll questions, posted by the Royal Society of Chemistry, were replicated in online classes to create awareness about the importance and application of chemistry as a subject.

*Research design*

Researcher has adopted a cross-sectional research design used to make a comparison of control and experimental group at the end of the experiment and where group of students' behavior is studied once for a short period of time. On the other hand, researcher also compared achievements of participants through pre-posttest where students' data is collected twice before and after the experiment.

**Table 2.**  
Students' engagement  
in online learning  
classes

Activities	Number of students engagement	% Of involvement
Attempting quiz	34	89%
Reading messages	25	66%
Watching videos	28	74%
Messaging teacher	7	18%
Panel discussion	5	13%
Answers questions on group discussion	5	13%

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### Research variables

The study comprises of the following variables:

- (1) The independent variables represented in 1—The teaching program
  - Blended learning program
  - Traditional method
- (2) The dependent variable represented in
  - Psychological Needs (Autonomy, Competence and Relatedness) Satisfaction
  - Achievement in Standardized Test
- (3) Control Variables:
  - **Instructor:** Researcher herself is an instructor who taught both groups (control and experimental) with same pace and activities in traditional classroom and online study settings.
  - **Content:** Similar content extracted from GCE O-Levels Chemistry Syllabus was discussed and tested. Content main topics included, Kinetic Particulate theory and applications, Experimental, Purification and Separation Techniques.

### Instrument

- (1) Questionnaire to Measure Basic Satisfaction of Psychological Needs includes 10 questions measuring three sub-variables, autonomy, relatedness, and competence, with 7 point Likert scale (1 = Not at all, 4 = somewhat true, 7 = Very true). This 10-item scale adapted to address need satisfaction in educational setup and was modified from measure used for need satisfaction in different contexts (Deci *et al.*, 2001; Ilardi *et al.*, 1993; Kasser *et al.*, 1992).
- (2) Standardized Test: This test was designed by the researcher to check and compare the academic achievements of both groups. This test comprised of two sections. Objective part was made of 20 multiple choice questions, with 20 marks. Subjective test had open ended questions designed with variations in marks. Total marks for subjective part were 20. An overall score calculated after the addition of both objective and subjective score marks.
- (3) Pre-test for Experimental Group: This test was based on 20 objective questions with 20 marks.

## 4. Data analysis and interpretations

Data were analyzed through independent sample *t*-test, paired sample *t*-test, Pearson's correlation and mediation through bootstrapping using SPSS Version 20 and PLS version 3. The level of significance for all statistics was set at  $p < 0.05$ .

### 4.1 Confirmatory factor analysis for instruments/questionnaires

Before running software for factor analysis, outliers were removed for the extraction of generalized results. Only one student information was removed and the final analysis was run on 53 students' information (37 experimental group and 16 control group).

**4.1.1 Questionnaire: basic psychological need questionnaire.** This questionnaire was developed by Deci *et al.* (2001) and was adapted to check satisfaction of students towards learning chemistry while engaged in traditional and blended learning program.



Three factors formed for assessing the satisfaction of psychological needs that may offer the best meaningful interpretation for this sample (Table 3). KMO test value was 0.682, which is representing that the items within each factor are adequate, and Bartlett's test significant value was 0.000, which is indicating that the matrix is not identity and factor analysis is possible. Final factor structure designed by using PLS version 3 for the satisfaction of basic psychological needs questionnaire comprises these:

Factor 1: Competence—3 items

Factor 2: Relatedness—4 items

Factor 3: Autonomy—3 items

Instrument reliability and validity is ensured with the help of Cronbach's alpha, composite reliability, and Fornell and Larcker (1981) criteria of average variance extracted using PLS version 3. In this case, data is reliable as Cronbach's values are more than 0.5. Composite reliability values are higher than 0.7, which has indicated that the instrument has established convergent validity for constructing relationships. Discriminant validity is also confirmed as all AVE values were correlated and are highest in row and column.

#### 4.2 Pearson correlation

Correlations between academic scores and psychological needs variables autonomy, competence, and relatedness were calculated with the help of SPSS version 20 following the procedure suggested by Hair *et al.* (2006). Table 4 has indicated significant positive correlations between competence, autonomy, relatedness, and overall satisfaction of psychological needs among the participants of the study. The satisfaction of competence is also positively associated with satisfaction of need for relatedness, autonomy, and overall satisfaction of psychological needs. It is evident from the results that autonomy satisfaction

Factor-items	Competence	Relatedness	Autonomy
<i>Competence-1</i>	0.721	–	–
Peers I know tell me I am good at what I do during lessons			
<i>Competence-2</i>	0.608	–	–
In chemistry classes I do not get much of a chance to show how capable I am (Reverse statement)			
<i>Competence-3</i>	0.802	–	–
I often do not feel very capable (Reverse statement)			
<i>Relatedness-1</i>	–	0.654	
I Really like the content I interact during classes			
<i>Relatedness-2</i>	–	0.668	–
I get along with peers during lessons			
<i>Relatedness-3</i>	–	0.647	–
I feel importance of the content and related to my life			
<i>Relatedness-4</i>	–	0.728	–
There are not much learnings in the class that I am close to in my real life (Reversed statement)			
<i>Autonomy-1</i>	–	–	0.721
I feel pressured during lessons. (Reverse statement)			
<i>Autonomy-2</i>	–	–	0.697
I generally feel free to express my ideas and opinions			
<i>Autonomy-3</i>	–	–	0.839
There is not much opportunity for me to decide for myself how to do things in my classroom settings (Reverse statement)			

**Note(s):** This table contains value of factor loadings, which are the correlations between the variable and the factor. Values in Factor Loadings are higher than 0.6 in each case and has shown a strong correlations between factor and variables used for interpretations

**Table 3.**  
Factor analysis



**Table 4.** Correlations

	1	2	3	4	5	6	7
Objective score (1)	1	0.606**	0.895**	0.116	0.205	0.522**	0.348*
Subjective score (2)	-	1	0.895**	0.126	0.232	0.598**	0.395**
Overall score (3)	-	-	1	0.137	0.245	0.630**	0.418**
Competence (4)	-	-	-	1	0.462**	0.464**	0.767**
Relatedness (5)	-	-	-	-	1	0.533**	0.844**
Autonomy (6)	-	-	-	-	-	1	0.820**
Overall satisfaction of psychological needs (7)	-	-	-	-	-	-	1

**Note(s):** Correlation is significant at the 0.05 level (2-tailed)\*. Correlation is significant at the 0.01 level (2-tailed)\*\*

has also correlated with objective, subjective, and overall scores of students. It shows that an increase in autonomy has positively influenced academic achievements.

#### 4.3 Comparison of controlled and experimental group (independent sample t-test)

A significant difference among the participants of experimental and control group was observed in terms of competence, autonomy, relatedness, and overall satisfaction of psychological needs as *p*-values were less than 0.05 percent in every construct. However, insignificant difference between control and experimental group in terms of academic scores were seen as values of significance were higher than 0.05 (refer to Table 5).

#### 4.4 Gender differences

Independent sample *t*-test used to establish differences between autonomy, competence, and relatedness among male and female students. No difference is evident among females and males in terms of competence, autonomy, and relatedness as significant values are greater than 0.05 (refer to Table 6). In the same way, similar academic achievements observed among male and female students (refer to Table 7).

#### 4.5 For mediating effect of blended learning on academic achievement through autonomy as mediator

Bootstrapping is one of the common and widely used method of testing mediation as it does not require the normality assumption to be met, and because it can be effectively utilized with

	Groups	N	Mean	Std. Deviation	Mean difference	t-value	df	Sig. (2-tailed)
Competence	Experimental	37	5.1892	1.30161	0.88570	2.304	51	0.025
	Control	16	4.3125	1.24406				
Relatedness	Experimental	37	4.8514	1.27674	0.82010	2.273	51	0.027
	Control	16	4.0313	1.01602				
Autonomy	Experimental	37	5.2432	1.40688	1.09741	2.612	51	0.012
	Control	16	4.4158	1.39825				
Satisfaction of psychological needs	Experimental	37	5.0730	1.07591	0.92297	3.032	51	0.004
	Control	16	4.1500	0.86101				
Objective test score	Experimental	37	13.38	2.938	1.066	1.229	51	0.225
	Control	16	12.31	2.798				
Subjective test score	Experimental	37	15.86	2.551	2.177	2.070	51	0.051
	Control	16	13.69	3.860				
Overall score	Experimental	37	29.2432	5.00780	3.11824	2.000	51	0.051
	Control	16	26.1250	5.66716				

**Table 5.** Group Statistics for independent sample *t*-test. (Impact of Teaching Style on Satisfaction of Psychological Needs and Academic Achievements)

smaller sample sizes ( $N < 25$ ) (Bollen and Stine, 1990; Shrout and Bolger, 2002). Bootstrapping for 5,000 sample size was run and Table 8 is formed for path coefficients.

Robins and Greenland (1992) explained direct and indirect effects as in the Figure II. The product of path coefficients “A” and “B” explained the indirect effect; however, coefficient “C” has represented the direct effect of the model. The direct effect indicates the

**Table 6.**  
Independent Sample  
*t*-test. (Gender  
Differences in terms of  
Satisfaction of  
Psychological Needs)

	Gender	N	Mean	Std. Deviation	Mean difference	<i>t</i> -value	df	Sig. (2-tailed)
Competence	Male	34	4.7941	1.42610	-0.38132	-0.996	51	0.324
	Female	19	5.1754	1.15667				
Relatedness	Male	34	4.6029	1.34575	-0.00232	-0.006	51	0.995
	Female	19	4.6053	1.10339				
Autonomy	Male	34	5.0588	1.45058	0.40970	0.965	51	0.339
	Female	19	4.6491	1.53749				
Satisfaction of psychological needs	Male	34	4.7971	1.21518	0.00759	0.024	51	0.237
	Female	19	4.7895	0.86852				

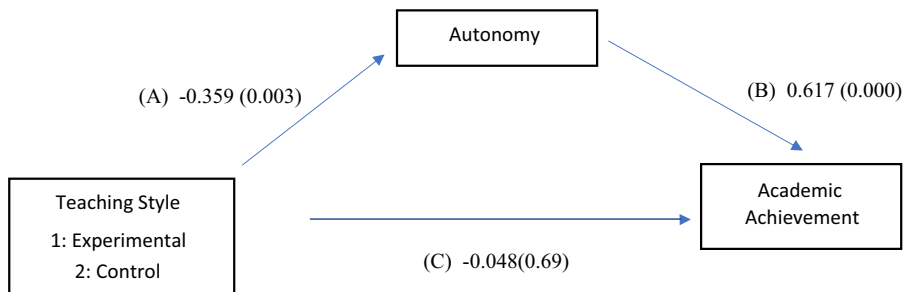
**Table 7.**  
Independent Sample  
*t*-test. (Gender  
Differences in terms of  
Academic  
Achievements)

	Gender	N	Mean	Std. Deviation	Std. Error mean	<i>t</i> -test for equality of means		
						<i>t</i>	df	Sig. (2-Tailed)
Objective score	Male	34	13.26	2.745	0.471	-	-	-
	Female	19	12.68	3.233	0.742			
Subjective score	Male	34	15.35	3.274	0.562	0.448	51	0.656
	Female	19	14.95	2.934	0.673			

**Table 8.**  
Path coefficients

	Original sample	Sample mean	Standard deviation	<i>t</i> -value	<i>p</i> -value
Autonomy—→academic achievements	0.617	0.628	0.083	7.468	0.000
Blended learning—→academic achievement	-0.048	-0.042	0.121	0.398	0.691
Blended learning—→autonomy	-0.0359	-0.0365	0.123	2.923	0.003

**Figure 2.**  
Model 2-mediating  
effect of autonomy on  
academic achievement



**Source(s):** Developed by the Author(s)

influence of independent variable on dependent variable, when independent variable increases by one unit and the mediator variable remains unchanged. The indirect effect measures the degree to which the dependent variable fluctuates when the independent variable is held fixed and the mediator variable changes by the amount it would have changed had the independent variable increased by one unit. In linear systems, the total effect is equal to the sum of the direct and indirect effects ( $C' + AB$  in the model). However, in nonlinear models, the total effect different from the sum of the direct and indirect effects, but to a modified combination of the two. Path coefficients have indicated that autonomy has an impact on academic achievement ( $p$ -value  $< 0.05$ ). Similarly, blended learning has also influenced on autonomy as  $p$ -values are less than 0.05. Thus, autonomy impact as a mediator on academic achievement is evident from Table 8. For further elaborations and analysis of mediating effect Indirect Effects (Table 9) and Total Effects (Table 10) are also highlighted.

Teaching Style has no direct effect on academic achievement as  $p$ -value is 0.69 which is greater than 0.05. However, Autonomy is acting as a mediator, where product of the  $p$ -values (0.000 and 0.003) is 0.000 which is lesser than 0.05 thus, mediating effect is proven.

#### 4.6 Pre-post academic achievement (paired sample t-test)

Students from experimental group were given pre-test at the start of the experimental design and those were used to compare improvement in post-test at the end of the research. Significant difference in the experimental group participants' academic achievement in terms of subjective score is observed and highlighted in Table 11.

	Original sample	Sample mean	Standard deviation	$t$ -value	$p$ -values
Autonomy→academic achievements	–	–	–	–	–
Blended learning→academic achievement	–0.222	–0.228	0.081	2.721	0.007
Blended learning→autonomy	–	–	–	–	–

**Table 9.**  
Indirect effects

	Original sample	Sample mean	Standard deviation	$t$ -value	$p$ -values
Autonomy→academic achievements	0.617	0.628	0.083	7.468	0.000
Blended learning→academic achievement	–0.270	–0.270	0.143	1.892	0.059
Blended learning→autonomy	–0.359	–0.365	0.123	2.923	0.003

**Table 10.**  
Total effects

	Mean	Paired differences		$T$	df	Sig. (2-Tailed)
		Std. Deviation	Std. Error mean			
Pair 1 Objective score – Pre test	0.676	3.986	0.655	1.031	36	0.309
Pair 2 Subjective score – Pre test	3.162	3.420	.562	5.624	36	0.000

**Table 11.**  
Paired samples test.  
(Pre-Post Test Comparison for Experimental Group)

## 5. Interpretations and conclusions

Most of the findings of this study are consistent with the previous researches. Hypothesis testing represented that the use of blended learning program has an impact on academic achievements through the mediation of autonomy. Consistent with the previous researches, the current study has also revealed a significant relationship of autonomy on other psychological facets such as competence (Edward *et al.*, 2018) and relatedness. Furthermore, as highlighted by Noor and Hubbard (2014), the use of blended learning has influenced level of self-determination and has shown better motivation toward learning. Deci and Ryan (2000) explained in reference to the SDT that people motivation demands a considerable distinctive psychological need for competence, autonomy, and relatedness, thus necessitating indispensable conditions for psychological growing, uprightness, and welfare and introduction of the different regulatory processes for differing degrees of need satisfaction. They believed in fulfillment of basic psychological needs as an alternative to pressure giving tasks for influencing engagement, learning and well-being among students. Providing an autonomous environment in comparison to the controlled environment also promotes learning and produces positive outcomes. Using this frame of thought, researchers have tried to integrate technology, in contrast to a traditional learning environment in order to enhance the satisfaction of psychological needs which in turn contributed to higher success rate in academic achievement.

Researches showed that successful learning is a result of the mutual engagement of learners and teachers in learning process and learners were found motivated and active in participation in an autonomy-supportive environment provided by teachers (Ryan and Deci, 2000). Consistent with the previous researches (Reeve, 2016; Zainuddin and Perera, 2019), it is found in the present study that autonomy supported environment which was achieved through the application of Learning Management System (EDMODO) has positively influenced academic achievement which was calculated using standardized test. Similarly, in continuation with previous reviews (Deci *et al.*, 1981; Kaplan and Madjar, 2015; Motta, 2016; Chan *et al.*, 2015), Person's correlation also proved that enhanced autonomy supported environment also influences competence and relatedness, positively. Thus, as suggested by Cheng and Chau (2016) and Zainuddin and Perera (2019), technology-based learning has a positive impact on the satisfaction of needs and positive outcomes. Continually, with the research by Edward *et al.* (2018) and Zainuddin and Perera (2019), current study has proven the significant differences among the participants of control and experimental group; thus, teaching through blended learning approach is found to be effective in terms of improving students' performance, competence, relatedness, and autonomy.

Consistent with other studies conducted in Asia, Maulana *et al.* (2016) found that Indonesian teachers' basic psychological needs support towards students, enhanced pupils autonomous motivation. Literature review reveals that autonomy-supported teachers' students were higher in learning's investments and had shown higher academic achievements. Furthermore, motivation with higher intrinsic values, and positive emotions were also encouraged. (Kaplan *et al.*, 2014; Assor *et al.*, 2002; Deci and Ryan, 2000; Datu, 2017; Yasmin *et al.*, 2017). Thus, the current study which is experimented in the South Asian region is consistent with the literature of other regions.

Findings of the difference in satisfaction of the psychological needs, especially autonomy, among the participants of experimental and control group revealed that one of the reasons for students' poor performance in an academic context can be their lack of confidence to ask questions and contributions in class discussions. These indications have clarified the fact that creating an environment where students feel autonomous and open to asking questions can improve performance of weak students. Thus, this recommends teachers to create a friendly ambiance where students have an autonomous environment to participate in class discussions. Suleman *et al.* (2011) explored the effects of technology in education. On

comparison of control and experimental group, researcher concluded that educational technology in teaching chemistry is important and crucial for explaining difficult concepts. Hence, experimented group's motivation level was not only aroused but they also performed much better than control group students. In contrast with the findings of [Suleman \*et al.\* \(2011\)](#), the current study has not shown a significant difference among experimental and control group participants in terms of academic achievements. However, mediation of autonomy has defended findings, and indirect influence of academic program is seen. One of the reasons for no direct impact of technology on learning can be limitations explained by [Lee \(2000\)](#) that contributed in demotivation of students in an online environment such as text-based and asynchronous communication, geographical separation, intensive technology skills requirements, hypermedia and the Internet, course content, learning activities, and support services. Similarly, [Appana \(2008\)](#) has pointed out the limitations of blended learning, and among these, one of the limitations is students' reluctance to study on the online portal. Another reason for insignificant relationships could be distractors such as popups, messages from friends, ads, or social media activities that resulted in a deviation of attention from the task at hand. It is recommended that students should be clearly instructed, how to stay on track, especially when they are learning online. Researchers of the current study designed and implemented activities via blended learning program for the very first time. There is a possibility that students were not ready to study via online forum, or that lack of competencies and skills required to be good online learners were missing, which resulted in insignificant differences in terms of academic achievements. It is recommended to have training sessions to make students familiar with the environment and making them technology savvy, before applying the technology-based lessons and activities.

In continuation with the findings of [Husain \(2014\)](#), no significant difference in academic achievement in terms of gender is observed. Thus, this cleared the fact that boys and girls have performed equally and the influence of gender in academic achievement is not found. Similarly, as highlighted by [Adie \*et al.\* \(2008\)](#), no significant difference in terms of autonomy found among different genders.

Paired sample *t*-test has also highlighted the significant difference in pre-posttest results of experimental group in terms of academic achievements. Thus, it can be concluded in continuation with the previous studies ([Cheng and Chau, 2016](#); [Suleman \*et al.\*, 2011](#)) that blended learning is an effective mode of knowledge delivery and improved performance.

## 6. Strength of the research design

Blended learning or use of Learning Management Systems is being commonly used mostly in tertiary level of studies ([Wiyarsi, 2017](#); [Sun \*et al.\*, 2017](#); [Waheed \*et al.\*, 2016](#)); however, blended learning with secondary classes, especially in the field of chemistry, are yet not studied in detail as limited literature is available in this context. Similarly, usefulness of the motivational strategies to learn chemistry is observed with university level students ([Ferrell \*et al.\*, 2016](#); [Rosenzweig and Wigfield, 2016](#)), but very rare data about encouraging students in secondary level have been gathered. Therefore, the researcher designed this blended learning program which can be used to enhance students' motivation toward achievements in secondary O-Levels Chemistry.

## 7. Recommendations

### 7.1 Creation of autonomous environment

Self-determination theory has proposed that providing an autonomous environment in comparison to the controlled environment also promotes learning and produces positive outcomes. The result of the current study has also proven the same. But to create such an

environment where the fulfillment of autonomous psychological need of students can be flourished is in instructors' hands. One of the qualitative studies conducted at 16 Universities of Pakistan proposed that teachers need to be trained for their new role, and must have teaching autonomy to materialize autonomy-supportive practices (Yasmin *et al.*, 2017). In continuation with the research by Yasmin *et al.* (2017), current findings are also promoting the training of teachers to create an autonomous environment to enhance students' academic achievements.

### *7.2 Designing more activities in virtual learning environment*

In the current study, a limited number of activities were designed to engage students in online learning such as, solving quizzes, interacting via text messages, learning with the help of videos, communicating with teachers, and involvement in panel discussions. However, there is a wide scope to design and execute technology-based novel activities for pupils to involve in blended learning programs.

Hashemyolia *et al.* (2014) suggested that though many activities are in use with virtual learning environment but, still there is a tendency to study more about Learning Management Systems, to benefit educational institutions' online learning activities. Wiyarsi (2017) concluded that chemistry teachers of Sleman's were able to design classroom action research in a hybrid learning environment and categorized it as good; however, continuous implementation along with continuous guidelines are needed to further develop teacher's competencies. Based on these conclusions, researchers of the current study recommend designing more activities to engage students vigorously and to enhance their achievements and skills of a hybrid learning environment.

### *7.3 Skills development to use blended learning*

Appana (2008) has pointed out some of the limitations of blended learning, and one among the limitations is students' reluctance or unwillingness to study on the online portal. In the current study, no significant direct impact on students' academic achievements has reinforced the impediments of the blended program as suggested by Appana (2008). It is recommended to train students and create readiness before engaging students in online classes, in order to make blended a learning approach more effective and influencing.

## **8. Future recommendations**

Other than three psychological needs proposed by Deci and Ryan (2000), González-Cutre *et al.* (2016) proposed the addition of novelty as an innate psychological need along with autonomy, relatedness, and competence from the SDT framework. Researchers suggest further development of a scale for the measurement of novelty and findings of novelty significant relationship with psychological needs, life satisfaction, and intrinsic motivation. The current study design is cross-sectional with a small sample size. Researchers recommend replicating this study with large sample size with longitudinal research design. Researchers have applied pre-posttest to compare the academic achievements of the experimental group. However, it is recommended that the pre-test should also be conducted with students from the control group, and Split Plot ANOVA analysis should be applied to further investigate impact of differences of teaching style.

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Blended  
learning  
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chemistry

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