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Goal Orientations, Self-Regulated Learning Strategies and Problem-Solving: A Mediational Analysis

Aisha Bibi[1]* and Mushtaq Ahmad[2]

[1]*Department of Education, National University of Modern Languages (NUML), Islamabad 74400, Pakistan*
[2]*Faculty of Engineering, Universiti Malaya, 50603, Kuala Lumpur, Malaysia*

ABSTRACT

This study investigates goal orientations, and self-regulated learning (SRL) strategies, particularly for differential equations (DEs) based problem-solving. Two adapted self-designed questionnaires for goal orientations, and SRL and an assessment test containing five self-developed DEs tasks were distributed among 430 students studying in inter-colleges. Collected data was further examined through SPSS and Smart PLS software. Initially, direct effects of goal orientations (mastery, performance, and avoidance goal) and SRL (elaboration and critical thinking) were considered. Findings revealed that mastery, avoidance goals, and elaboration had a significant direct effect on DEs' problem-solving. However, no such effect was observed for performance goals and critical thinking. Similarly, it was revealed that only elaboration had the role of mediation for both mastery and performance goals. Likewise, in the case of critical thinking, no significant effects were observed. The current study confirmed that goal orientations and SRL strategies influence DE problem-solving. Therefore, educators and teachers may structure their classroom activities to review and incorporate these learning strategies, which will enhance students' internal motivation, resulting in significant improvement in their problem-solving ability.

Keywords: Goal orientations, problem-solving, self-regulated learning strategies, SEM

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E-mail addresses:
aishabibi@numl.edu.pk (Aisha Bibi)
engr.mushtaq27@gmail.com (Mushtaq Ahmad)
*Corresponding author

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INTRODUCTION

Differential equations (DEs) have an essential role in mathematics and have been at the center of calculus for centuries. In addition, the concept of DE is used for modeling purposes and to comprehend real-life problems (Bibi et al., 2017, 2018). Therefore, these provide opportunities to formulate the application of phenomena from other disciplines of science and social science fields such as Physics, Astronomy, Biology, and Economics (Bibi et al., 2018).

Five main categories, including algebraic, graphical, numerical, technological, and inquiry-oriented approaches, have been identified for solving DE-based problems. Algebraic approaches are based on the several steps to solve the DEs analytically (Arslan, 2010; Artigue, 1989; Bibi et al., 2017), while graphical methods are qualitative, used to analyze either a graph or direction fields to solve a DE problem (Camacho-Machín et al., 2012). Finally, numerical methods offer the solution of DEs through appropriate approximations. Recently development in technology has integrated these three categories into a single approach (Rowland, 2006). These developments have opened new avenues for assembling the concepts and their connections to real-world situations (West et al., 1997). As a result, various real-world problems were identified, and mechanisms were developed to solve these problems through solving their related DEs (Pollak, 2015).

Apart from these reforms, several researchers proposed that mathematics beliefs are among the most important mechanisms contributing to successful problem-solving (Kloosterman, 2002). For example, Pintrich (2000) explored students' motivation to learn and emphasized the consequences of motivational factors, for instance, goal achievement. Earlier, goal setting theory, grounded on conscious human behavior, is meaningful and influenced by the individual's goals. It was based on Ryan's (1970) hypothesis that cognitive goals impact behavior. These goals are stimulating because they demand more effort to be fulfilled than common or easy goals. This theory was established inductively within organization psychology, based on over 400 field experiments (Locke & Latham, 2006). These studies found that setting explicit and high goals result in better task performance than setting low goals. Several other researchers applied and explored this theory for different aspects (Locke & Latham, 2012, 2013, 2015, 2019; Lunenburg, 2011). In this respect, goal orientation, a class of self-motivational beliefs, was a significant predictor of the students' performance (Sommet & Elliot, 2017). To implement students' motivation in academic settings, the important role of goal orientation beliefs remained the focus of researchers.

Likewise, regarding students' motivation, it was observed that mathematical problem-solving skills that increase student learning depend upon the attainment of self-regulatory skills in the mathematics learning environment (Stockton, 2010). In addition, it increases students' self-sufficiency and personal dominance over their problem-solving experiences (Zimmerman, 2002). Therefore, students' ability to utilize self-regulated strategies can best predict their problem-solving success by resolving complicated and challenging problems (Schwartz et al., 1998).

Several mathematics educators endorsed the theory of SRL as an important change and anticipated students to assume control and agency over their knowledge and problem-solving activities (Ahmed et al., 2013; Sahdan et al., 2017). Moreover, these SRL strategies also have an essential role in the inquiry and online learning community framework because of their affective outcomes (Sommet & Elliot, 2017). Previously, Pintrich (1991) conceptualized SRL in three distinct ways. First, refer to the metacognitive strategies (planning, monitoring, and regulating. Second, it views self-regulation as students' potential to use metacognitive and cognitive strategies (rehearsal, elaboration, and organizational strategies) (Pintrich, 1999). Third, it is concerned with emphasizing the worth of integrating motivation, cognitive, and metacognitive aspects of learning (Mattern & Shaw, 2010). Moreover, Rheinberg et al. (2000) suggested that motivation and SRL strategies are interconnected because the former promotes and sustains the latter variable.

Overall, literature shows that SRL strategies and goal orientations strongly affect mathematics achievement and problem-solving (Özcan, 2016; Rokhmat et al., 2017). However, no study had combined these two important factors (goal orientations and SRL) for DE problem-solving, particularly non-routine-based problems. Non-routine differential equation problems facilitate students to develop higher-order thinking during the exploration, analysis, understanding, and application of mathematical concepts. Therefore, his study focuses on the effects of goal orientations and SRL strategies on non-routine-based DE problem-solving at the pre-university level. Besides this, the potential mediating role of SRL between goal orientations and DE problem-solving was also considered.

CONCEPTUAL FRAMEWORK

SRL strategies and goal orientations are significant predictors of the students' achievement (Jansen et al., 2017; Zhou & Urhahne, 2017). Therefore, to implement students' self-regulated skills and motivation in academic settings, the role of goal orientation is particularly important. In this aspect, goal theorists recognized the most important goal, including mastery goals, performance goal orientations, and avoidance goals (Dweck, 1986).

Mastery goal-oriented students prefer situations where they can develop new skills and expand their intellectual capabilities, whereas performance-oriented students like showing their competencies and comparing them with others (Ames, 1992). Avoidance goal-oriented students get negative beliefs like fear of rejection or failure. Due to these, most students give up in unfamiliar and difficult situations resulting in no effect on students' mathematics achievement (Elliot et al., 1999; Wolters, 2004). Wolters et al. (1996) studied the relationship between mastery, performance, and avoidance goals and self-regulated learning, focusing on the subject of mathematics. Therefore, these three constructs were considered for this work. Several mathematics educators also suggested that these factors alone are not enough to foster students' mathematics achievement. SRL strategies may mediate the association between motivational factors and mathematics achievement. Several authors observed that performance and mastery-oriented students show more inclination toward self-regulation. Liem et al. (2008) reported that performance and mastery goals are the best predictors of SRL strategies, which generate positive outcomes. Most SRL strategies are comprised of nine subscales. Literature reveals that among nine subscales, critical thinking and elaboration particularly facilitate a better understanding of knowledge and skill improvement (Phan, 2008). Therefore, these two constructs were considered.

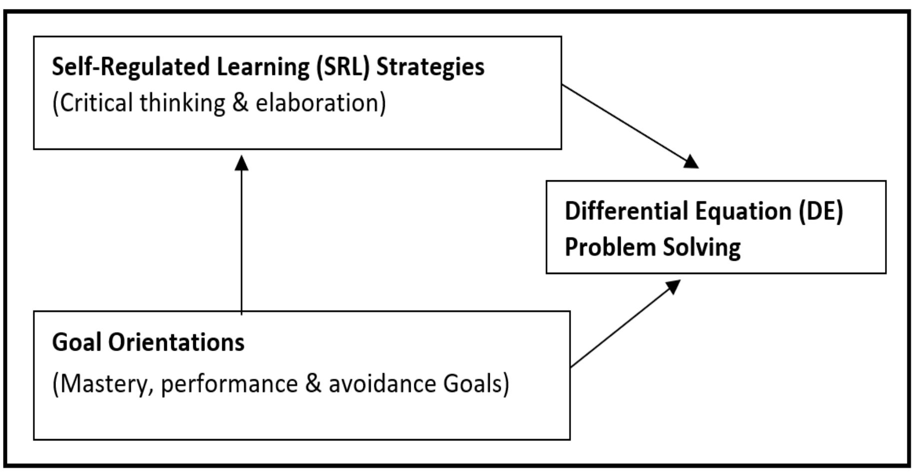

Figure 1. *Conceptual model showing goal orientations, SRL strategies, and DE problem-solving*

Based on the literature, it may hypothesize that SRL strategies and goal orientations strongly affect mathematics achievement and problem-solving (Muis et al., 2018). However, no study had combined goal orientations and SRL for the DE problem-solving. Therefore, a model (Figure 1) was conceptualized in this study to study the effects of goal orientations and SRL strategies on DE problem-solving at the pre-university level. Furthermore, through the investigation of direct each factor and the mediating role of SRL, several important implications were anticipated for the curriculum designers and teachers to enhance conceptual understanding of DE problem-solving.

Research Objectives

The main purpose of this work was to explore the effects of goal orientations and SRL strategies on DE Problem solving at the pre-university level. The second aim was to study the potential meditating role of SRL strategies between goal orientations and DE problem-solving. The following research questions are addressed to achieve the desired purpose:

1. Do goal orientations and self-regulated learning (SRL) strategies directly affect DE problem-solving?
2. Does elaboration (a part of SRL strategies) play a mediating role between mastery goal and DE problem-solving?
3. Does elaboration play a mediating role between performance goals and DE problem-solving?
4. Does elaboration play a mediating role between avoidance goal and DE solving?
5. Does critical thinking (a part of SRL strategies) play a mediating role between mastery goal and DE problem-solving?
6. Does critical thinking play a mediating role between performance goals and DE problem-solving?
7. Does critical thinking play a mediating role between avoidance goals and DE problem-solving?

The focus was on student perceptions and learning strategies to solve DE-based tasks.

METHODOLOGY AND RESEARCH DESIGN

Creswell (2013) speculated that correlation research design through non-experimental quantitative data could be employed to explain the relationship among variables. Wolf et al. (2013) explained the role of the sample size in correlation-based design, particularly for structural equation modeling (SEM). Therefore, this correlation approach was used to validate the relationships in the current study model. Details of the population, samples, and instruments have been described in the following sections.

Research Instruments

The current research used two adapted self-reported questionnaires for SRL strategies and goal orientation and an assessment test containing five self-developed differential equation tasks. These tasks were given non-routine nature to assess students' differential equation problem-solving ability and examine the full picture of difficulties faced by the students when they were engaged in solving the assessment test.

A scoring rubric containing three main stages (understanding, planning toward the solution, and getting an answer) was prepared to measure their problem-solving skills and score achievement. Each stage had a maximum of two marks, while each task had six marks. This scoring rubric was based on an analytic scale for problem-solving (Charles et al., 1987). Detail of the score is provided in Table S1. The second instrument, achievement goal orientations, was grouped into mastery goal, performance goal, and avoidance-goal orientation dimensions and was determined by the adapted scales from the Patterns of Adaptive Learning Survey (Midgley et al., 2000). The mastery goal was assessed through six items. The assessment of performance goal contains five items, while the evaluation of performance-avoidance goal includes six items. All responses were categorized on a 5-point scale ranging from 1 (not at all true) to 5 (very true).

The SRL strategy's third instrument was assessed with a Norwegian adaptation of the motivated strategies for learning questionnaire (MSLQ) (Pintrich, 1991). Further, it is separated into two broad categories: A motivation section with six subscales and a learning strategies section with nine subscales. However, only two dimensions, critical thinking and elaboration, were chosen from the learning strategies for this study. The elaboration strategy has six items, while the measure of critical thinking includes five items. All responses were categorized on a 7-point scale ranging from 1 (not at all true) to 7 (very true).

The current study had used adapted instruments; therefore, there was a need to confirm instrument reliability. The survey and assessment instruments were validated by four experts, including one mathematician, one psychological educator, and two mathematics educators who were teaching at college and university levels to ensure content reliability and validity. As a result, they accomplished an anonymous consensus on the instrument reliability and content validity. Besides this, a pilot study was also carried out with 70 students who had already attended differential equation lessons. The participants' responses demonstrated that the differential equation tasks and adapted questionnaire were suitable for the data collection and eventually for the study's objective.

Data Collection

The target population for the current study was students studying in their 12th year in Khyber Pakhtunkhwa (a large province of Pakistan). A 12th-year study can be carried out in inter-colleges and higher secondary schools in Pakistan. This study considered the population ratio from six institutes in government and three from the private sector. Overall, 430 questionnaires were distributed and excluded all the responses with missing data. Ultimately, 394 responses were deemed fit for further analysis. The sample size error was below 5% (4.7%) with a 95% confidence level. This margin of error is considered powerful for predicting the accuracy and reliability of the survey results.

The study had major limitations that might influence the collecting and interpretation of data from that context. This research used non-routine differential equation tasks to investigate students' problems, which strongly needed students' special attention, efforts, and learning strategies to solve them. Besides, the assessment test was an informal exam having no short-term incentives for them. Hence, participants' lack of cooperation was possible. The adapted instruments containing goal orientations and self-regulated learning (MSLQ) questionnaires were based on the theories and findings of developed countries. As Pakistan is a developing country, due to changes in resources and infrastructure, teachers' and students' abilities and findings might not be the same as hypothesized.

The results of this small-scale study were another important limitation. It might not be generalized data for all secondary mathematics students of all provinces in Pakistan. This research was carried out in a limited number of institutes in one province of Pakistan. Results in other provinces or states might differ due to students' learning capacity, teacher training, availability, infrastructure, cultural, and regional constraints. Other major limitations were investigating a limited range of strategies, tasks, and problem-solving approaches. Similarly, five non-routine tasks involving only two problem-solving approaches (algebraic and graphical) were considered here.

Non-routine tasks exhibiting daily life problems were the best option to reduce the limitation of using non-routine differential equation problems to assess the students' problems and overcome participants' lack of cooperation. Daily life-based problems were able to capture the students' attention. In addition, sufficient efforts were carried out to give them the shape of non-routine problems with adequate hidden data to analyze different factors. In addition, reducing the number of tasks up to five helped students solve these tasks without feeling boring.

An additional questionnaire (in addition to the research instrument) was designed for the field experts (educators/teachers) to overcome the adapted instrument's validity for the developing countries. Consents of the experts were assessed concerning different parameters, such as suitability of the country/province, selected factors, their inter-connection in the present study, and clarity of representations. Responses of the experts were also analyzed for the final data collection.

The suitable sample size and random sampling from both public and private sectors and urban and rural areas enabled the generalization of this research to most Pakistani students studying at the secondary level. In addition, comparing and confirming the demographic information with the institutional data about participants may help delimitate the error in self-reporting data.

RESULTS

For this work, an initial pilot study was carried out. The responses collected from the 70 students were used to analyze the reliability coefficient (Cronbach's alpha values) for all constructs of the research instruments. The Cronbach's alpha values for mastery, performance, and avoidance goal orientations were .83, .76, and .76, respectively (Table S2). These values had shown well agreement with the literature reported values. The reported values were .86, .86, and .75 for mastery, performance, and avoidance goals (Midgley et al., 2000).

Similarly, for critical thinking and elaboration strategy, Cronbach's alpha values (α) were .90 and .89, respectively. Again, a good agreement with previously reported values was noticed. The reported reliability coefficient for elaboration strategy was .75 and for critical thinking was .80 (Duncan & McKeachie, 2005). For differential equation-based task solving, Cronbach's alpha value was .66 (≈ .7), indicating a good internal consistency of items (George & Mallery, 2003). In the present case, all the values were in an acceptable range, and hence there were no items whose elimination would have improved the coefficient substantially.

Besides this, SRL and goal orientation scales were validated using exploratory factor analysis. Exploratory Factor Analysis (EFA) determined items that belong to a factor in a multiple factor structure. EFA is normally analyzed through two methods, including common factor analysis and Principal component analysis (PCA). Even so, for current research, principal component analysis was employed to reveal the original structure of the preliminary model of the questionnaire. Prior to PCA, a preliminary assessment of inter-item correlation, such as a bivariate correlation matrix, was visually inspected. The bivariate correlation matrix conveys information regarding the scale dimensionality, as it is not influenced by scale length (Briggs & Cheek, 1986). Moreover, Tabachnick and Fidell (2007) recommended that inter-item correlations bigger than .9 indicate a multicollinearity problem. Exploratory results of the item total correlations are shown in Table S3. The range of all correlation coefficients suggested that subscales were quite independent to be used as independent variables.

The next step was to conduct factor analysis for goal orientation and SRL strategies. However, before carrying out factor analysis, Kaiser-Meyer-Olkin (*KMO*) results, a measure of sampling adequacy, and Bartlett's test of sphericity were explored. Both techniques were used to determine the appropriateness of the factor analysis. The *KMO* results for goal orientation were .92, which had come in a quite acceptable range and is indicative of appropriate factor analysis for the scale. In addition to it, Bartlett's Test of Sphericity results [$\chi 2 = 5328.87$; $p < .001$] were also observed to be significant, which rejected the null hypothesis that the correlation matrix was an identity matrix. Therefore, goal orientations were considered adequate for factor analysis. Initial results from varimax rotation revealed communalities range from .49 to .84 (high range) and showed three factors with eigenvalues greater than 1.00.

Furthermore, the three-factor structure elucidated 73% of the total variance, in which the contribution of factor 1 was 37%, factor 2 contributed 28%, and the involvement of factor 3 was 7%, as shown in Table 1. In addition, the scree plot was also inspected to select the correct number of factors to be extracted. From the scree plot (Figure S1) and the Kaiser-Guttman rule, factor analysis of results on the 17 items indicated that three factors were interpretable.

Table 1

Rotated component matrix of goal orientation

Construct	Item code	Component			Communalities
		1	2	3	
Mastery goal	MA1		.80		.74
	MA2		.81		.72
	MA3		.74		.64
	MA4		.80		.72
	MA5		.76		.67
	MA6		.80		.71
Performance goal	PER1			.79	.72
	PER2			.76	.69
	PER3			.79	.71
	PER4			.80	.74
	PER5			.59	.49
Avoidance goal	AV1	.89			.80
	AV2	.90			.82
	AV3	.90			.82
	AV4	.92			.84
	AV5	.92			.84
	AV6	.89			.80

Table 2

Factor loadings, communalities, eigenvalue, % variances explained by SRL strategies

Factor	Item code	Component 1	2	Communalities	Eigen values	% Variance
Critical thinking	CR1		.75	.60	1.76	15.96
	CR2		.78	.63		
	CR3		.71	.57		
	CR4		.74	.58		
	CR5		.75	.59		
Elaboration	EL1	.76		.64	5.36	48.73
	EL2	.82		.71		
	EL3	.82		.70		
	EL4	.82		.72		
	EL5	.80		.67		
	EL6	.80		.69		

The *KMO* value for SRL strategies was also acceptable at .92, representing an appropriate factor analysis for the scale. In addition to it, Bartlett 's Test of Sphericity results [$\chi 2$ = 2,182.75; $p < .001$] were also significant. SRL strategies were also considered acceptable for the factor analytic method like goal orientations. In this case, initial varimax rotation results showed high communalities ranging from .57 to .72, along with two factors whose eigenvalues were greater than 1.00. Furthermore, the two-factor structure explained 64% of the total variance, with factor 1 contributing 48%, and the contribution of factor 2 was 15%. Table 2 shows the detail of factor loadings, communalities, eigenvalue, and percent variances explained by SRL strategies. Similarly, the scree plot was also visually inspected to choose the correct number of factors to be extracted for self-regulation (Figure S2). Like the Kaiser-Guttman rule, the scree plot also showed two factors containing 11 items.

Confirmatory Factor Analysis (CFA)

Confirmatory factor analysis (CFA) is usually employed to validate the factors of the instruments. It examined the mode of interrelationships among latent variables without explicit directional relationships (Gunzler et al., 2013; Raykov & Marcoulides, 2006). For the current study, the factor validity of the instrument was assessed by two consecutive confirmatory factor analyses for each subscale. In this study, the achievement goal orientation scale having 17 items was tested using AMOSS to ensure how they fit the three latent factors: mastery, performance, and avoidance goal. In line with the results, achievement goal had three latent variables ($\chi 2$ = 389, df = 116, $\chi 2$/ df = 3.3, CFI= .95, RMSEA = .07), which is a good fit (Steiger, 2007). However, according to Schumacker and Lomax (2016), the RMSEA range between 0.05 to 0.08 indicates a close fit.

Next, SRL strategies were measured through eleven items or observed variables. After EFA, elaboration and critical thinking were identified. Among 11 items of SRL strategies, elaboration was allotted six items. In contrast, five items were clustered with critical thinking. The first order confirmatory round was performed, and a single factor model was a good fit ($\chi 2$ = 75, df = 43, $\chi 2$/ df = 1.7, CFI= .98, RMSEA= .04).

Analytic Method Using Smart PLS

The structural equation model (SEM) was used to evaluate the validity of the proposed model. Figure 1 is showing the proposed model for the current study. Figure 2 shows an overall structural model for goal orientation, self-regulation, and DE problem-solving. In SEM, two models, including the measurement model (outer model) and structural model (inner model), are embedded (Lin & Hsieh, 2010; Valente et al., 2016). Therefore, PLS's two-stage analytical procedures have been carried out in the current research analysis. First, the measurement model demonstrates the relationship between latent variables and their indicators. In contrast, the structural model determines the relationships between the determinants (Fritz et al., 2012). Furthermore, the measurement model usually enables the evaluation of the construct's reliability and validity, measured through convergent and discriminant validity.

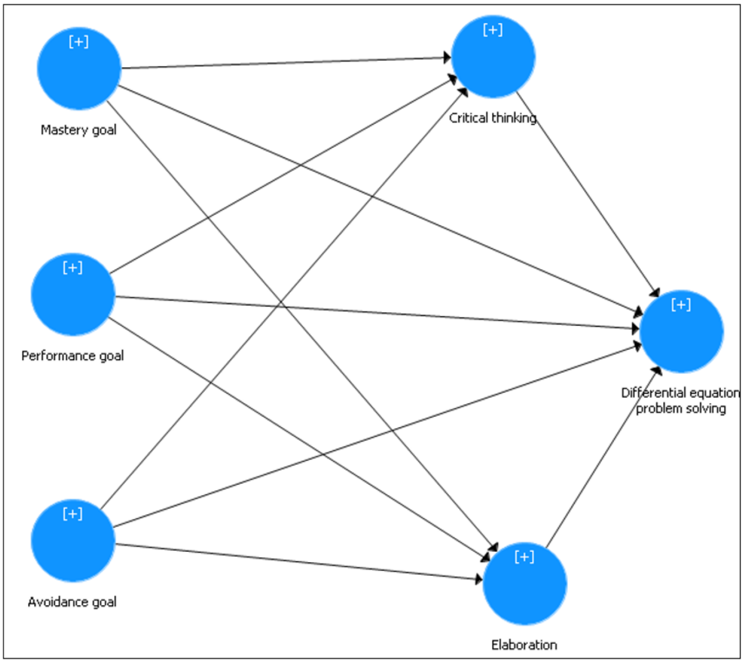

Figure 2. An Overall structural model for goal orientation, self-regulation, and differential equation problem-solving

The convergent validity is assessed through factor loading, composite reliability (CR), and average variance extracted (AVE). In contrast, discriminant validity is evaluated by comparing the square root of AVE with the correlation between the variables (Hair Jr et al., 2016). For the present work, the results are provided in Table 3. These values illustrated that all constructs loadings that exceeded the recommended value for AVE and CR were greater than 0.5 and .7, respectively (Hair, 2010). The value of R^2 expresses the explanatory power of the predictor variables on the respective construct. The endogenous latent variables are classified as substantial, moderate, or weak based on R^2 values of .67, .33, or .19, respectively (Chin, 2010). In analyzing the estimates, it was noticed that elaboration (R^2 = .59) and DE problem-solving (R^2 = .52) were in the moderate range, while critical thinking (R^2 = .24) was in the weak range.

Table 3

Construct reliability and validity of mediation model

Construct	CR	AVE	R^2	GoF=√(AVE*R^2)
Avoidance goal	.964	.818	-	
Critical thinking	.88	.594	.24	
Differential equation problem-solving	1.00	1.00	.52	.58
Elaboration	.93	.689	.594	
Mastery goal	.933	.7	-	
Performance goal	.908	.666	-	

The second way to validate the measurement model is discriminant validity, an extent to which items differentiate among constructs. Discriminant validity was evaluated through the square root of AVE for each construct's correlations (Gefen & Straub, 2005). In this respect, Hulland and Business (1999) further illustrated that the variables could be considered distinct theoretical entities while the correlation between the variables is lower than the square root of the AVE. For the current study, relevant values are provided in Table 4, confirming that estimated values agree with the reported scheme.

The values of predictive relevancy (Q^2), effect size (f^2), and significance levels of the loadings, weight, and path coefficients were also calculated before testing the structural model. Several researchers also recommended the calculation of goodness of fit (GoF) prior to the structural model estimates. GoF is a diagnostic tool used to assess the model fit (Tenenhaus et al., 2005). It is usually measured using the geometric mean of the average communality (AVE) and the average R^2 (GoF = $\sqrt{AVE \times R^2}$). Reported cutoff values for evaluating the results of the GoF analysis are : GoF small = 0.1; GoF medium = .25; GoF large = .36 (Hoffmann & Birnbrich, 2012). The current model yielded a (GoF) value of .58, indicating a large model fit (Table 3).

Table 4

Discriminant validity of mediation model

Constructs	Avoidance goal	Critical thinking	DE problem-solving	Elaboration	Mastery goal	Performance goal
Avoidance goal	.91					
Critical thinking	.02	.77				

Table 4 *(Continue)*

Constructs	Avoidance goal	Critical thinking	DE problem-solving	Elaboration	Mastery goal	Performance goal
DE problem-solving	-.26	.38	1.00			
Elaboration	.04	.49	.61	.83		
Mastery goal	.02	.42	.63	.75	.84	
Performance goal	.07	.47	.50	.63	.68	.82

In the current model, the endogenous variable is predicted by more than one exogenous variable. In such situations, effect size calculations are usually recommended to assess how a predicting (exogenous) variable contributes to the R^2 value of an endogenous latent variable. According to Cohen (1988), an f^2 value up to 0.02, 0.15, and 0.35 shows a small, medium, and large effect size. For the current model, the predicted f^2 vales for the DE problem-solving were .08, .17, and .06 for mastery, avoidance goal, and elaboration, respectively. The analysis of f^2 values revealed that avoidance has a moderate effect while elaboration has a small effect. Whereas the performance goal and critical thinking had relatively very small effects. Similarly, when the f^2 values of mastery, performance, and avoidance goal towards the mediating variables were considered (Table 5), it was revealed that in predicting elaboration and critical thinking, the effect of mastery goal with f^2 values of .49 (large) and .02 (small), respectively (Table 6). Similarly, the effect of performance goals for elaboration and critical thinking, with f^2 values of .06 and .09, respectively, showed a small effect. However, a small effect was noticed in the avoidance goal on elaboration and critical thinking (Table 5).

Table 5

Predictive relevancy (Q^2) and effect size (f^2) for the mediation model

Constructs	Q^2	f^2 (DE problem-solving)	f^2 (Elaboration)	f^2 (Critical thinking)
Avoidance goal	-	.17	.00	.00
Critical thinking	.13	.01	-	-
DE problem-solving	.50	-	-	-
Elaboration	.41	.06	-	-
Mastery goal	-	.08	.49	.02
Performance goal	-	.01	.06	.09

Likewise, the predictive sample reuses technique was used as a criterion for predictive relevance (Q^2) (Akter et al., 2011). Based on the blindfolding procedures, Q^2 evaluates the predictive validity of a complex model. Fornell and Larcker (1981) suggested that a Q^2 value greater than 0 means the model has predictive relevance and vice versa. Chin (2010) suggested cross-validated redundancy procedures to obtain Q^2 value. For this model, Q^2 values for elaboration, critical thinking, and DE problem-solving are .41, .13, and .50, respectively (Table 6). These were all above zero and thus, indicated acceptable predictive relevance. The second phase of PLS's two-stage analytical procedure was to examine the structural model. Then, it is used to test the hypothesized relationship within the model. Hair Jr et al. (2016) recommended a bootstrapping method (with 5000 samples) to establish path coefficient, weight, and the significance levels of the loadings.

Structural Model Results for Direct Paths. According to Hair Jr and Lukas (2014), the recommended critical t-values for two-tailed tests are 1.65 ($\alpha = .10$), 1.96 ($\alpha = .05$), or 2.58 ($\alpha = .01$). The findings of the structural model for direct path revealed that among goal orientations, mastery goal and avoidance goal strongly affected the differential equation problem-solving. The results of direct effects are provided in Table 6. It was observed that avoidance goal (β = -.283, t = 9.027, sig < .00) had relatively larger effect as compared to mastery goal (β = .334, t = 5.628, sig < .00). In the case of a performance goal, no such significant direct path was observed.

Interestingly, in SRL strategies, elaboration have shown direct effects (β = .274, t = 4.953, p < .00) on differential equation problem-solving. Whereas no significant direct path was an observer for critical thinking. The results of direct effects are provided in Table 6.

Table 6

Structural estimates for direct path (hypothesis testing)

Mediation	B	SE	t value	p value	Findings
Mastery goal -> DE problem-solving	.334	.059	5.628	.00	Supported
Performance goal -> DE problem-solving	.09	.053	1.691	.091	Not supported
Avoidance goal -> DE problem-solving	-.283	.031	9.027	.00	Supported
Critical thinking -> DE problem-solving	.069	.057	1.216	.224	Not supported
Elaboration -> DE problem-solving	.274	.055	4.953	.00	Supported

Path Analysis of Goal Orientation, SRL Strategies, and DE Problem-Solving. To evaluate the mediating role of SRL strategies, mediating model estimations were calculated. This model comprised of goal orientation subscales (mastery, performance, and avoidance goal), self-regulated subscales and DE problem-solving. Table 7 illustrates elaboration had partial mediation role with respect to mastery (β = .17, t = 4.07, $p < 0.05$) and performance goal (β = .06, t = 2.66, $p < .05$). Performance goal had optimistic as well as significant affects (β = .06, t = 2.66, $p < .05$) via elaboration. Results of avoidance goal orientation (β = .00, t = 1.02, $p < 0.05$) showed that SRL strategies both (elaboration and critical thinking) did not play a mediation role between avoidance goal and differential equation problem-solving.

During the mediation evaluation, it was observed that elaboration had played a significant mediating role (β = .17, t = 4.07, sig < .05) between mastery goal and differential equation problem-solving. The detailed results of mediation effects for this model are provided in Table 7. The avoidance goal orientation results (β = 0.00, t = 1.02, $p < 0.05$) showed that the SRL strategies (elaboration and critical thinking) did not mediate the relationship between avoidance goal and differential equation problem-solving.

Table 7

Structural estimates (hypothesis testing) for the mediation model

Mediation	B	SE	t value	Findings
Mastery goal -> Elaboration -> DE problem-solving	.17	.04	4.07	Partial mediation
Performance goal -> Elaboration -> DE problem-solving	.06	.02	2.66	Full mediation
Avoidance goal -> Elaboration -> DE problem-solving	.00	.01	.31	No mediation
Mastery goal -> Critical thinking -> DE problem-solving	.01	.01	1.02	No mediation
Performance goal -> Critical thinking -> DE problem-solving	.02	.02	1.17	No mediation
Mastery goal -> Critical thinking -> DE problem-solving	.00	.00	-.24	No mediation

DISCUSSIONS

The main aim of this study was twofold. The first aim was to explore the potential role of goal orientations and SRL strategies in mathematics problem-solving, particularly DE problem-solving. The second aim was to study the potential meditating role of SRL strategies.

Direct Effects of Epistemological Math Beliefs, Goal Orientations, and SRL on DE Problem Solving

The analysis confirmed that goal orientation and SRL strategies strongly affect DE problem-solving (Table 6). Among the constructs, mastery goal and elaboration significantly influence the DE problem. Avoidance goal had shown negative contribution while no such significant direct path was observed in the case of a performance goal.

Mastery goal results were aligned with the study of Wolters et al. (1996), who has provided evidence that the accomplishment of mastery goals is positively related to achievement. Additionally, current study results were also well supported by several researchers (Kaplan et al., 2002). It was also observed that avoidance goal (β = -.283, t = 9.027, sig < .00) had relatively larger effect as compared to mastery goal (β = .334, t = 5.628, sig < .00). Avoidance goal results provide a new direction and a good agreement with the literature because the simultaneous presence of multiple goals is associated with more positive outcomes (Elliot & McGregor, 2001). Although empirically, goals are independent, the presence of a set goal does not imply the absence of others. However, these findings contradicted a few studies, reporting a null relationship between these variables (Kingir et al., 2013).

In the case of a performance goal, no such significant direct path was observed. The previous findings of several researchers are well supported (Coutinho, 2007). Barron and Harackiewicz (2001) suggested that optimal achievement outcomes may occur when students pursue both mastery and performance goals together because when they have the option of pursuing both types of goals, they can better negotiate their achievement experiences by focusing on the achievement goal that is more relevant at a particular time.

Interestingly, in SRL strategies, elaboration have shown direct effects (β = .274, t = 4.953, p < .00) on differential equation problem-solving. Whereas no significant direct path was an observer for critical thinking Table 7. These elaboration results are aligned with several other researchers (Pintrich & De Groot, 1990). These researchers strongly recommended that the employment of various learning strategies impart an important predictor of students' academic performance and mathematics problem-solving. Similarly, critical thinking results were consistent with Fadlelmula et al. (2015) study, who claimed that only elaboration was considerably related to mathematics achievement among SRL strategies. Authors have explained that applying an inadequate set of learning strategies might contradict the previously reported findings. Therefore, in the present study, the non-significance of critical thinking might be appeared because of considering only two strategies (elaboration and critical thinking). Another reason may be the complex relationship between self-regulatory strategies and achievement. It was reported that a few high-achieving students succeed without using SRL strategies. Sometimes learning-related emotions influence SRL, especially critical thinking (Villavicencio, 2011). Usually, positive emotions are positively associated with SRL, whereas negative emotions are negatively correlated with these learning strategies.

Partial Mediation of SRL Between Goal Orientations and Problem Solving. SRL strategies, including elaboration and critical, were expected to mediate the relationship between the goal orientations (mastery, performance, and avoidance goal) and DE problem-solving. SRL strategies were expected, to improve students' beliefs, thereby enhancing students' problem-solving. The analysis confirmed that only elaboration mediated problem-solving mastery and performance goals (Table 7). In addition to the non-mediation role, negative and non-significant results of avoidance goal had also supported the proposed hypothesis (Table 7).

Partial Mediation of Elaboration Between Mastery Goal and Problem Solving. Analysis showed that elaboration mediated the mastery goal of problem-solving (Table 7). However, it was observed that the indirect effect of mastery goal ($\beta = .17$, $t = 4.07$, sig $< .05$) via elaboration on problem-solving is small, while the direct effects of mastery goal on problem-solving were seen as significant even after including SRL strategies as a mediator ($\beta = .33$, $t = 5.63$, $p < .00$). Therefore, on the one side, the findings supported the often-made assumptions that SRL strategies improve the students' achievements. On the other hand, in contrast to common belief, elaboration (SRL strategies) has only partially mediated math problem-solving. These results also indicate that other factors improve problem-solving resulting from mastery goals besides elaboration. Therefore, it may be concluded that mastery goal probably has similar effects on other factors than elaboration, which cause impartments in students' problem-solving.

Wolters (2004) described that high efficacious mastery goal-oriented students view their course work as fascinating, imperative, and valuable, hence becoming probable involved in diverse metacognitive and cognitive activities to enhance their learning capabilities. These results were also best supported by the study of Fadlelmula et al. (2015). Findings showed that among achievement goals, mastery was significantly interrelated with the use of learning strategies and math achievement (Fadlelmula et al., 2015). In addition, Mohsenpour (2006) reported that achievement goals partially mediate the association between the use of cognitive strategies and achievement. Several other researchers also reported that only the mastery goal predicts deeper level strategies, such as elaboration (Elliot & McGregor, 2001; Yumusak et al., 2007).

Partial Mediation of Elaboration Between Performance Goal and Problem Solving. The current study showed that performance goals were also positively linked to elaboration. However, via critical thinking, no significant effects were observed. A possible justification for this mediation role of elaboration might be that the students, who tried to outperform others, used more strategies to achieve better results in DE problem-solving. These findings align with Kadioglu and Kondakci (2014) study, where performance goal was linked to strategy use. The current study's findings can also be attributed to the common evaluation practices in the Pakistan educational context, such as grade-focused evaluation, the dominance of the entrance exam, and secondary school score to calculate final entry test results for admission into ranked universities. Therefore, the contribution of the performance goal in solving the differential equation problems model was believable. However, no direct or indirect effects were observed in a few studies. This contradiction may be explained because the nature of learning skills, characteristics of individuals, and environmental conditions also affect performance goals (Midgley et al., 2001).

Overall, it can be concluded that to ensure optimum achievement and problem-solving, students have to pursue the option of both mastery and performance goals together. By utilizing both options, they can better negotiate their achievement experience that is more relevant at a particular time.

An explanation for the Avoidance Goal Not Supporting Mediation. Results of avoidance goal orientation ($\beta = 0.00$, $t = 1.02$, $p < 0.05$) showed that both SRL strategies (elaboration and critical thinking) did not play a mediation role between avoidance goal and DE problem-solving. These results were consistent with Fadlelmula et al. (2015) research findings. He explained that students who avoid looking incompetent could not use more learning strategies and consequently become unsuccessful in mathematics. Kadioglu and Kondakci (2014) also reported that avoidance goal is not a significant predictor of learning strategies. Goal theorists suggest that once learners adopt an avoidance goal, they become defensive and impassive about their learning and tend to withdraw from learning; as a result, self-regulation does not happen (He, 2004).

An explanation for the Critical Thinking Not Performing Mediation Role. Critical thinking did not mediate the relationship between goal orientations and DE problem-solving (Table 7). These results supported the study of Fadlelmula et al. (2015), where performance goals did not mediate the relationship between self-regulation and math achievement. He suggested that students, who tried to outperform other students, might not be able to use more strategies. Therefore, these students were unable to achieve math achievement. Several other factors possibly affect the goal orientations in problem-solving can be identified. One possible reason for the lack of mediation of critical thinking on DE problem-solving is the difficulty with critical thinking measurements. Another reason might be the questionnaire, which could not measure the students' adaptation to SRL over time (Jansen et al., 2019).

Several authors pointed out that although critical thinking is also one of the important constructs of self-regulation, it has been proved that goal orientation, particularly mastery goals, employs a positive exertion on critical thinking and facilitates a better understanding of knowledge and skill improvement. However, few research studies have addressed this construct (Phan, 2009). Therefore, research studies on achievement goals and critical thinking persist in their earliest year and are limited to a few research bodies. Besides this, the self-report of critical thinking used in a few studies is not permanently valid and reliable.

Implications of the Study

To summarize, we investigated the potential role of goal orientations and SRL strategies in DE problem-solving. In addition, the meditating role of SRL strategies was also examined. The positive effect of goal orientations on SRL and problem-solving leads to practical implications that these motivational beliefs effectively affect students' problem-solving and performance. We, therefore, advise mathematics teachers and educators to implement these factors in both college and higher education to support students' engagements in SRL strategies and their achievements.

The results of the performance goal were more positive and significant as compared to previous studies. The current study's findings can be accredited to the appraisal practices in the developing countries' educational contexts (like Pakistan). Grade-focused evaluation, dominance of the entrance exam, and secondary school scores to calculate final results are important for admission to ranked universities. Therefore, the contribution of the performance goal in solving the DE problems model was believable. However, optimum achievement outcomes may occur when students collectively pursue each mastery and performance goal. Because once they have a choice of pursuing both types of goals, they could better negotiate their achievement by focusing on the achievement goal that is more applicable at a selected time.

The partial mediation of goal orientations on DE problem-solving by SRL results in the theoretical implications that the improvements in the problem-solving result from the intervention of beliefs are mostly due to factors other than goal orientations and SRL strategies. For example, we have described the influence of the non-routine nature of the task, context familiarities, and time on a task that may affect the problem-solving. Therefore, it might be useful to review the relation of these factors to explain the students' problem-solving and achievements in mathematics.

CONCLUSION

In this study, the role of goal orientations and SRL have been investigated for problem-solving, particularly related to Des-based problem-solving. Results illustrated that mastery and avoidance goals directly affected the DE problem-solving in goal orientations. While in SRL, elaboration directly influenced the DE problem-solving. However, no such effect was observed for performance goals and critical thinking. Similarly, it was also noted that only elaboration had the mediation role for both mastery and performance goals. In the case of critical thinking, no significant effects were noticed. The study's findings confirmed that motivational beliefs and learning strategies influence problem-solving. Therefore, teachers and educators must design their instructional strategies by incorporating the students' motivational beliefs and learning strategies for the effective learning of the DE course.

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SUPPLEMENTARY DATA

Table S1

Adopted Scoring rubric for non-routine words problem based on Analytic Scoring Scale (Charles et al., 1987)

Stages for differential equation problem-solving	Score for understanding	Characteristics	Description
Understanding	0	Compete for misunderstanding	Lack of comprehension problem Not able to identify important given data
	1	Partial understanding	Some parts of the problem misinterpreted Partially understand data, partially understand goals and hidden data
	2	Complete understanding	Ability to take information and translate it into the mathematical model, fully retrieve given and hidden data, formulate proper equation
Planning a solution	0	No attempt/ inappropriate plan	Wrong Integration procedure, not able to put constant of integration,
	1	Partially correct plan	Correct interpretation up to a certain point, but the strategy remains major flawed
	2	The plan led to a correct solution	Successful findings
Getting answers	0	No answer	Cannot execute integration steps
	1	Copying error, computer error	Mathematical/computational error
	2	Correct answer, correct label	No error in answer

Table S2

Cronbach's alpha values for the research instruments

Instrument	Scale	Number of items	Cronbach's alpha value	Reported Cronbach's alpha value	Reference
Differential equation task	DE task	5 (Each task requires 6 steps for its solution)	0.66		
Achievement goal orientations	Mastery goal	6	0.83	0.86	Midgley et al. (1996)
	Performance goal	6	0.76	0.86	
	Avoidance goal	6	0.76	0.75	
Self-regulated learning strategy (SRL)	Critical thinking	5	0.90	0.75	Pintrich (1991)
	Elaboration	6	0.89	0.80	

Table S3

Inter-item correlation matrix

Constructs	1	2	3	4	5	6
Mastery (1)	1	.67**	.02	.28**	.75**	.62*
Performance (2)	.67**	1	.07	.35**	.62**	.50**
Avoidance (3)	.02	.07	1	.05	.04	.25**
Critical thinking (4)	.28**	.35**	.05	1	.38**	.27**
Elaboration (5)	.75**	.62**	.04	.38**	1	.60**
DE problems (6)	.62**	.50**	.25**	.27**	.60**	1

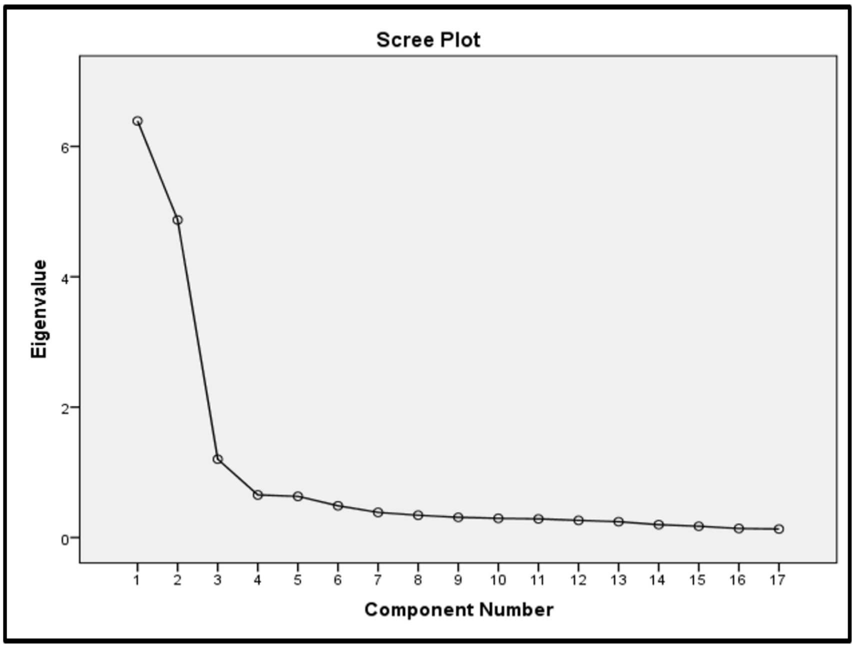

Figure S1. Scree plot of goal orientations

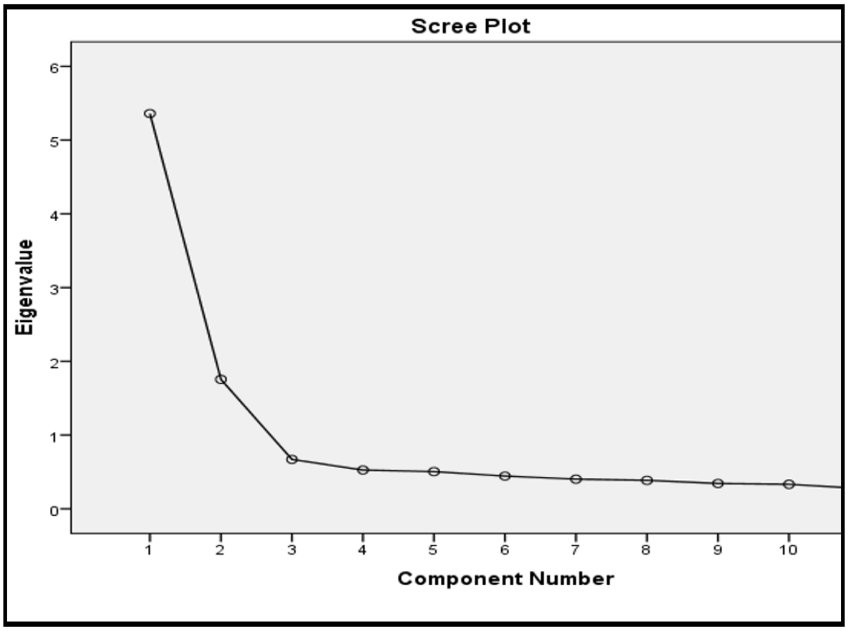

Figure S2. Scree plot of self-regulated learning strategies