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Journal of Education and Training Studies
Vol. 5, No. 12; December 2017
ISSN 2324-805X E-ISSN 2324-8068
Published by Redfame Publishing
URL: http://jets.redfame.com

# Identifying the Relationships between Motivational Features of High and Low Performing Students and Science Literacy Achievement in PISA 2015 Turkey

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Received: November 7, 2017 Accepted: November 22, 2017 Online Published: November 23, 2017

doi:10.11114/jets.v5i12.2816 URL: https://doi.org/10.11114/jets.v5i12.2816

**Abstract**

In this study, the predictive roles of intrinsic and instrumental motivations, science self-efficacy on success in the lower and upper quartiles of score distribution are analyzed in scientific domain of PISA 2015 Turkey sample. Since their index values can't be calculated due to missing values, some students are excluded from the sample and the study sample is comprised of 5287 students. Regression models in which intrinsic and instrumental motivation, science self-efficacy are predictive variables and success is response variable are formed for the lower and upper quartiles of score distribution of science literacy. Models are analyzed by quantile regression analysis. It is found that self-efficacy in science, intrinsic and instrumental motivations towards science are significant predictors of science success. The predictive roles of science self-efficacy and intrinsic motivation towards science are much more effective in the upper quartile of score distribution than the lower quartile. Instrumental motivation has significant relationship with science success only in the lowest and highest $10^{th}$ percentages. Based on these results, suggestions are made both for researchers and teachers regarding the classroom activities, assessment processes and possible future studies that might be conducted related with the success and motivation of the students.

**Keywords:** students' achievement, intrinsic motivation, instrumental motivation, science self-efficacy, pisa, quantile regression analysis

## 1. Introduction

The roles of the cognitive factors on the students' success are emphasized much more in the studies conducted it the field of education. However, the studies on the conative features like motivation accepted as related with the student success are also implemented today. Motivation is a psychological structure affecting student achievement and providing psychological force that is necessary for making an activity for the people (Schunk, Meece and Pintrich, 2014). While motivation levels of people who do not have this necessary force become low, the people who are acting towards a goal are considered as motivated. It is acknowledged that the motivational traits of the students have essential roles on their achievements and career preferences. Motivational features of the students in science literacy are among the points that are dealt with great attention in PISA 2015. Because of the high effects on the career preferences of the students, instrumental motivation to learn science, science self-efficacy, enjoyment of science and interest in science topics and their relationships with students' science achievement are attached importance. It is accepted that the motivation levels of the students to science are shaped by their self-perceptions and perceptions towards science activities in PISA 2015. Therefore, the motivation of students to science is examined by depending on their science self-efficacy together with their intrinsic and extrinsic motivation (Organization for Economic Co-operation and Development [OECD], 2016). Similarly, it is observed that self-efficacy, intrinsic and extrinsic motivations are the concepts that are discussed in well-accepted motivation theories (Bandura, 1977; 1982; Deci and Ryan 1985; 2000).

The researchers agree on that types of motivation are based on the individuals' goals leading them to accomplish specific behaviors. For instance, students who are motivated to doing homework thanks to his/her interest to the course or just because of getting approval of the teacher might have similar in terms of motivation levels. However, these students have different features in terms of nature and focus of the motivation (Stipek, 1998). Deci and Ryan (1985; 2000) defined different types of motivation by basing on attributions and goals of the individuals' behaviors. Main

difference among those motivation types is between intrinsic motivation indicating accomplishing activities just because they are enjoyable and attractive and extrinsic motivation leading individuals to doing activities with the aim of accomplish some specific goals.

Intrinsic motivated individuals do their actions not with the effect from an exterior source but with the effect of inner sources. In that case, those individuals do not need any rewards for their actions. The pleasure taken from the activity itself and improving their skills thanks to doing the activity becomes equal to getting rewards for the intrinsic motivated people (Deci and Ryan, 1985; 2000; Viau, 2015). According to Deci (1975), it is required that people feel themselves free against the exterior pressures and are able to accomplish their actions autonomously. It is clear that showing interest and enjoying the activity are the things that the researchers emphasize most while defining the intrinsic motivation. On the other hand, there are some students who are motivated to persist decisively and accomplish the task with great success even if they do not find the course or the activity interesting or enjoyable. It is considered that the thing that motivates student to study in such context becomes the meaning and importance of the activity to the student. For instance, even though student does not find the topics of the course interesting he/she might show high effort in this course since the student believes that the course is necessary and significant for his/her career (Stipek, 1998; Schunk, Meece and Pintrich, 2014; İlhan, 2015). This kind of motivation type is accepted as instrumental motivation (OECD, 2016).

As mentioned before, in addition to showing interest, self-efficacy is a significant trait affecting motivations of the students. Bandura (1977) defines self-efficacy as self-evaluation of the skills and equipment that are required to have so as to accomplish specific targets. Individuals consider themselves sufficient when they believe that they can accomplish the tasks successfully (Zimmerman, 2000). Self-efficacy perceptions of individuals affect their behaviors, thinking patterns, emotional reactions and preferences (Bandura, 1982; Pajares, 1996). If a person believes that he/she is able to achieve a goal the person is more likely to prefer showing effort in order to reach his/her goal. People who have high self-efficacy define more difficult goals for themselves compared to people having low self-efficacy (Locke and Latham, 1994). While people avoid from the activities requiring beyond their skills, they undertake the activities that they believe that they have sufficient skills for the task (Bandura, 1982).

The studies on the relationships among self-efficacy, intrinsic motivation and students' achievement reveal that they have positive relations with the students' success (Benware and Deci, 1984; Grolnick and Ryan, 1987; Utman, 1997; Caraway, Tucker, Reinke and Hall, 2003; Sui and Ho, 2007; Corpus, Gilbert and Hayenga, 2009; Hayenga and Corpus, 2010; McConney and Perry, 2010; Weiser and Riggio, 2010; Kusurkar, Cate, Vos, Westers and Croiset, 2011; Logan, Medford and Hughes, 2011). Furthermore, it is found that there is positive relation between students' science self-efficacy and science achievement in all participant countries in PISA 2006. One point increase on the self-efficacy scores creates averagely 20 points increase on the science achievements of the 49 of the 57 participant countries. Similarly, variables of interest in science and enjoyment of science have positive correlations with the science achievements of the all of the participant countries except for three countries. Besides, these variables increase science achievement by 25 points. Positive relations between instrumental motivation and achievement are also obtained in most of the participant countries (OECD, 2007).

When the results of the PISA 2006 and 2015 are compared in terms of the focus variables of this study, it can be found out that there are increases on the variable of the enjoyment of science in 17 of the participant countries while there are decreases in the 32 of the participant countries. Turkey ranks 7 out of 32 countries in which the steepest declines in students' enjoyment of science are observed. The results related with the variable of the interest in science in Turkey PISA 2015 reveal that Turkey ranks below the average across OECD countries in terms of the interest in specific topics such as the universe and its history or the role of science on preventing diseases. Furthermore, students in 2015 report significantly greater instrumental motivation towards science than their counterparts in 2006 did in 35 of the participant countries while some decline is revealed in 16 of the participant countries. Turkey is among the countries in which greater level of instrumental motivation is observed. However, when the countries are ordered in terms of the amount of increase observed in instrumental motivation Turkey ranks 28 out of 35 countries (OECD, 2016). Besides, the results obtained in PISA 2006 and 2015 indicate that the relationships among the variables related with the motivation, self-efficacy and science achievement vary for high and low performing students (OECD, 2007; 2016). Similarly, the studies on the motivation and self-efficacy of the students point out that these traits might create various patterns of behavior by depending on the achievement levels of the students. There are studies suggesting that high and low performing students are different in terms of the self-efficacy levels and these students might embrace dissimilar and unique behavior patterns (Katz and Shoshani, 2010; Mantilla, 2015). The study conducted by Logan, Medford and Hughes (2011) brings out that the positive affect of the intrinsic motivation on students' achievement is greater for low-performing students than high-performing students.

Comparison of the results of Turkey PISA 2006 and 2015 indicates that students' motivation towards science tends to

decline and the relationships between the motivational traits and the science achievement vary for high and low performing students. These results related with the motivational traits show that it is required to give more importance to the students' motivational competences and the effects of these traits on students' achievement. Therefore, the objective of this study is to examine the roles of self-efficacy in science, intrinsic and instrumental motivation towards science as predictors of science achievement in lower and upper success groups. Within this scope, the research questions to be answered are;

1) Do the following motivational variables;

   a) self-efficacy in science,

   b) intrinsic motivation towards science (enjoyment of science)

   c) instrumental motivation towards science predict students' science achievement significantly for lower and upper quartiles in PISA 2015?

## 2. Method

### *2.1 Research Design*

In this study, it is aimed to investigate the predictive roles of motivation and self-efficacy on science success in the lower and upper quartiles of score distribution of PISA 2015 Turkey sample. The research is designed as a relational survey model in order to investigate the relationships between the variables (Tabachnick and Fidell, 2007). Variables are correlated with each other based on the theoretical foundations in the relational survey model (Cohen, Manion and Morrison, 2007).

### *2.2 Participant (Subject) Characteristics*

The sample of the study consists of 5895 students from 231 schools in PISA 2015 Turkey sample. After excluding some students because of missing data the final study sample is comprised of 5287 students. The sample distribution according to gender and classroom levels of the students is presented in Table 1.

Table 1. Sample Distribution According to Gender and Classroom Level

| **Classroom Level** | **Gender** | | |
|---|---|---|---|
| | **Female** | **Male** | **Total** |
| $7^{th}$ grade | 6 | 9 | 15 |
| $8^{th}$ grade | 34 | 51 | 85 |
| $9^{th}$ grade | 442 | 645 | 1087 |
| $10^{th}$ grade | 2123 | 1800 | 3923 |
| $11^{th}$ grade | 116 | 55 | 171 |
| $12^{th}$ grade | 3 | 3 | 6 |
| **Total** | 2724 | 2563 | 5287 |

### *2.3 Measures and Covariates*

PISA 2015 student questionnaire measures enjoyment of science variable by depending on the answers given by the students to questions related with enjoying learning science topics, liking science reading, enjoying studying on science topics, interest in science, enjoying learning new information about science. Furthermore, there are four items developed to measure students' instrumental motivation in the student questionnaire. It is asked students to report how it is easy or difficult for them to accomplish each of the eight different tasks requiring them to use various knowledge and skills so as to measure students' science self-efficacy. Students give answers to the questions related with self-efficacy, instrumental and intrinsic motivation on four-point Likert scale. The scores of the students obtained for these three variables are transformed into index values calculated to summarize their answers to the questions (OECD, 2016). The scores that students obtained in PISA 2015 science domain are accepted as the measures of their science achievement. Ten different datasets without missing values are created using multiple imputation method in PISA 2015. The scores indicating students' science success are calculated by averaging the pseudo values created by basing on these ten datasets.

### *2.4 Data Analysis*

Quantile regression analysis is used in order to analyze the predictor roles of the science self-efficacy, intrinsic and instrumental motivations towards science on science achievement in lower and upper quartiles. According to Chen and

Deville (2014) quantile regression is a better method than standard regression analysis if previous studies indicate that the relationships between variables change on the different points of the dependent variable distribution. Quantile regression analysis finds out the differences in the nature of the relationships on various point of the distribution more effectively. The most important feature of quantile regression analysis is that it enables the effect of independent variables to be analyzed for every point of the dependent variable distribution (Koenker and Hallock, 2011). The quantile analysis was done on R program by using "quantreg" package. Simplex algorithm is widely used for estimating constant and intercept parameters. Since the sample size and the numbers of the variables are appropriate for this algorithm simplex algorithm was used to estimate parameters (Chen and Deville, 2014). So, the predictor roles of science self-efficacy, instrumental and intrinsic motivation towards science on the science success of the students who are in the $0.1^{th}$, $0.25^{th}$, $0.5^{th}$, $0.75^{th}$ and $0.9^{th}$ percentiles were analyzed by using Simplex algorithm of "quantreg package" on R program.

## 3. Results

With the aim of finding answers to the research questions regression model in which science self-efficacy, intrinsic and instrumental motivation towards science are predictive variables and science success is response variable is formed for 0.25, 0.50, and 0.75 percentages (lower, middle, and upper quartiles of score distribution). The results obtained with the quantile regression analysis of this model in specified percentages are presented in Table 2.

Table 2. The Results of Quantile Regression Analysis

| | **Quantiles** | | | | |
|---|---|---|---|---|---|
| | **0.10** | **0.25** | **0.50** | **0.75** | **0.90** |
| Constant Coefficient | 333.6 | 371.1 | 417.9 | 473.8 | 522.5 |
| Intrinsic (Slope) | 7.77* | 8.79* | 11.90* | 12.57* | 15.05* |
| Instrumental (Slope) | 4.11* | 1.51 | 0.86 | -2.57 | -4.62** |
| Self-efficacy (Slope) | 2.33** | 2.82* | 5.24* | 7.79* | 5.90* |

* = $p<0.01$ ** = $p< 0.05$

The results of quantile regression analysis given in Table 2 reveal that self-efficacy in science, intrinsic and instrumental motivations towards science are significant predictors of students' science success. The predictive roles of self-efficacy and intrinsic motivation towards science are much more effective in the upper quartile of score distribution than the lower quartile. With the increase on the students' science success, the slope estimated for intrinsic motivation increases from 7.77 to 15.05 and for science self-efficacy from 2.33 to 5.9. When the results are examined in terms of instrumental motivation, it can be seen that the positive effect of the variable on success in bottom $0.1^{st}$ percentage changes into negative in the upper $0.9^{th}$ percentage. With the increase on science success, the slopes estimated for instrumental motivation varies between 4.11 and -4.62. Figure 1 shows the changes in predictive roles of science self-efficacy, intrinsic and instrumental motivation towards science on lower and upper quartiles of score distributions.

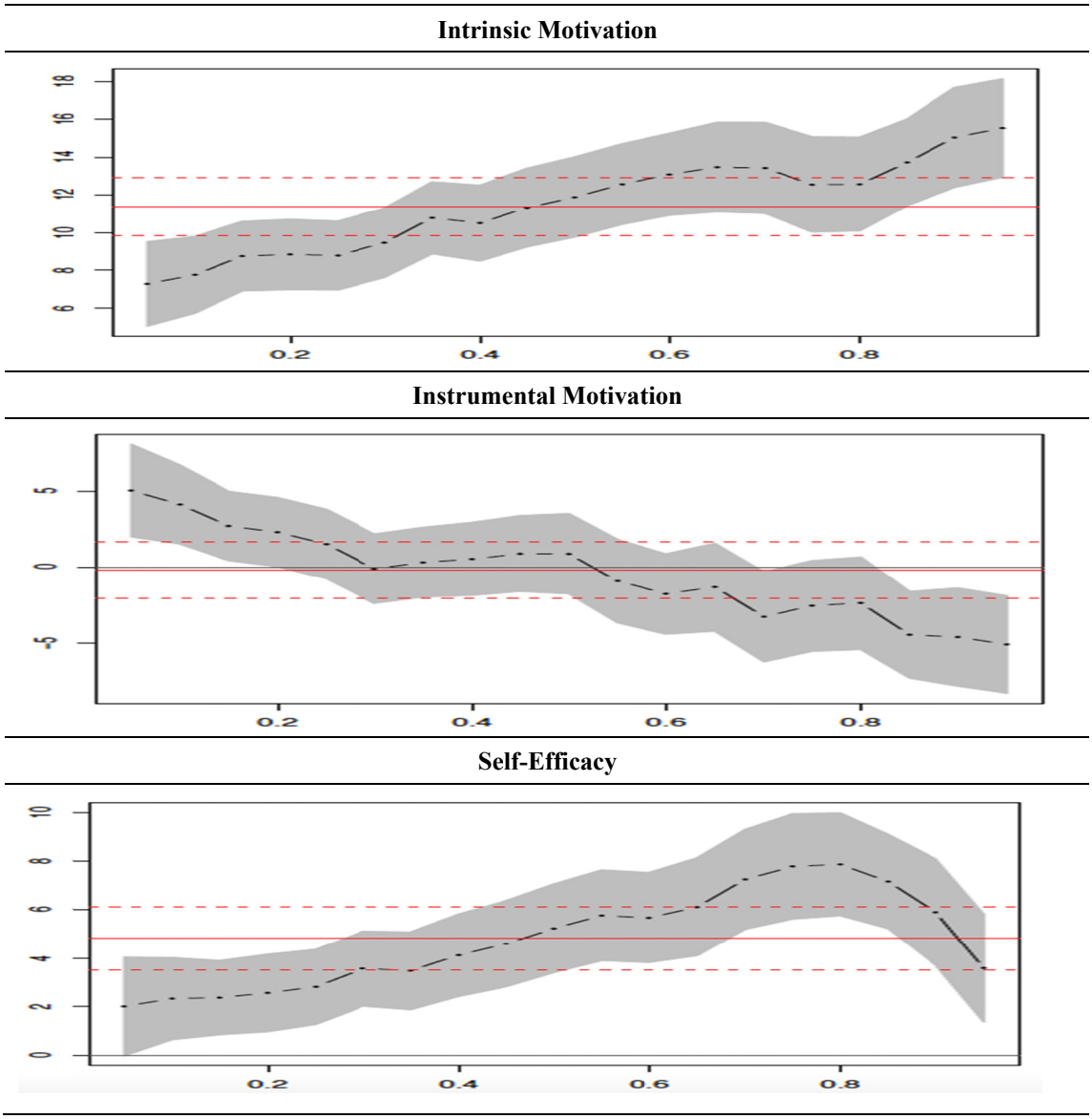


Figure 1. Graphs of Quantile Regression Analysis for Predictor Variables

In the graphs presented in Figure 1, the slopes estimated for the predictor variables in each specified percentages are shown in the vertical axis and the percentages are on the horizontal axis. Estimated slope coefficients for intrinsic motivation towards science and science self-efficacy are above the zero reference line. Therefore, these two variables have positive relationships with science success on each point of the distribution of the science success. The graphs visualize that the value of slope coefficients of intrinsic motivation and self-efficacy increase from lower quartiles to upper quartiles of score distributions. This patterns of the change observed in the graphics bring out that both of the variables predict science success much more in upper quartiles than lower quartiles. When related graph is examined, it can be seen that more different pattern is obtained in terms of the slope of the instrumental motivation. It has significant relationship with science success only in the lowest and highest $10^{th}$ percentages. Furthermore, graphs reveal that instrumental motivation has positive effects on science success in lower percentages but this effect turns into negative in upper percentages.

The results of quantile regression analysis show that intrinsic motivation and self-efficacy predict science success much better and create more increase on success in upper quartiles. On the other hand, instrumental motivation creates increase on science success in lower percentages while it causes decline in upper percentages. Besides, instrumental motivation predict science success significantly only in the lowest and highest $10^{th}$ percentages. The results of the variance analysis done in order to test the significance of the difference between the slope coefficients estimated on various points of the distribution are presented in Table 3.

Table 3. The Results of the Variance Analysis

| | F | p |
|---|---|---|
| Intrinsic motivation | 4.22 | 0.002 |
| Self-efficacy | 8.55 | 0.000 |
| Instrumental motivation | 0.29 | 0.882 |

The results given in Table 3 indicate that the differences between the slopes estimated for the various points of the distribution are significant for intrinsic motivation and self-efficacy. However, there are not significant differences among the slopes of instrumental motivation estimated in the different points of distribution.

## 4. Discussion

In the study, the predictive roles of the motivational traits on students' science achievement are analyzed. It is found out that intrinsic motivation is a significant predictor of success on every point of distribution of the students' science success. This finding of the study is parallel with the findings of the study conducted by Benware and Deci (1984). In their study, the researchers compare the students learning a material so as to teach it to other students or to obtain high scores from the test in terms of enjoyment of the task, willing to accomplish the task and learning levels. It is concluded that the students who are asked to teach the materials to other students are more motivated than those who are studying just with the aim of getting high scores. Besides, it is revealed that those students who are more intrinsically motivated find the task more enjoyable and they are more willing to accomplish it than the students only aiming to having high scores. Similarly, students motivated intrinsically have higher score in terms of conceptual learning in the study of Grolnick and Ryan (1987). In a meta-analysis study made by Utman (1997) it is brought out that intrinsic motivation has positive effect on achievement and this effect becomes greater in case of difficult tasks.

In this study, it is revealed that both high and low performing students reporting that they enjoy science topics have higher science scores than the ones reporting otherwise. Furthermore, the predictive role of the intrinsic motivation on success is much more for high-performing students than low performing students. In a parallel way with this finding, it is concluded that high performing students is more intrinsically motivated than low performing students in socio economically disadvantaged student groups in PISA 2006 (OECD, 2011). The study of Logan, Medford and Hughes (2011) shows that intrinsic motivation explains more variance in reading comprehension success in low performing group than high performing group, which is different from the finding of this study. The researchers express that low performing students in terms of reading comprehension need more intrinsic motivation in order to put more effort and perform well while dealing with the tasks. However, the results of this study indicate that intrinsic motivation has positive effect on science success bot in low and high performing student group.

Students motivated intrinsically towards a specific field take more pleasure from that field, study more willingly and put much more effort while studying (Stipek, 1998; Schunck, Meece and Pintrich, 2014). Therefore, it might be suggested that the increase on the enjoyment of science, liking reading and studying on science enable students persist decisively and increase their success in science thanks to their effort. Studies point out that intrinsically motivated individuals show better performance especially on the difficult tasks requiring creativity, flexible thinking and strategy use (Benware and Deci, 1984; Grolnick and Ryan, 1987; Utman, 1997). When the use of items that require students to use their knowledge and skills in authentic and complex problem situations in PISA 2015 is taken into consideration, it can be expressed that the finding indicating that intrinsic motivation is significant predictor of science achievement is consistent with the findings of mentioned researches.

Another result of this study is that science self-efficacy is a significant predictor of science success on each point of score distribution. This finding is in concordance with the propositions of the social cognitive theory in which self-efficacy is examined. According to Bandura (1991) individuals construct beliefs on what they might be able to accomplish, predict the results of their own behaviors and specify goals for themselves. Their predictions and beliefs enable individuals to motivate themselves. They lead their behaviors consistently with their predictions and beliefs. The individuals finding themselves enough define more difficult targets for themselves and commit much more to these targets. When they accomplish their goals, an increase occurs on their self-efficacy (Caraway, Tucker, Reinke and Hall, 2003). In the study of McConney and Perry (2010) it is found out that students having low socio economic conditions but high self-efficacy have higher Math success than students having low self-efficacy. Caraway, Tucker, Reinke and Hall (2003) reveal that self-efficacy of students is significant predictor of academic success in their study.

The beliefs of the students about their own skills lead their task preferences together with cognitive and emotional process they experience while accomplishing the tasks. It is known that students having high self-efficacy tend to use various strategies while doing tasks, putting more effort into the task, persist more decisively and have positive approach towards challenging tasks (Reinke and Hall, 2003; Ho, 2007; McConney and Perry, 2010). It can be expressed that the cognitive and emotional contributions of self-efficacy on students enable it to be more effective on success.

Corpus, Gilbert and Hayenga (2009) suggest that the reverse relationship is also possible. They indicate that high performing students might trust their skills much more and their high self-efficacy might increase their success.

In this study, it is concluded that the predictive role of self-efficacy on science success varies depending on the success of the students and it predicts achievement more strongly in high performing student group. According to Bandura (1995) the experiences of individuals, which they had while dealing with various tasks in the past, affect their self-efficacy the most. Students evaluate the results they obtain after accomplishing a task. When students believe that they studied hard and obtained the result that they expect, their self-efficacy in specific field or task increase while it decreases if they are not be able to get the expected result even though they studied hard. However, Bandura (1995) also states that success, which is obtained easily and without effort, might not cause such an effect and might lead to people developing the behavior of giving up easily in case of failure. The possibility of accomplishing various kinds of tasks successfully is higher for high-performing students than the low-performing students. Therefore, it might be suggested that the past experiences of being successful in science enables the relationship between self-efficacy and success to be stronger in upper quantile.

Another finding of the research is related with the relationship between instrumental motivation levels and science success of students. It is found out that the variable of instrumental motivation is a significant predictor of science success only in the lowest and highest quantile of the distribution, which is different from the findings regarding intrinsic motivation and self-efficacy. While instrumental motivation contributes in students' success, this effect turns into negative in upper quantile. It is concluded that instrumental motivation increase the success of low performing students to some extent but it negatively affects the success of high performing students. In a parallel way with this finding, in a study done by Li and Pan (2009) it is revealed that low performing students agree more on the items related with the instrumental motivation towards learning English than high performing students.

When the targets and rewards lead individuals' behaviors instead of the pleasure taken from doing specific task individuals motivate themselves to accomplish that task because of the benefit that it will provide. According to Deci and Ryan (1985) people focus mainly on obtaining rewards rather than developing their skills in that case. Besides, Utman (1997) states that focusing on developing skills increase the pleasure in doing the task and lead to better results. When individuals focus only on the goals or rewards they enjoy the task less and their performance might get worse. Amabile (1983 cited Grolnick and Ryan, 1987) considers that rewards or other exterior sources cause people to embrace an instrumental approach. The researcher suggests that this instrumental approach might prevents the people from thinking in a strategy-oriented way and might lead them to select the easiest and quickest solution to obtain a result. So, different researchers express that instrumental motivation has negative effects on cognitive processes of the people. In this study, it is found out that instrumental motivation has negative relationship with the success of the students in the highest quantile while it has positive relationship with the success of the students in the lowest quantile. Similarly, Corpus, Gilbert and Hayenga (2009) express that if students continue getting low scores they might embrace more instrumental approaches, focus options guaranteeing the success in the future, focus more on exterior factors.

In the study, it is concluded that self-efficacy and intrinsic motivation are significant predictors of science success on each specified points of success distribution and they predict the success more in upper quantile. This finding of the research draws attention to the importance of developing both high and low performing students' proficiencies in terms of self-efficacy and intrinsic motivation so as to increase their success. The literature on motivation includes implementations that should be given importance in both teaching and evaluation processes in order to increase students' self-efficacy and intrinsic motivation. When students have problems with motivation, instructional program and social atmosphere of the class are required to be examined. Since intrinsic motivation of students is affected mainly by the nature of the teaching and the tasks given to the students, it is recommended teachers to select activities of appropriate difficulty that are clear, understandable, attractive. Too easy and too difficult tasks might not be able to contribute on developing positive self-efficacy. Therefore, teachers are suggested to give challenging but doable tasks to the students. It is required to diversify the difficulties of the tasks according to the skills of the students and prepare tasks that would be challenging for high-performing students too. In terms of measurement and evaluation, it is recommended to teachers to use problems varying in difficulties, give their remarks or rewards by depending on the success criteria or personal development of the students, decrease the rate of the evaluations which base on normative criteria, try to improve students' skills of monitoring their own development and take the effort showed by the students into consideration while evaluating their success levels (Stipek, 1998; Schunk, Meece and Pintrich, 2014). Furthermore, Utman (1997) suggests that focusing on the normative evaluations much more cause students to concentrate on the results more rather than enjoying the experiences they have during the learning process. Therefore, teachers' focus on improving self-evaluation skills of students so as to enable them to enjoy the learning process, give more importance to learning is regarded as significant. Another important finding of the research is related with the negative relationship of instrumental motivation with the students in the upper percentages. This finding is required to take into consideration while planning activities and more importance should be given to increasing the intrinsic motivation of students so as to

enhance the success of the all students but especially high-performing students.

It is recommended the researchers to conduct research on the motivational traits of the students to examine how the efficacy of the teaching program implemented on high and low performing students' groups with the aim of developing their motivational features varies depending on the students' success levels. It is considered that the results of that kind of study provide rich information about how the effects of motivation on high and low performance groups vary. Furthermore, related researches indicate that the difficulty level of the task has important role on the student's motivation (Harter, 1978 cited Grolnick, Gurland, Jacob and DeCourcey, 2002; Dweck and Leggett, 1988). Therefore, it can also be suggested to the researchers to make a study in which the relationships between motivational traits and the success scores obtained from the items measuring different cognitive levels of science literacy in PISA 2015 is analyzed.

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