Eurasia Journal of Mathematics, Science & Technology Education, 2014, **10**(6), 667-680

Impact of Portfolio Assessment on Physics Students' Outcomes: Examination of Learning and Attitude

Abdulkadir Gunay
Bilecik Anatolian High School, TURKEY

Feral Ogan-Bekiroglu
Marmara University, TURKEY

Received 14 December 2013; accepted 27 April 2014

In spite of the commendations for the use of portfolio assessment, there is still little evidence indicating that such assessment actually supports and encourages student learning. Hence, this research study aimed to empirically identify the effects of implementation of portfolio assessment on student learning and attitudes. True-experimental design was used for the study. Participants of the research were nine-grade students. Portfolio assessment was implemented in the experimental group for eight-week duration in the physics course. Findings illustrate that the students assessed by the portfolio constructed more knowledge than the students that did not prepare a portfolio. On the other hand, portfolio assessment did not make any difference in the students' attitudes towards physics. This study concludes that portfolios are not only an indication for student growth but also a learning tool.

Keywords: Portfolio assessment, learning, attitude, physics

INTRODUCTION

"More established traditions of emphasizing assessment on objective testing at the end of instruction are being supplemented with assessments during instruction to help teachers make moment by moment decisions and with what are called alternative assessments" (McMillan, 2011, p.15). Alternative forms of assessment include authentic assessments, performance assessments, portfolios, journals and other forms of assessment that involve the active construction of meaning rather than the passive regurgitation of isolated facts. Since these assessments engage students in learning and call for thinking skills, they are consistent with cognitive theories of learning and motivation as well as societal needs to prepare students for an increasingly complex workplace (Maeroff, 1991).

This research attempted to examine the impacts of an alternative assessment method, portfolio, on students' physics learning and their attitudes towards physics.

Correspondence to: Feral Ogan-Bekiroglu; Marmara Universitesi Ataturk Egitim Fakultesi OFMA Eğitimi Bölümü Fizik Egitimi Anabilim Dalı 34722 Göztepe Istanbul/ TURKIYE
E-mail: feralogan@yahoo.com
doi: 10.12973/eurasia.2014.1227a

THEORETICAL FRAMEWORK

Since the current research focused on the effectiveness of portfolio assessment on performance learning and attitude, theoretical background of the study was framed with the relations between portfolio

ISSN: 1305-8223

State of the literature

- Self-regulated learning has become a major attention of research
- As a result, there is a need for more studies looking for the influence of portfolio assessment on students' learning by addressing and solving such limitations.
- Reviewing the literature indicates that research examining the effects of portfolio assessment on students' attitudes towards science have been inadequate.

Contribution of this paper to the literature

- Results of this study reveal that portfolio assessment, which students come across for the first time does not decrease students' positive attitudes towards physics
- This study concludes that portfolio assessment is not only an indication for students' cognitive growth but also a learning tool. In other words, portfolio assessment increases understanding in physics
- This study suggests that portfolio assessment including self-evaluation, self-reflection and feedback facilitates learning

assessment and learning as well as portfolio assessment and attitude.

Portfolio Assessment and Self-Regulated Learning

Self-regulated learning has become a major attention of research (Pintrich, 2000). Self-regulated learning refers to 1) students' proactive efforts to mobilize emotional, cognitive, and environmental resources during learning and 2) self-observation, judgment, and reaction to one's progress (Bandura, 1986). Schunk and Zimmerman (1994) considered self-regulation to be reciprocal of motivation and defined it as "the process whereby students activate and sustain cognitions, behaviors, and affects, which are systematically oriented toward the attainment of their goals" (p. 309).

This theory describes the factors essential to the accomplishment of complex capabilities in any domain or discipline. Learners who self-regulate "set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behavior, guided and constrained by their goals and the contextual features of the environment" (Pintrich, 2000, p. 453).

To promote student-centered self-regulation, assessments need to be part of formative evaluation, which is specifically aimed at generating feedback on performance to improve and reinforce self-regulated learning (Bose & Rengel, 2009; Nicol & Macfarlane-Dick, 2006; Sadler, 1989; Sadler, 1998).

The literature on strategic learning (Palinscar & Brown, 1984; Paris, Lipscorn & Wilson, 1985) stresses the importance of self-regulation in portfolios. Portfolio assessment facilitates self-regulated learning because students become increasingly self-regulated when they acquire skills to plan their learning, monitor their own progress, and evaluate the success of their efforts so as to improve their strategies in the future (Driscoll, 2005). A key influence on self-regulation process is achievement of outcomes. By reflecting in a portfolio, students can regulate their own learning and improve their performance themselves (De Bruin, Van der Schaaf, Oosterbaan & Prins, 2012). With the help of periodic meetings with students during portfolio assessment, students receive information about achievement, determine whether or not it meets their goals, and change their performances accordingly. If the achievement does not meet the present goal, the student may alter his or her strategies, increase effort, or lower the goals (Gredler, 2009). Learners must be given choices in and control over learning, with many opportunities for self-appraisal. Portfolio assessment provides students an opportunity to show their capacities.

Since self-regulation is a responsible component for learning (Bandura, 1986), this study suggests portfolio assessment as a tool to improve students' learning.

Portfolio Assessment and Attitude Change

The importance of learning is that it is responsible for all the skills, knowledge, attitudes, and values that are acquired by human beings (Gagne, 1977). Thus, attitude is one of the outcomes of learning.

Gagne (1985) defines attitudes as acquired internal states that influence the choice of personal action toward some class of things, persons, or events. In general, attitudes are considered to include three different aspects. One is a cognitive aspect, that is, an idea or a proposition. The second is an affective aspect, the feeling that accompanies the idea or the choice of personal action. The third is a behavioral aspect that pertains to the readiness or predisposition for action (Gagne, 1985). All three aspects are important to consider when designing an instruction to teach or influence attitudes (Driscoll, 2005).

Attitude change depends on reinforcement for positive behaviors (Gredler, 2009). Providing feedback can enable reinforcement. For attitude as a learning outcome, Gagne and Driscoll (1988) suggest the following steps:

1. *Establish an expectancy of success associated with the desired attitude,*

2. Assure student identification with an admired human model,
3. Arrange for communication or demonstration of choice personal action,
4. Give feedback for successful performance, or allow observation of feedback in the human model.

These steps are almost followed when portfolio assessment is being implemented. The first step is compatible with setting the learning goals. The second step can be achieved by encouraging students to work as scientists to complete the tasks. The third step is consisted with periodic meetings between students and their teacher about their performances on tasks in portfolios. And finally, the fourth step, giving feedback, is already part of portfolio assessment. Therefore, it is argued in this study that portfolio assessment can improve attitude.

LITERATURE REVIEW

The literature review of this study is composed of the following three sections: Why portfolios are needed, effects of portfolio assessment on learning, and effects of portfolio assessment on attitude towards science.

Why Portfolios are needed

"Portfolio is a purposeful, systematic process of collecting and evaluating student products to document progress toward the attainment of learning targets" (McMillan, 2011, p. 257). Portfolios require students to collect and reflect on examples of their work; thus, they can provide an effective means for helping students become more self-reflective and involved in their own learning (Zollman & Jones, 1994). Portfolios help students demonstrate that they have not merely mastered the facts about natural events but have constructed knowledge that represents the concepts and processes of science and captures the excitement of the scientific enterprise (Collins, 1992). They enhance students' intrinsic motivation because students see portfolios as more like real life activities and as more appropriate to powerful learning environments than examinations (Dochy & McDowell, 1997).

Effects of Portfolio Assessment on Learning

Some empirical research was carried out to find evidence demonstrating that portfolio assessment actually supports and encourages students' learning. Valdez (2001), for example, used monthly portfolio projects to track student progress in a 7th grade life science course. Results of the study revealed that students found opportunities to explain concepts they learned and produced products to present what they learned due to portfolio assessment.

Dori (2003) conducted a research at two experimental and two control groups with senior high school students to investigate their learning outcomes in chemistry and biology. Alternative assessment methods included portfolios, individual projects, and concept maps applied in the experimental groups. The experimental students scored significantly higher than their control group peers on low-level assignments and more on assignments that required higher-order thinking skills. Participants of Century (2002)'s study were from two sixth grade classes. His findings indicated that the traditional method yielded more concrete cognitive content learning than did the alternative assessment. The alternative assessment yielded more psychomotor, cooperative learning and critical thinking skills. It was suggested that the two assessment methods were complementary to each other and thus had to be used together (Century, 2002). In the research done by Chang and Tseng (2009), the experimental group was distinguished from the control group on the basis that it used the Web-based portfolio assessment system. The subjects were students drawn from two computer classes at a junior high school. Their findings demonstrated that after excluding the influence of academic achievement and computer achievement, there was a significant difference in the students' performances between both groups in terms of reflection, continuous improvement, goal setting, problem solving, data gathering, work and peer interaction.

On the other hand, some studies presented that portfolio implementation did not cause any difference in students' learning. Slater, Ryan and Samson (1997), for instance, made a comparison between two groups in an introductory physics course. While the experimental group was assessed by using portfolio assessment, the control group was assessed by using traditional, objective examinations. They found no significant differences in learner achievement between the two groups on the final examination or on the self-report of achievement given before and after the instruction. In addition, at the elementary-level education, Chu (2002) compared one experimental group that adopted portfolio assessment emphasizing the elements of writing process and cognitive strategies with one control group in which students received the product-based writing instruction. The results indicated that the experimental group did not significantly outperform the control group in the aspects of writing performance, conception of learning and self-regulated learning strategies.

In spite of the recommendations for the use of portfolio assessment, some studies brought up contradictory results about the benefits of portfolio assessment on learning. Since learning is a sociocultural process, some limitations of these studies such as insufficiently structured portfolios or the learning environment offering too little guidance on how to use the portfolio adequately (Kicken, Brand-Gruwel, van Merrienboer & 2009) may prevent that portfolio assessment supports and encourages student learning. For example, Struyven, Dochy, Janssens and Gielen (2006) found that portfolio assessment did not deepen students' approaches to learning because the students tended to experience high pressures and workload, and felt that tasks were complex. As a result, there is a need for more studies looking for the influence of portfolio assessment on students' learning by addressing and solving such limitations.

Effects of Portfolio Assessment on Attitude towards Science

Among the studies mentioned above, Century (2002) investigated the students' attitudes toward science in her study and illustrated that the students' attitudes toward science were positive in both the alternative and the traditional methods. Slater, Ryan and Samson (1997) showed that analysis of two focus group discussions divulged that students assessed by portfolios felt less anxious about learning physics, devoted considerable time to reading and studying outside of class, internalized and personalized the content material, and enjoyed the learning experience. Reviewing the literature indicates that research examining the effects of portfolio assessment on students' attitudes towards science has been inadequate. There is a need for research into significant role of portfolio assessment on students' attitudes towards science by relying on experimental-based approaches.

Purposes of the Study

Although some studies report positive results of portfolio use, much more research is still essential, especially contextualizing the fields where particular learning experiences may occur (Martinez-Lirola & Rubio, 2009). That is the case for the context of science learning. Therefore, more empirical studies investigating the products of students' learning after they are engaged in portfolio assessment are necessary to support the theoretical assertions about why portfolio assessment is beneficial for learning and attitude. This research study aimed to determine the effects of portfolio assessment on students' learning of physics and their attitudes towards physics. Therefore, the research question explored in this current study was as follows: How does formative evaluation with and without the use of a portfolio assessment affect students' learning of optics and their attitudes towards physics? This current study contributes toward a better understanding of whether portfolio assessment facilitates learning of science and attitude towards science by using a control group.

METHODOLOGY

True-experimental design using quantitative and qualitative research methods was carried out for this study (Krathwohl, 1997). The research was conducted in two physics classrooms, one was experimental and one was control. The experimental group was randomly selected by drawing lots. Both the experimental and control groups were taught the same optics concepts with the same teaching methods by the same teacher. The only difference between the experimental and control groups was that the students in the experimental group prepared a portfolio while the students in the control group completed the tasks required in the portfolio as homework assignments in eight-week duration. Their homework was graded. However, the control group neither filled out scoring rubrics nor answered reflective questions that were part of the portfolio assessment. The students in the control group were not given any feedback about their performances on the homework assignments. That is to say, portfolio assessment in this study consisted of self-evaluation, self-reflection and feedback.

Participants and Setting

Participants in this study were ninth graders studying in an urban high school. The educational system, which formed the context of this study, has a national curriculum in all grades. The curriculum has recommendations for using alternative assessment methods. The ninth-grade physics course is compulsory for all students. Students who choose social sciences do not take any physics course after ninth-grade. Therefore, students in Grade 9 may have various levels of attitude towards physics.

The students in both classrooms took physics for two hours per week. There were 30 students in each group. However, two students in the experimental group did not return their portfolios; thus, experimental data were gathered from 28 participants.

Portfolio Assessment

Portfolio assessment was used for formative evaluation and implemented for eight-week duration in the physics course where the subject was geometrical optics. This was the first time that the students were creating a portfolio. Therefore, they were informed about the portfolio assessment in the beginning. In addition, some informational documents were distributed to the students. They were given a week to think and ask questions about the portfolio assessment.

Table 1. Holistic rubric

Criteria	Category
Well documented and organized; format is accurate, complete and easy to follow; good quality portfolio shows high effort.	Good
Fairly documented and organized; format is half accurate, moderately complete and/or difficult to follow; medium quality portfolio shows average effort.	Medium
Poorly documented and unorganized; format is inaccurate, large parts are incomplete and/or very hard to follow; poor quality portfolio shows little effort.	Poor

The content of the portfolio was prepared by two authors together by taking the following steps: First, learning goals were identified by considering the research on students' misconceptions in optics (Bendall, Galili, & Goldberg, 1993; Colin & Viennot, 2000; Galili & Hazan, 2000) and the current physics curriculum. Second, performance objectives were determined based on the learning goals. These objectives were prepared as specific as possible. Number of the performance objectives assessed by the portfolio assessment was 55. There were 17 objectives related to the concept of light, seven objectives related to the concept of shadow, eight objectives related to the concept of illumination, four objectives related to the concept of reflection, 10 objectives related to the concept of refraction, five objectives related to the concept of full reflection, and four objectives related to the concept of color. Third, tasks were prepared according to the performance objectives. There were 16 tasks in the portfolio requiring the students to write essays, draw diagrams and do individual projects including experiments.

In order to properly evaluate portfolio contents, the judgment of artifacts should be incorporated into the assessment rubrics, for it not only evaluates how materials in a portfolio are collected and displayed but involves the extent to which students have grasped a subject matter or professional skills (Chang, Tseng, Lou, 2012). Hence, one scoring rubric and some reflective questions were prepared for each task as the final step. The rubrics and questions offered opportunities for self-evaluation and self-reflection. Additionally, the students' portfolios were evaluated in terms of organization, format, and showing effort. Portfolios were categorized as good, medium and poor by using a holistic rubric given in Table 1.

The students and the teacher met five times during the eight-week process and discussed the students' performances. During the implementation, the students in both groups filled in the K and W (what I know, what I want to know) columns of the KWLH chart before teaching a physics concept or a law. After teaching, they filled in the L and H (what I learned, how I learned it) columns of the chart.

Data Collection

Qualitative and quantitative data were gathered for this research.

Quantitative Data: Both the experimental and control groups took one pre-instruction exam and one post-instruction exam. The pre-instruction exam consisted of 21 open-ended questions, which were prepared to assess the students' prior knowledge in geometrical optics. The questions were related to the optics concepts in the fifth grade curriculum as well as the common misconceptions about optics mentioned in the literature (Hirn & Viennot, 2000; Galili & Hazan, 2000; Sen, 2003).

There were 10 open-ended questions in the post-instruction exam. The questions were prepared based on the learning goals that grounded the portfolio tasks and homework assignments. The number of performance objectives assessed in this exam was 38. The following seven concepts were assessed: light, shadow, illumination, reflection, refraction, full reflection, and color. The students in both groups took the exam after the instruction in order to compare their learning. The authors ensured content validity of the exams and face validity of the questions by working together with one physics teacher and one physics educator. The students were given 60 minutes to complete each exam.

The students' attitudes towards physics were measured before and after the instruction by using Test of Science Related Attitudes (TOSRA). The reason for selecting of the TOSRA among many other attitude measurements was its high reliability and applicability in various cultures. The TOSRA had 70 items distributed under seven factors (Fraser, 1978). The word "science" was changed to "physics" in the TOSRA to measure the attitude towards physics. Pilot study was conducted with 30 tenth grade students. The Cronbach Alpha was calculated as .87 and the number of factors found was nine in the pilot study. The students in the pilot study stated that the items were clear and easy to understand. As a result, it was decided that the physics version of the TOSRA could be used without making any change.

Qualitative Data: After the students' portfolios were categorized as poor, medium, and good, three portfolios from each category were selected by using stratified random sampling in order to conduct

Table 2. *S3's performance during the portfolio implementation*

Performance Objectives	T1	T2	T3	T4	T5	T6	T7	T8	T9	T 10	T 11	T 12	T 13	T 14	T 15	T 16	Evidence
A: LIGHT																	
Can specify that light has a constant speed	+																**
Can specify that ligh travels on a straight line		+	+	+	+			+									
Can specify the direction of rays		+	+	-	+			+				+					***
B: SHADOW																	
Can describe the total shadow				+	+												*, **
Can plot the partial shadow				+	+												*,**
Can specify that size of a shadow depends on the distance between the obtacle and the light source				+													*
C: ILLUMINATION																	
Can express the formula luminous flux						+											*
Can specify the unit of illuminance						+											*
D: REFLECTION																	
Can express the angle of incidence								+									*
Can experss the angle of reflection								+									*
Can express the laws of reflection by showing on a diagram								+									*
E: REFRACTION																	
Can specify why light changes its direction at the interface between two media of different refractive indices										+	+						**
Can specify the transition of light from a higher-index medium to a lower-index medium and the results of the transition										+	+						
Can make a relationship between the movement of light in different media and daily life events										+	+		+		+		*
F: FULL REFLECTION																	
Can specify the concept of critical angle												-	-	+	+		
Can specify the conditions of full reflection												+	+	+	+		*
Can plot the full reflection												+	+	+	+		**
G: COLOR																	
Can specify that white light consists of the combination of all colors															+	+	*,**
Can explain how the objects seem colored																+	***,**

T1-T16: Tasks in the portfolio, *: KWLH charts, **: Self-evaluation based on the rubrics, ***: Interviews

interviews with their owners. As a result, nine students from the experimental group were interviewed about their views on portfolio assessment by using semi-structured interview protocol. Students' names were coded as S1 through S9 in order to provide anonymity. While the portfolios of S1, S2, and S3 were in good category, the portfolios of S4, S5, and S6 were in medium category. The portfolios of S7, S8, and S9 were in poor category. The purpose of the interviews was to collect data to support the quantitative data. The questions were related to the processes followed to do the tasks in the portfolio, problems experienced while preparing the portfolio, benefits of the portfolio, the most enjoyable part of the portfolio, effects of the portfolio on learning of the concepts, and personal attribution discovered while preparing the portfolio (Bekirgolu, 2005). Each interview lasted about 25 minutes and was video-recorded. The students were assured that they did not have to answer any questions they were not comfortable with, and encouraged to ask for clarification when necessary. The students were explained that their responses would not affect their grades. In addition to the interviews, the students' responses to the L and H columns of the KWLH charts and their self-evaluation on based on the rubrics were analyzed as written documents.

Data Analysis

Quantitative Data: The group's pre-instruction exams were compared to demonstrate group equivalence with regards to learning. The post-instruction comparison gave a chance to examine the effects of portfolio assessment on student learning. In order to make the comparison, a performance table was constructed for each participant. Thus, the total number of performance tables was 58. In tables, 38 performance objectives were placed in the rows and the questions in the post-instruction exam were placed in the columns because most of the performance objectives were assessed by more than one question. For example, one objective, i.e. "s/he can specify that light travels on a straight line", was measured by four questions whereas another objective, "s/he can describe the total shadow", was measured by three questions. If the participant was in nowhere in the process of constructing the knowledge, s/he was given negative sign (-) for the objective assessed by a particular question. If the participant was in somewhere in the process of constructing the knowledge, s/he was given half positive sign ($\perp$). If the student, on the other hand, constructed the knowledge assessed by the objective, s/he was given positive sign (+). For instance, one of the questions in the exam measuring the performance objective, i.e. "s/he can specify that light travels on a straight line", was that "explain how a person's shadow change while s/he is walking in the street at night where there is a street lamp above (diagram was provided)". The student named Jack drew light rays straightly from the lamp as they pass tangent the person's head and feet and then, he specified the shadow. Therefore, he was given positive sign (+) for this objective measured by the question written above. His performance over this objective was measured by three more questions.

The first author assessed the students' post-instruction exam objective by objective. To assess the reliability of this coding, the second author randomly selected six students from the control group and six students from the experimental group and coded their performance objectives. Then, the two authors compared their coding and were able to reach 88% agreement. The reliability measured by Cohen's κ was 0.74. There seems to be general agreement that Cohen's κ value should be at least 0.60 or 0.70 (Wood, 2007). Consequently, the coding done for the participants' knowledge had adequate reliability. The authors re-coded the performance objectives that they could not have agreement on and the final coding scheme was constructed by reaching consensus. The first author then revised all the codes of the students' knowledge one more time.

In order to make a statistical analysis, if the number of the negative signs was higher than the number of the positive signs, the student was considered to be "unsuccessful" for the particular performance objective. On the other hand, if the number of the positive signs was higher than the number of the negative signs, the student was considered to be "successful" for the objective. The percentage of successful students was calculated for each objective. This calculation was done separately for the experimental and control groups.

Independent samples t-tests were used to compare the experimental group's attitudes with the control group's attitudes. Paired samples t-tests were performed to make comparisons within the groups.

Qualitative data: Performance tables were also made for the students' portfolios by evaluating the rubrics based on the 55 objectives assessed by the portfolio. These tables were also filled in as negative (-), half positive ($\perp$), and positive (+) signs. The performance tables of the students' portfolios provided an opportunity to observe the students' cognitive growth during the portfolio implementation.

In order to examine the effects of portfolio assessment on the participants' learning and attitude, data gathered from the written documents and interviews were analyzed to find patterns and codes. The interviews were transcribed and examined to discover evidences showing the impact of portfolio assessment on the students' learning and attitude. Furthermore, the students' responses to the KWLH charts, their self-evaluation based on the rubrics and their interviews were compared. For instance, if a student stated on the KWLH chart that s/he learned something with the help of portfolio assessment and confirmed it on the rubric while s/he was self-evaluating herself/himself, the effect of portfolio on her/his learning was proved. S3's performance table is given as an example in Table 2 by showing just some of the performance objectives due to the length of the table.

RESULTS AND DISCUSSION

Results are presented separately for the students' learning and their attitudes.

Students' Learning

The control group received an average score of 46.2 (out of 100) and the experimental group earned an average score of 44.9 (out of 100) on the pre-instruction exam. Thus, the participants' prior knowledge was almost equal before the instruction.

On the other hand, the control group's average score was 66.5 (out of 100), while the experimental group's average score was 83.7 (out of 100) on the post-instruction exam. These findings illustrate that the students assessed by the portfolio constructed more knowledge than the students that did not prepare a portfolio. Table 3 presents the percentage of successful students both in the experimental and control groups

Table 3. Percentage of the successful students in the groups for each objective

#	Performance Objectives	Experimental Group (%)	Control Group (%)
	A: Light		
1	Can compare the speed of light with other types of speed *	63	**96.7**
2	Can specify that light travels on a straight line	**96.3**	90
3	Can specify the directions of rays *	**81.5**	0
4	Can specify that light has a constant speed	92.6	**100**
	B: Shadow		
5	Can describe the total shadow	**100**	96.7
6	Can plot the total shadow *	**96.2**	76.7
7	Can describe the partial shadow	**100**	90
8	Can plot the partial shadow	**92.3**	76.7
9	Can specify that size of a shadow depends on the distance between the obstacle and the light source *	60.9	**96.7**
10	Can specify that shape of the shadow looks like the shape of the object	**100**	96.7
	C: Illumination		
11	Can specify the symbol of luminous flux	71.4	**73.1**
12	Can specify the unit of luminous flux	52.4	**69.2**
13	Can express the formula of luminous flux	52.4	**61.5**
14	Can specify the unit of luminance *	**47.6**	7.7
15	Can specify the symbol of luminance	42.9	**50**
16	Can specify the symbol of illuminance	71.4	**84.6**
17	Can specify the unit of illuminance *	**66.7**	23.1
18	Can express the formula of illuminance	66.7	**73.1**
	D: Reflection		
19	Can express the angle of incidence	85	**90**
20	Can express the angle of reflection	**85**	80
21	Can express the laws of reflection by showing on a diagram *	**100**	80
	E: Refraction		
22	Can specify the angle of incidence	**85.7**	80
23	Can specify that light changes its direction by observing the movement of light in different mediums	**100**	86.7
24	Can express the angle of refraction by showing on a diagram	**71.4**	53.3
25	Can specify Snell's Law	**90.5**	86.7
26	Can specify the transition of light from a lower-index medium to a higher-index medium and the results of the transition *	**90.9**	56.7
27	Can specify the transition of light from a higher-index medium to a lower-index medium and the results of the transition *	**83.3**	50
28	Can specify why light changes its direction at the interface between two media of different refractive indices	**95.5**	76.7
29	Can make a relationship between the movement of light in different media and daily life events	91.7	**96.7**
30	Can express the refractive index and its relationship with the speed of light *	77.3	**96.7**
31	Can specify the concept of "Apparent depth"	**80**	53.6
	F: Full Reflection		
32	Can specify the concept of critical angle *	**69.2**	32.1
33	Can specify the conditions of full reflection *	**92.3**	30
34	Can plot the full reflection *	**96.2**	53.6
	G: Color		
35	Can specify that white light consists of the combination of all colors	**95.8**	90
36	Can express the conditions of creation of a rainbow *	**100**	36.7
37	Can explain how the objects seem colored	**89.5**	70
38	Can do the necessary mathematical calculations *	**69.2**	40
	Mean	**81.6**	68.4

***** significant at $p \leq 0.05$

for each objective. The higher percentage value achieved by the groups for each objective is shown in bold. The mean of percentage values for the experimental group (81.6%) was higher than the mean of percentage values for the control group (68.4%). In addition, the percentage values in the experimental group's column were higher than the percentage values in the control group's column in terms of 26 objectives. The difference in the percentage values was significant for 12 of these 26 objectives. By contrast, the percentage values in the control group's column were higher than those in the experimental group's column in terms of 12 objectives. The difference in the percentage values was significant for 3 of these 12 objectives.

Comparison of the experimental group's and control group's columns in Table 3 shows the students' performances in construction of knowledge representing the concepts. The higher percentage values were in majority in the experimental group's column for the concepts of shadow, reflection, refraction, full reflection, and color. For instance, the students' understanding of concept of shadow was assessed by six performance objectives and five of these objectives had higher value in the experimental group column. That is, percentage of the students who achieved these five objectives in the experimental group was higher than percentage of the students who were successful at these objectives in the control group. On the other hand, the students in the control group performed better than those in the experimental group for the concept of illumination. The objectives that assessed the illumination concept were related to specification of the symbols and expression of the formulas. Therefore, the reason for this finding might be that the students assessed by the homework relied more on rote learning.

Detailed analysis demonstrated that the students in the experimental group were more successful in the objectives related to the properties of light than their peers in the control group. Moreover, the students assessed by the portfolio learned the concepts of total shadow, partial shadow, apparent depth, critical angle, full reflection, and color as well as the laws of reflection and Snell's law better. However, the students that did not prepare a portfolio learned the speed of light better. The experimental group's performance in specifying the units and expressing the angles were higher than the performance of the control group. The students assessed by the portfolio became more careful about the units and angles. Furthermore, the students' performances in the experimental group on the mathematical calculations were higher. Doing self-evaluation and self-reflection might provide higher achievement in understanding of the physical meaning of propositions and the mathematical computational skills for the students assessed by the portfolio.

Results of qualitative data support the results of quantitative data. All nine students stated that they learned with the help of portfolio assessment. Some students' excerpts are given below as examples.

S7 showed little effort during the portfolio preparation process and completed 11 tasks out of 16. He was known as an introvert student who did not have much interest in physics. He neither liked challenging himself nor pushing his limits. Nevertheless, his perception about portfolio assessment was positive. He explained that:

"I struggled to interpret the information I reached and had difficulty to write my thoughts while I was preparing my portfolio. But at the end, I did not forget what I learned."

S3 was a student who had self-confident and could express herself freely. She showed very high effort during preparation of her portfolio and completed all the tasks. However, she complained about inadequate resources and the time spent to complete the tasks. She said that:

"I found a chance to repeat the content we discussed in the class and learned many new things while I was preparing my portfolio. I enjoyed doing research in order to do the tasks. Preparing this portfolio made me realize that I could learn physics……. I believe that both my writing and interpretation skills were improved during this assessment process"

S2 was a self-motivated and well-organized student who was successful as well.

She completed all the tasks in the portfolio. Although she expressed displeasure about having limited time to prepare her portfolio, she found this kind of assessment very useful. She stated that:

"I did not like the idea of portfolio assessment in the beginning. I could not do the reflective writing well for my tasks. But then, I realized that preparation of the portfolio was not that difficult. Instead, it was fun. I learned how the physics concepts worked in our daily lives while I was doing the tasks. My writing skills improved during this process."

The second column of Table 4 presents the nine students' learning benefits from the portfolio assessment that they declared during the interviews. Acquisition of more knowledge, making relationships between physics concepts and daily life events, durability of understanding and learning new things were the benefits cited by the students. The third column of the table shows the number of performance objectives achieved by the students due to the portfolio assessment. This column was filled by examining the students' performance tables created for their portfolios (see Table 2). For example, S1 stated that she could acquire more knowledge, make relationships between physics concepts and daily life events as well as learn the content faster while preparing her portfolio. She could reach 12 performance objectives as a result of her portfolio preparation. S8, on the other hand, declared

Table 4. The students' learning benefits and number of performance achievements due to the portfolio assessment

S.	Learning Benefits	Number of the Achieved Performanc Objectives According to the Concepts
S1	• Acquisition of more knowledge • Making relationships between physics concepts and daily life events • Learning the content faster	Light: 6 Shadow: 2 Reflection: 1 Refraction: 2 Color: 1
S2	• Acquisition of deeper knowledge	Light: 4 Illumination: 1
S3	• Durability of understanding • Making relationships between physics concepts and daily life events	Light: 1 Shadow: 5 Illumination: 8 Reflection: 4 Refraction: 2 Color: 2
S4	• Durability of understanding • Acquisition of more knowledge	Light: 1 Reflection: 1
S5	• Durability of understanding • Making relationships between physics concepts and daily life events	
S6	• Durability of understanding • Acquisition of more knowledge	Light: 1 Shadow: 4 Reflection: 2 Color: 1
S7	• Learning new things	Light: 1
S8	• Durability of understanding • Learning new things • Making relationships between physics concepts and daily life events	Light. 1
S9	• Improvement in cultural knowledge • Durability of understanding • Making relationships between physics concepts and daily life events	Light: 1

S.: Students

that his portfolio helped him sustain his understanding, learn new things, make relationships between physics concepts and daily life events and improve his cultural knowledge. Portfolio assessment provided him for achieving one performance objective. Reminding that the portfolios of S1, S2 and S3 were good and the portfolios of S7, S8 and S9 were poor, Table 4 indicates a relationship between the quality of portfolio and the achieved performance objectives. In other words, there is a possibility that the more quality a portfolio has the more performance objectives its owner accomplishes. However, more research is needed to validate this relationship.

The results of this study are in line with the results that emerged from the research by Century (2002), Dori (2003a) and Bagley (2010), who found that alternative assessment improved student performance. For example, Bagley (2010) concluded that by giving students the chance to participate in the process of their own evaluation through end-of-year presentations, and ensuring that they clearly understood the requirements for receiving certain grades via detailed rubrics, students were ultimately encouraged to take charge of their own growth and learning as students.

Nevertheless, the results are not consistent with what Slater and his colleagues (1997) presented. In their findings, there were no significant differences in learner achievement between the two groups on the final examination.

Students' Attitude

The Cronbach Alpha value was determined as 0.94 illustrating the high reliability of the TOSRA

Table 5. The results of independent samples t-tests for the groups' attitudes

	Group	Mean (Standard Deviation)	*T*	*df*
Pre-Test	Control	3.56 (.44)	.057 (p = .478)	57
	Experimental	3.37 (.44)		
Post-Test	Control	3.40 (.57)		
	Experimental	3.22 (.45)		

Table 6. The results of paired samples t-tests for the groups' attitudes

Group	Measurement	Mean Difference (Standard Deviation)	*t*	*df*
Control Class	Pre-Test – Post-Test	.16 (.72)	1.26 (p = .110)	29
Experimental Class	Pre-Test – Post-Test	.15 (.64)	1.22 (p = .176)	28

measurement. The items were subjected to principal component analysis by using Varimax rotation. The explanatory factor analysis generated 19 factors with an Eigen value of one or greater than one, which explained the 79% of the total variance in the data.

Table 5 shows the results of independent samples t-tests for the control and experimental groups' attitudes. According to the table, there was no significant difference between the attitudes of two groups before the instruction. Similarly, no significant difference was found between the attitudes of two groups after the instruction. That is, portfolio assessment did not make any difference in the students' attitudes towards physics. The students' attitudes towards physics were positive before the instruction and the portfolio assessment, which the students involved in for the first time did not affect or decrease their attitudes. This finding is consistent with Century (2002)'s finding.

Table 6 presents that the control group's attitudes towards physics did not change after eight-week duration. Likewise, attitudes of the experimental group did not change after the implementation of portfolio assessment.

Even though statistical difference was not found in the students' attitudes towards physics after portfolio assessment, some students' excerpts indicated positive attitude because of portfolio preparation. For instance, S1 completed all the tasks in her portfolio. She expressed that preparation of the portfolio provided her for being able to make relationships between physics concepts and daily life events. She enjoyed doing experiment and felt like a scientist. S1 noticed that she could plot like an engineer.

Table 7 obtained from the interviews. This table displays the students' views about the enjoyable parts of the portfolio assessment and their attributions discovered during the portfolio assessment. Table 7 can be an indication for the students' attitude towards physics. The students asserted that they enjoyed doing home experiments, doing research and learning new things while preparing their portfolios. They felt like a scientist during this process. They discovered that they had interest in doing research, liked performing an experiment and could actually learn physics. There was only one negative thought, which belonged to S7 and about performing an experiment.

The first time implementation of portfolio assessment did not make any statistical difference in the students' attitudes towards physics. Nevertheless, results are promising that as students get used to this assessment, their attitudes towards physics might increase.

From a different perspective, there is a similarity between Gagne's concept of attitude and self-regulation. Portfolio assessment can facilitate self-regulation and a self-motivated learner attempts to instill certain attitudes in him/her (Driscoll, 2005). Results of this study illustrated that the portfolio assessment improved the students' learning. Consequently, their self-regulation, most probably, increased. However, there may be more time needed to enhance the students' attitude.

CONCLUSIONS AND SUGGESTIONS

According to Wiggins (1993), if a test or quiz represents a snapshot -a part of the learning at a specific moment, then a portfolio is more like a photo album - a collection of pictures showing growth and change over time. This study concludes that portfolio assessment is not only an indication for students' cognitive growth

Table 7. Enjoyable parts of the portfolio assessment and discovered attributions

S.	Enjoyable Parts of the Portfolio Assessment	Attribution Discovered during the Portfolio Preparation
S1	• Doing home experiments	• Interest in doing research
S2	• Learning new things • Feel like a scientist	• Like performing an experiment
S3	• Doing research • Doing home experiments	• Can do research • Can perform an experiment
S4		• Can be a better researcher • No need to afraid of physics • Can take responsibility
S5		• Can do things in order • Have patience
S6	• Doing home experiments • Feel like a scientist	• Can perform an experiment
S7	• Doing research	• Can do research • Can actually learn physics • <u>Performing an experiment is boring</u>
S8	• Doing research • Doing home experiments • Learning new things	• Like doing research • Have patience
S9	• Doing experiment • Feel like a scientist	• Can plot like an engineer • Like performing an experiment • Can actually learn physics

S.: Students

but also a learning tool. In other words, portfolio assessment increases understanding in physics. The current study reinforces the assertions about positive effects of portfolio assessment on learning and empirically demonstrates how portfolio assessment improved students' knowledge.

Results of this study reveal that portfolio assessment, which students come across for the first time does not decrease students' positive attitudes towards physics. It can be suggested from the results that when portfolio assessment becomes part of the physics instruction, students' attitudes towards physics would increase.

This study suggests that portfolio assessment including self-evaluation, self-reflection and feedback facilitates learning. Further studies are needed which facet of the portfolio is most effective in constructing interrelated propositions.

Further studies are also needed to show a possible relationship between quality of portfolio and learning gains.

Although this research demonstrates the effectiveness of portfolio assessment, as Wilson (1994) advises, the teacher must necessarily gather evidence from multiple sources in order to produce the most valid inferences about what a student knows or understands. This study would add to the growing literature that proclaims that portfolio assessment highlights opportunities for learning and instruction.

REFERENCES

Bekiroğlu, F. (. (2005). Ölçme ve değerlendirmede alternatif yöntemler ve portfolyo kullanımı. *Edu7 Yeditepe Üniversitesi Eğitim Fakültesi Dergisi. 1*(1) 5.

Bagley, S. S. (2010). Students, teachers and alternative assessment in secondary school: Relational models theory (RMT) in the field of education. *The Australian Educational Researcher*, *37*(1), 83–106.

Bandura, A. (1986). *Social foundations of thought and instruction: A social-cognitive theory*.Upper Saddle River, NJ: Prentice-Hall.

Bendall, S., Galili, I., & Goldberg, F. (1993). Prospective elementary teachers' prior knowledge about light. *Journal of Research in Science Teaching, 30*(9), 1169–1187.

Bose, J., & Rengel, Z. (2009). A model formative assessment strategy to promote student-centered self-regulated learning in higher education. *US-China Education Review*, *6*(12), 29–35.

Century, D.N. (2002). *Alternative and traditional assessment: Their comparative impact on students' attitudes and science learning outcomes: An exploratory study*. Unpublished dissertation. Philadelphia, USA: Temple University.

Chang, C. C., & Tseng, K. H. (2009). Use and performances of Web-based portfolio assessment. *British Journal of Educational Technology*, *40*(2), 358–370.

Chang, C., Tseng, K., & Lou, S. (2012). A comparative analysis of the consistency and difference among teacher-assessment, student self-assessment and peer-assessment in a Web-based portfolio assessment environment for high school students. *Computers & Education*, *58*, 303–320.

Chen, G., Liu, C., Ou, K., & Lin, M. (2000). Web learning portfolios: A tool for supporting performance awareness. *Innovations in Education and Teaching International*, *38*, 19–30.

Chu, V. (2002). *Effects of portfolio assessment on children's writing performance and conceptions of learning*. Unpublished MEd dissertation, University of Hong Kong, Hong Kong.

Colin, P., & Viennot, L.(2000). Using two models in optics: Students' difficulties and suggestions for teaching. *American Journal of Physics. 69*(7), 36–44.

Collins, A. (1992). Portfolios for science education: Issues in purpose, structure, and authenticity. *Science Education*, *76*(4), 451–463.

De Bruin, H. L., Van der Schaaf, M. F., Oosterbaan, A. E., & Prins, F. J. (2012). Secondary-school students' motivation for portfolio reflection. *Irish Educational Studies*, 31(4), 415–431.

Dochy, F.J.R.C., & McDowell, l. (1997). Assessment as a tool for learning. *Studies in Educational Evaluation, 4*(23), 279–298.

Dori, Y. J. (2003). From nationwide standardized testing to school-based alternative embedded assessment in Israel: Students' performance in the "Matriculation 2000" Project. *Journal of Research in Science Teaching*, *40*(1), 34–52.

Driessen, E. W., van Tartwijk, J., Overeem, K., Vermunt, J. D., & van der Vleuten, C. P. M. (2005). Conditions for successful reflective use of portfolios in undergraduate medical education. *Medical Education*, *39*, 1230–1235.

Driscoll, M.P. (2005). *Psychology of learning for instruction* (3rd ed.). Boston, MA: Pearson Education.

Fraser, B. J. (1978). Development of a test of science-related attitudes. *Science Education*, *62* (4), 509–515.

Gagne, R.M. (1977). *The conditions of learning* (3rd ed.). New York : Holt, Rinehart & Winston.

Gagne, R.M. (1985). *The conditions of learning* (4th ed.). New York: Holt, Rinehart & Winston.

Gagne, R.M., & Driscoll, M. P. (1988). *Essential of learning for instruction* (2nd ed.). Boston, MA: Allyn and Bacon.

Galili, I., & Hazan, A. (2000). Learners' knowledge in optics: Interpretation, structure and analysis. *International Journal of Science Education, 22*(1), 57–88.

Gredler, M. E. (2009). *Learning and instruction: Theory into practice* (6th ed.). Upper Saddle River, NJ: Prentice Hall

Hirn, C., & Viennot, L. (2000). Transformation of didactic intentions by teachers: the case of geometric optics in grade 8. *International Journal of Science Education, 22*(4), 357–384.

Kicken, W., Brand-Gruwel, S., van Merrienboer, J., & Slot, W. (2009). The effects of portfolio-based advice on the development of self-directed learning skills in secondary vocational education. *Educational Technology Research and Development*, *57*, 439–460.

Krathwohl, D. R. (1997). *Methods of educational and social science research: An integrated approach*. Reading, MA: Addison-Wesley Educational Publishers, Inc.

Maeroff, G.I. (1991). Assessing alternative assessment. *Phi Delta Kappan*, *73*(4), 272–281.

Mansvelder-Longayroux, D., Beijaard, D., & Verloop, N. (2007). The portfolio as a tool for stimulating reflection by student teachers. *Teaching and Teacher Education*, *23*, 47–62.

Martinez-Lirola, M., & Rubio, F. (2009). Students' beliefs about portfolio evaluation and its influence on their learning outcomes to develop EFL in a Spanish context. *International Journal of English Studies, 9* (1), 91–111.

McMillan, J.H. (2011). *Classroom assessment: Principles and practice for effective standards-based instruction* (5th ed.). Boston, MA: Allyn & Bacon.

Nicol, D. J. & Macfarlane-Dick, D. (2006). Formative assessment and self-regulated learning: A model and seven principles of good feedback practice. *Studies in Higher Education*, *31*(2), 199–218.

Palinscar, A.S., & Brown, A.L. (1984). Reciprocal teaching of comprehension-fostering and comprehension-monitoring activities. *Cognition and Instruction*, *1*(2), 117–175.

Paris, S., Lipscorn, M., & Wilson, K. (1985). Becoming a strategic reader. *Contemporary Educational Psychology*, *8*, 293–316.

Pintrich, P.R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts & P.R. Pintrich & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 452–502). New York: Academic Press.

Sadler, D. R. (1989). Formative assessment and the design of instructional systems. *Instructional Science*, *18*(2), 119–144.

Sadler, D. R. (1998). Formative assessment: Revisiting the territory. *Assessment in Education*, *5*(1), 77-84.

Schunk, D. H., & Zimmerman, B. J. (1994) *Self-regulation of learning and performance: Issues and educational applications*. Mahwah, NJ: Lawrence Erlbaum Associates.

Sen, I.A. (2003). Examination of elementary science students' misconceptions and learning difficulties about light, vision, and mirrors. *Journal of Hacettepe University Faculty of Education*, *25*, 176–185.

Slater, T. F., Ryan, J. M., & Samson, S. L. (1997). Impact and dynamics of portfolio assessment and traditional assessment in a college physics course. *Journal of Research in Science Teaching, 34*(3), 255–271.

Struyven, K., Dochy, F., Janssens, S., & Gielen, S. (2006). On the dynamics of approaches to learning: The effects of the teaching/learning environment. *Learning and Instruction*, *16*(4), 279–294.

Tezci, E., & Dikici, A. (2006). The effects of digital portfolio assessment process on students' writing and drawing performances. *The Turkish Online Journal of Educational Technology*, *5*(2) Article 2.

Wiggins, G. (1993). *Assessing student performance: Exploring the purpose and limits of teaching*. San Francisco, CA: Jossey-Bass Publishers.

Wilson, L. (April, 1994). *A Theoretical framework linking beliefs with assessment practices in school mathematics: Assessment* *reforms in search of a theory*. Paper presented at the Annual Meeting of the American Educational Research Association, New Orleans, L.A. (ERIC Document Reproduction Service No. ED377215).

Wood, J. M. (2007). *Understanding and computing Cohen's Kappa: A tutorial*. WebPsychEmpiricist. Retrieved October 3, 2007 from http://wpe.info/papers_table.html.

Valdez, P.S. (2001). Alternative assessment: A monthly portfolio project improves student performance. *Science Teacher*, *68*(8), 41–43.

Zeichner, K., & Wray, S. (2001). The teaching portfolio in US teacher education programs: What we know and what we need to know. *Teaching and Teacher Education*, *17*, 613–621.

Zollman, A., & Jones, D. L. (1994, February). *Accommodating assessment and learning: Utilizing portfolios in teacher education with pre-service teachers*. Paper presented at the 21st Annual Meeting of the Research Council on Diagnostic and Prescriptive Mathematics, Fort Worth, TX. (ERIC Document Reproduction Service No. ED368551).

◈◇◈