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A SHORT COURSE ON SPECTROSCOPY AND SPECTROPHOTOMETRY TRAINING FOR WORKERS IN INDUSTRY

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ABSTRACT: The use of spectrophotometers pass beyond academic research laboratories and become widely used in many industries including plastics, medical, chemical, textile, food, painting, paper, pharmaceutical etc. They are used for processing, quality control, testing and research purposes. Although they become more common as a tool in industry, mostly, industry workers do not have scientific knowledge and practical usage experience. These unexperienced workers cause misinterpreted results and loss of time and money. Due to this fact we offered a two days course for introduction to spectroscopy and practical usage of a common spectrophotometer.

The course includes lectures and experimental work. Contents are introduction to spectroscopy, safety usage requirements, sample preparation for testing, calibration of device for different references, two experiments and data processing of the results. This paper describes the need for the course, learning objectives of the course, the explanation of the course contents and used tools for experiments. Finally we report the results of the assessment in terms of trainee's responses and evaluations. The goal of this lifelong learning course is to help industry workers to study the fundamentals of spectroscopy, to use modern spectrophotometer instrumentation safely and correctly and to obtain accurate results. The results shows remarkable success in terms of course requirement and improvement of workers knowledge and expertise about spectrophotometry.

Key words: Spectroscopy, spectrophotometer, lifelong learning, industry education

INTRODUCTION

Lifelong learning is now recognized as both a social right and economic necessity, there is a constant need to improve and update knowledge and skills (Anderson, 1999). Improving quality in products and services results high level of competence among companies. In many rapidly developing and already developed industries competence becomes obsolete especially technical competence. Due to this fact employees working in industries need continuous updating and upgrading. Implementing lifelong learning through Industry-University partnership is going to be a requirement in business life. (Otala, 1994)

We (SASAN, Ankara, Turkey) as a medical disposable producer company use spectrophotometer analysis for our process, quality control and research. We experienced that using a scientific equipment efficiently is not possible to just reading the manual or just by getting the application education provided by the supplier

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company. We also observed that misinterpreted results caused loss of time and money. So we asked for a collaboration to a training course to understand the details of spectrophotometry.

In order to satisfied similar needs of the industry we designed a course named "A short course on spectroscopy and spectrophotometry training for workers in industry" and we taught it as a trial to employees of SASAN. In this paper we described the details of the course design and trainees opinions before and after the course.

For designing the course we survey similar courses, mostly the similar example is laboratory experiments in applied science and engineering department of universities. Then the contents of the course is defined, experiments are organized and for the assessment, quiz examinations are prepared.
The final purpose of this lifelong learning course is to help industry workers to study the fundamentals of spectroscopy, to use modern spectrophotometer instrumentation efficiently.

LIFELONG LEARNING

Ongoing, voluntary, self-motivated and systematic learning of adults who concluded initial education or training is called lifelong learning (Cliath & Rialtais, 2000). Education and training are critical factors for achieving the economic growth, competitiveness and social inclusion. And the need for education and training not for only young people, because research in natural and social science, technological improvements and professional experience are ongoing so adults should learn and practice what they need on these and practice them in their life. (*Adult learning: It is never too late to learn*, 2006)

Lifelong learning should supported by a systemic approach, for teaching and education planning. Cliath 2000, report the necessary properties for quality adult education. We summarize and adapted them for our purposes. A quality adult education should include the following.

- A holistic curriculum.
- A view of the student as a self-directed, self-motivated learner.
- A participative model.
- A solid course objective.
- A high-standard learning outcomes.

The curriculum should focused on learner's educational needs and personal background also it should reflects learner's experiences about the contents of the education. Courses should be supported both by the teachers and the learners. (Cliath & Rialtais, 2000)

Also European Commission (*Adult learning: It is never too late to learn*, 2006) advised that for a quality adult education teaching methods should cover the following:

- Teaching methods and materials should be organized to the specific needs of learns.
- Learning outcomes should be explicit.
- Education resources should be considered as a guidance, literacy provision and study skill developer.

In order to provide to good lifelong learning course for an industry worker both industry and education institute should work together they should combine institutes strategic capabilities and industries operational capabilities (Otala, 1994).

COURSE DESIGN

According to the lifelong learning strategies and literature review on spectrophotometry laboratory experiments we define a course content:

- Spectroscopy (1 hour)
- Spectrophotometry (3 hours)
- Spectrophotometer devices (1 hour)
- Particular spectrophotometry device and software (3 hours)
- Sample preparation (2 hours)
- Experiments (6 hours)

The total course period is two days. Hand-outs are prepared beforehand. There is not a textbook, we use the manuals and handouts. 3 quiz examinations are applied and evaluated. The details of the lectures are explained below.

Spectroscopy

In order to understand the concepts learners should first learn what spectroscopy is. We start with definition spectroscopy and theory background of it.

Spectrophotometry

Spectroscopy is study of interaction between matter and electromagnetic radiation. Spectrophotometry is the quantitative measurement of the absorption, transmission or reflection properties of electromagnetic waves through a matter. (Pavia, Lampman, Kriz, & Vyvyan, 2014) By spectrometric analysis the properties of materials can be understood and classified. In the second part of the course details of spectrophotometry is explained. The analyzing methods and how to observe the results are discussed.

Spectrophotometer Devices

This part of the course is deal with the devices and the properties of devices. Theoretical background and the working principles of the device are explained. The components of the instruments are observed. Different types of spectrophotometers and their application fields are discussed.

Particular Spectrophotometry Device and Software

Particular spectrophotometer that we have were observed before and in this part of the course it is taught to the learners. Measurement methods which is specific for the device is discussed and the evaluation of the output results are trained.

Sample preparation

Our samples were observed before the course. Specific sample preparation methods are organized and taught to the learners.

Experiments

The measurement which is specific for the company needs are examined before the course. And experiments are protocols are design and they are applied with the learners in this part of the course.

Course Materials

We organize hand-outs about the theoretical knowledge of spectroscopy and spectrometry. Protocols for sample preparation and experimental procedure has been revised and reports are developed. Finally spectrometer, light source and software manuals are revised and organized. Trainees used these materials. Spectrometer, light source, software, fiber cables and cuvette holder are shown in Figure 1 and 2.

Figure 1. From Left To Right: Fiber Cable, Light Source And Cuvette Holder.

Figure 2. From Left To Right: Spectrometer, Whole Measurement System And Software.

After an intensity absorbance measurement of the system is shown in Figure 3.

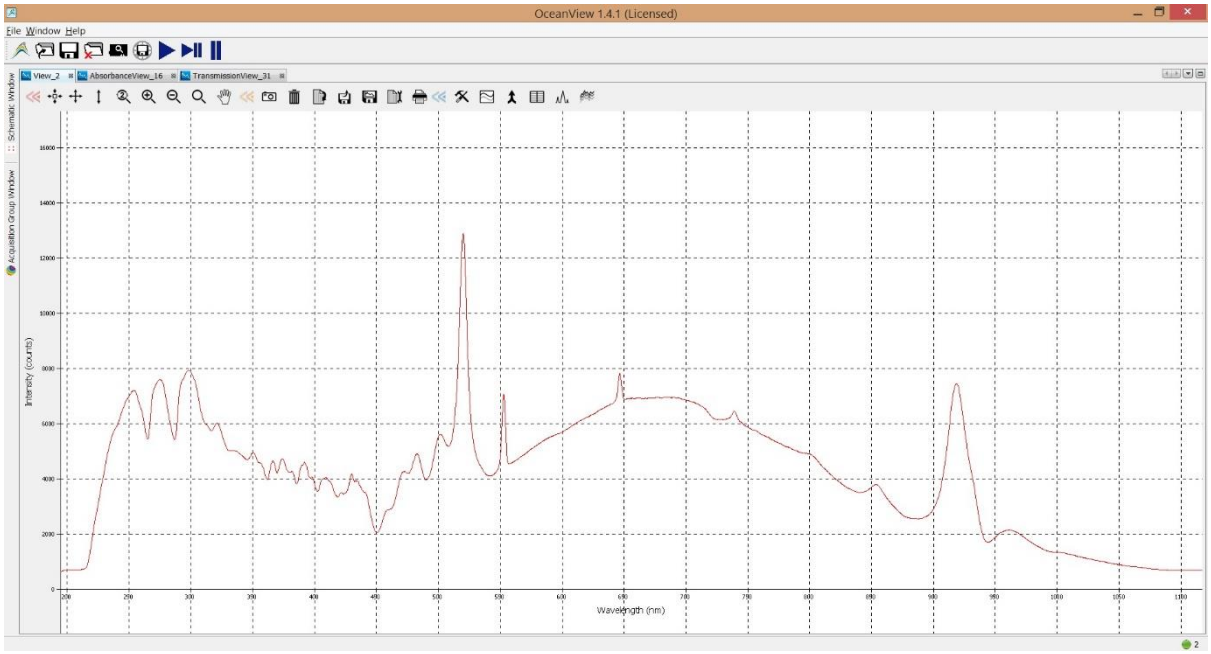

Figure 3. Absorbance Intensity Measurement Screen.

ASSESSMENTS

We did the course assessments in qualitative and quantitative ways. Qualitative ways we evaluate learners' responses on survey about their opinion of their knowledge and expertise. Quantitative way is their quiz examination results.

We have 5 learners 1 is biology laboratory technicians, 2 is biochemistry technicians and 2 are engineers.

For the qualitative analyses we did a survey before and after the course the questions are below:

- Do you have general knowledge of spectroscopy?
- Do you have a general knowledge of spectrophotometry?
- How well you know the spectrophotometer you have
- Do you know how to prepare your sample?
- Do you know how to analyze your results?
- Do you think that do you need to get a course on spectrophotometry?
- After the course do you think that you should get the course before?

The evaluation levels are: 1 for none, 2 for fair, 3 for average, 4 for good, 5 for very good. The survey evaluation results are given Table 1.

Table 1. Survey On Trainees' Qualitative Evaluation Of Progress.

	1. Trainee		2. Trainee		3. Trainee		4. Trainee		5. Trainee		Average	
Questions	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**	**Before**	**After**
Do you have general knowledge about spectroscopy?	1	4	1	4	2	4	2	3	4	5	2,0	4,0
Do you have a general knowledge about spectrophotometry?	3	5	1	4	2	5	3	5	5	5	2,8	4,8
How well you know the spectrophotometer you have?	3	4	5	5	5	4	5	4	5	5	4,6	4,4

Do you know how to prepare your sample?	5	5	5	5	5	5	5	5	4	5	4,8	5,0
Do you know how to analyze your results?	2	4	2	5	3	5	4	5	4	5	3,0	4,8
Average	2,8	4,4	2,8	4,6	3,4	4,6	3,8	4,4	4,4	5,0	3,4	4,6
Do you think that do you need to get a course on spectrophotometry?	5		3		3		1		1		2,6	
After the course do you think that you should get the course before?		5		5		5		5		2		4,4

For the quantitative analyses we did 3 quiz examinations the quiz examinations are about:

- Spectroscopy, spectrophotometer and theoretical knowledge.
- Spectrophotometer device and software.
- Hands-on experience, sample preparation, graph analyzes.

1st quiz is about theoretical knowledge and applied in the end of the first day. 2nd quiz about spectrophotometer device and applied at the midday in second day. 3rd quiz applied at the end of the course. The results are given in Table 2.

Table 2. Quiz Evaluation For All Trainees.

QUIZES	1. T	2. T	3. T	4. T	5. T	Average
Spectroscopy, spectrophotometer and theoretical knowledge.	80	70	70	70	80	74,0
Spectrophotometer device and software.	70	60	80	80	80	74,0
Hands-on experience, sample preparation, graph analyzes.	70	70	80	70	90	76,0
Average	73,3	66,7	76,7	73,3	83,3	74,7

DISCUSSION

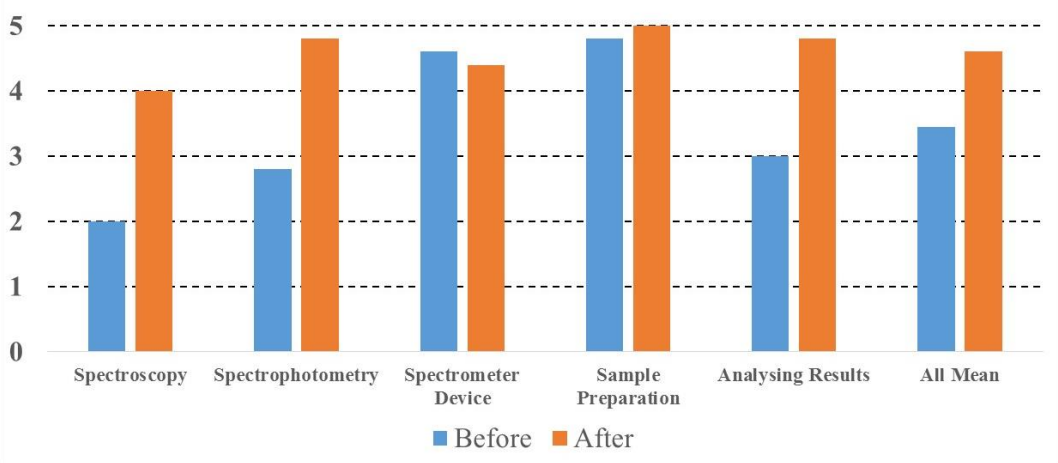

Figure 4. Survey On Trainees' Qualitative Evaluation Of Progress.

The survey on trainees' qualitative evaluation of progress in shown in Figure 4. They think that their knowledge was around average before the course and after the course their knowledge and expertise are good-very good. One of the important point is that they were think that their knowledge on spectrophotometer device was better than after course. This could be because they do not know what they know before.

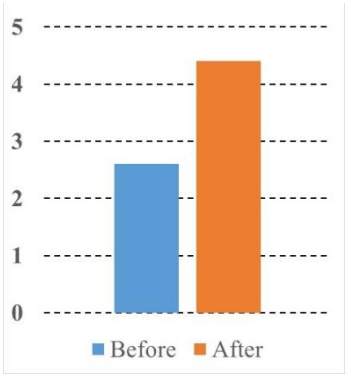

Figure 5. Trainees' Opinions On Course Requirement.

Trainees' opinions on course requirement is reported in Figure 5. And it is obvious that they thing thy do not need the course before the course after the course they agree that they need it.

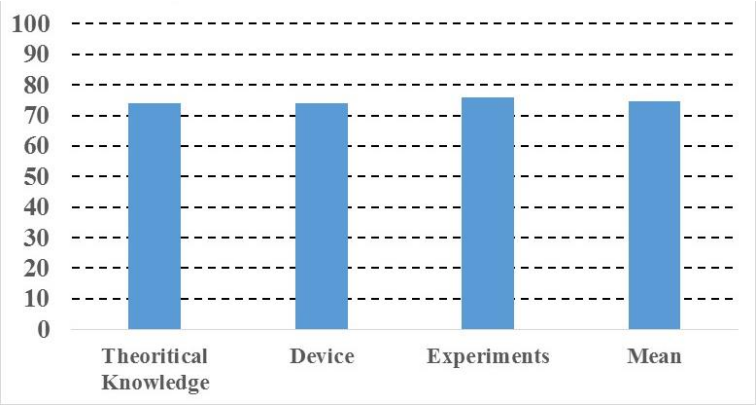

Figure 6. Quiz Evaluation For All Trainees.

Figure 6. and Figure 7. shows the quiz evaluation results, and it is obvious that they are successful.

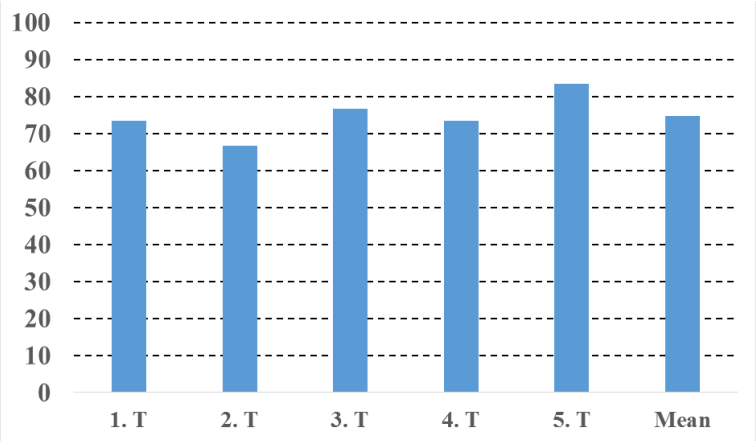

Figure 7. Trainees' Average Grades.

CONCLUSION

Successful companies are need to have a competitive nature, according to this they need to improve their workers performance. In order to improve our workers performance on spectrophotometry analysis we design a 2 day short course on spectroscopy and spectrophotometry. Lifelong learning is a crucial component according to the recent literature and teaching methods should be systematic due to this fact we collaborate with a university professor and his student for the course planning and evaluation.

We evaluate the course qualitatively and quantitatively, and we show that workers needed the course and they have improve themselves after the course.

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