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A Blended Learning Approach for Educating Software Project Management

Moh'd A. Radaideh[1] and Qasem Abu Al-Haija *[2]

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Abstract: Aim: A prevalent field of study within Software engineering (SE), software project management (SPM) has attracted an increasing percentage of scholars and professionals in recent years. It is a component of project management where software projects are designed, carried out, monitored, and administered. This article explores the author's strategy for delivering an SPM course in an integrated online format. By January 2020, the course above will have been reorganized into three modules, including a new one on Agile/Scrum project management, and transformed into a blended online course. The novelty and contribution of this work can be depicted from the status of the "SE440 SPM" course as the first academic senior SPM course to be delivered as a blended online one. At the same time, it incorporates four views of SPM: the author's view, the PMI's approach, the IEEE-CS perspective, and the SCRUM SPM approach. In addition, it sought to identify the optimal course contents and delivery method and define a set of instruments that could be used to facilitate the accepted delivery method. Throughout its extensive revisions, the course adheres to the Institute of Engineering and Technology (IET) and Accreditation Board for Engineering and Technology (ABET) accreditation standards.

Keywords: *Software Engineering (SE), Blended-online learning (BOL), Software project management (SPM), Scrum.*

1. Introduction

SPM incorporates the expertise, approaches, and instruments required to manage the development of software products. SPM is the foundation of software project planning and management. SPM is a sub-discipline of project management in which software initiatives are planned, implemented, monitored, and controlled [1-3].

This paper elaborates on the author's delivery approach of the "SE440 SPM" course as part of the SE undergraduate curriculum at the Jordan University of Science and Technology (JUST) [4]. It started in September 2017 and is ongoing [5-7]. The author's delivery approach can be best described as a BOL approach. "Blended" means a composition of synchronous and asynchronous lectures and activities. The author has already delivered this course fifteen times. In addition, it has been delivered as an online course since the second semester of the 2020/21 academic year. To facilitate its online delivery, the author uses several platforms, like ZOOM, to deliver and record all synchronous and asynchronous online lectures, YouTube to host all lecture recordings, and JUST e-Learning to host the course material. The course's content is currently composed of the following:

1.1. Module I:

Module I provides an overview of project management. It presents the author's view of SPM, its phases and processes, and experience in Information Technology (IT) Consulting and project management [8]. It also elaborates on the Project Management Institute's (PMI) project management approach in terms of its phases and processes [9, 10] and the ISO/IEC 12207, the International Standard for Software Life-Cycle processes [11].

1.2. Module II:

Module II explains the fifteen knowledge domains of Software Engineering (SE) as defined by the IEEE-CS's SWEBOK-V3.0, the recognized body of knowledge for SE [11, 12]. The areas of expertise encompassed in this domain include software requirements, software design, software construction, software testing, software maintenance, software configuration management, software engineering management, software models and methods, software quality, software engineering professional practice, software engineering economics, computing foundation, software engineering mathematical foundation, and engineering foundation. In addition, this module addresses SE management in further detail. In his publications, the author refers to the knowledge mentioned above as the IEEE-CS's SPM approach [11] and compares it with his view of SPM and the PMI project management approach [9].

[1] *Department of Software Engineering, Jordan University of Science and Technology, PO Box 3030, Irbid 22110, Jordan*
ORCID ID : 0000-0002-3900-9710
2 Department of Cybersecurity, Jordan University of Science and Technology, PO Box 3030, Irbid 22110, Jordan
ORCID ID : 0000-0003-2422-0297
** Corresponding Author Email: qsabuhaija@just.edu.jo*

1.3. Module III:

Module III elaborates on SCRUM software development and the SCRUM project management approach regarding its principles, aspects, phases, and processes [13, 14].

1.4. Course Project:

Besides being a BOL course, the SE440 course is based on project-based programming. Participating students will either undertake research tasks involving one or more than ten SPM knowledge areas or undertake detailed action plans for some case studies provided to them by their instructor.

At this point, it is vital to indicate that the course was offered as an in-class course from the 2017/18 academic year until the first semester of the 2020/21 academic year inclusive and as an online course since then. The first online version of the course is still available through a dedicated YouTube playlist [15]. The latest version of the course has been and is currently being offered as a BOL course. About 65% of the course's lectures are delivered synchronously online to the students. In comparison, about 35% are delivered asynchronously online; lectures are recorded in advance and then made available to the students. During the past two years, the author conducted a research project to investigate and benchmark the SE curriculum at JUST [16] with its international counterparts, particularly with the IEEE-CS's SWEBOK-V3.0, the SE body of knowledge [11, 17]. The outcomes of the said study were published earlier, as indicated in [8, 18].

The driving force behind that study was to find out what it takes for the SE curriculum at JUST to become ABET-accredited [19]. It is essential to mention that a few years ago, the said curriculum obtained an I.E.T. accreditation [20]. There have been many attempts to teach, train, and assess students using various methods and approaches, such as online, blended, hybrid, and multi-fold. However, none attempted to develop and deliver a blended online SPM course. Some of the earlier studies that focused on this subject matter include but are not limited to, the ones by Anderson *et al.* 2022, who proposed a pedagogical approach for teaching basic clinical reasoning skills to undergraduate anatomy students. Mladenovici *et al. (2022) proposed a revised set of guidelines for training at higher education institutions based on their review of the various existing approaches from the network analysis perspective*. Li *et al.* (2012) conducted a literature survey on approaches to learning. Gosper (2014) introduced a BOL curriculum design toolkit. Wang *et al.* (2015) presented their way to design and deliver a new course on I.T. for small business. Santally *et al.* (2020) enabled continuous online teaching and learning improvement through some e-learning capabilities and maturity assessment. Gokberk Cinbis *et al.* (2014) presented their way of delivering multi-fold training for weekly supervised object localization. Nunez *et al. (2016) provided a multi-fold assessment framework for virtualized collaborative learning to support engineering education* [21-28].

The novelty and contribution of this work can be easily depicted from the status of the SE440 course as the first academic senior BOL. SPM course that incorporates four perspectives of SPM, including the author's view and the perspectives of three reputable bodies of project management: the PMI, the IEEE-CS SWEBOKV3.0, and the Scrum.

1.5. The author's BOL delivery approach:

The author's method of delivering BOL courses is made more accessible with the help of the tools presented in this article. These tools include the following:

1.5.1. JUST e-Learning

This platform hosts and distributes course materials (lecture slides, reference documents, exams, homework, and others). It includes and posts links to the synchronous and asynchronous lecture recordings and hosts. It distributes synchronous and asynchronous activities, such as assessments and exams, and online activities, such as assignments. Assign the announcements necessary to the participating students. Create essential forums for discussing issues that arise during integrated online delivery.

1.5.2.ZOOM

This platform is used to deliver and record synchronous and asynchronous online lectures.

1.5.3.Video-Editing

This tool is used to edit the lectures' recordings, convert them to the required format, and upload them onto the YouTube platform.

1.5.4.JUST Students Attendance

This system records the students' attendance during the synchronous online lectures.

1.5.5.YouTube

The platform stores the edited and prepared recordings of the online lectures, both synchronous and asynchronous, which have been processed using the Video Editing tool. The author's BOL process (*e.g.,* synchronous online and pre-recorded lectures) is shown in the supplementary data file (S1). In comparison, the author's BOL activities delivery process is described in the **S2** file.

1.6. **Elaboration on the course content**

This section elaborates on and presents samples of the content of the SE440 course.

1.6.1.**Course content highlights**

In its three modules, the SE440 course elaborates on the author's view of SPM, the PMI project management approach, the IEEE-CS SPM approach, and the Scrum SPM approach. Examples of these topics include:

I. SPM is based on the SE Management Knowledge Area (SEMKA), which proposes 6 phases. The phases are Initiation and Scope Definition, Software Project Planning, Software Project Enactment, Software Project Review and Evaluation, Software Project Closure, and SE Measurements. Instead of 5 phases as in the PMI project management approach (Initiation, Planning, Execution, Monitoring and Control, and Closure) [8, 29].

II. The author's definitions of the SPM knowledge areas are ten. The software project encompasses various management areas, including integration, scope, schedule, cost, quality, resource, communications, risk, procurement, and stakeholder management [7, 8].

III. The author categorizes the necessary skills for software project managers. It includes:

- Project management skills: adequate knowledge and experience with the various project management principles, methods, processes, tools, and others
- Software project context-related technical skills: adequate expertise in the domain of the project being managed
- Sociological skills
- Psychological skills

IV. The author classifies software project planning as explicit and implicit questions. It includes the WHAT, WHY, WHEN, WHO, HOW, and WHERE classes of planning questions [7, 29].

V. The author's approach for software project staffing. It includes:

- The In-House-Recruits: Circle#1, Circle#2, and Circle#3;
- The External-Recruits: Option#1, Option#2, and Option#3.

VI. The author views SPM in terms of its phases and processes [7, 29].

VII. The PMI project management approach in terms of its phases and processes [7, 29, 30].

VIII. The IEEE-CS SPM approach is based on the seventh knowledge area of SE defined in SEWBOK V3.0 [7, 11, 29].

IX. For the SCRUM SPM approach in terms of its phases, processes, aspects, and others, refer to [7, 13, 29].

X. In this regard, there is a set of comparisons between the author's view of SPM and the PMI / IEEE-CS / SCRUM approaches [31].

XI. A comparison between the SCRUM SPM and traditional project management approaches.

1.6.2. **The author's classification of software project planning questions**

Any project plan is a composition of direct and indirect answers to a large set of explicit and implicit questions. As described in the **S3** file, the author classified such questions into six classes: WHAT, WHY, WHEN, WHO, HOW, and WHERE.

1.6.3. **The author's view of SPM vs. the PMI approach**

The PMI project management approach has 5 phases: initiation, planning, execution, monitoring and control, and closure [30]. The author viewed the various SPM phases and their associated processes as defined by the PMI, as shown in the **S4** file.

1.6.4. The author's view of SPM vs. the IEEE-CS approach

The IEEE SPM approach has six phases: initiation and scope definition, software project planning, software project enactment, review and evaluation, closure, and SE measurement [11]. Finally, the author's methods are compared to the IEEE-CS SPM processes, as shown in the **S5** file.

1.6.5. The author's view of software project staffing

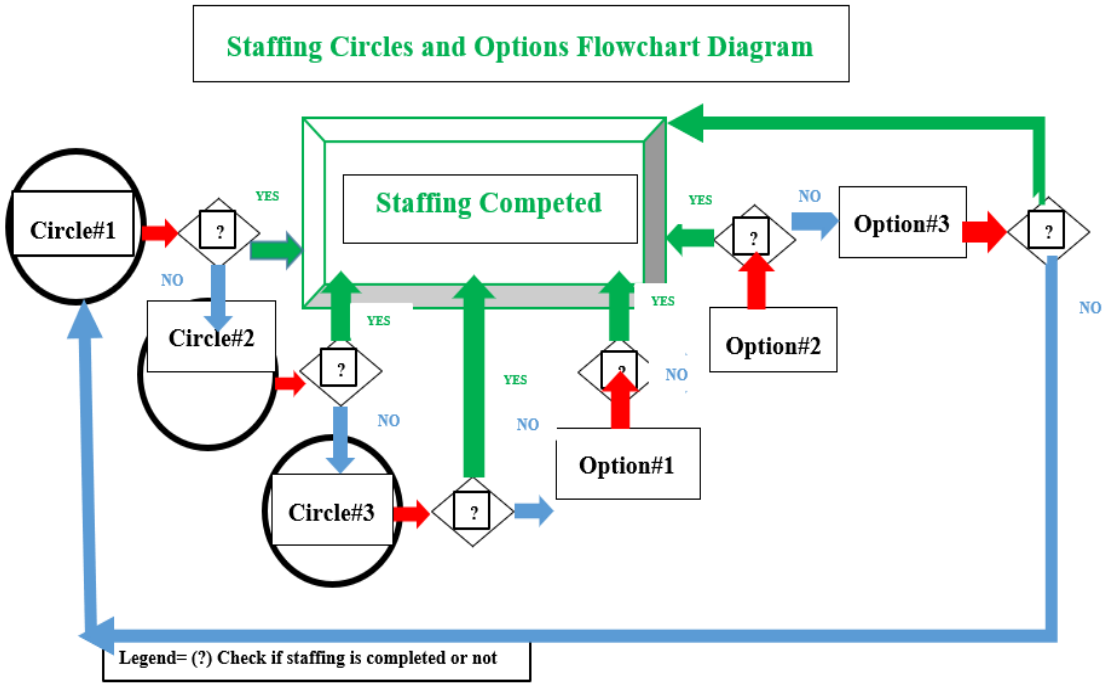

Fig. 1. The author's view of software project staffing.

1.6.5.1.

In-House-recruits:

It represents the first stage of the author's view of project staffing and is composed of three circles:

- **(a)** The project manager attempts to hire staff with the assistance of their past projects' staff members who did good work in the past.
- **(b)** If Circle#1 is not completed, the project manager hires the remaining positions their colleague project managers strongly recommend.
- **(c)** If staffing is still not completed, then the project manager approaches the human resources department at their company to access the profiles of all available technical staff members to fill as many left positions as possible**.**

1.6.5.2. External-recruits:

If there are any remaining vacant positions, the project manager will systematically consider the following three alternatives for External-Recruits:

- **(a) Option#1**: The project manager advertises the vacant positions, searching for hirable external staff members. However, the human resources department should consider hiring external employees full-time; otherwise, the project manager must consider the following option.
- **(b)** The project manager would provide contract-based employment to those not employed in Option #2.
- **(c)** If things don't work well with Option#2, the project manager will contact external employment agencies to provide them with the necessary staff.

2. Aims and Objectives:

This work sought to identify the appropriate content for a senior SPM undergraduate course and the optimal delivery method. Following is a description of the author's investigation methodology:

I. A set of essential topics for an old SPM course.
II. A way for shifting the paradigms from teaching project management to teaching SPM
III. A set of comparisons between the author's view of SPM and similar approaches from the PMI, IEEE-CS SWEBOK, and Scrum.
IV. A BOL delivery approach.
V. Tools facilitating BOL delivery approach.

3. Results and Discussion:

3.1. Observational qualitative assessments of the course

Before stepping into a quantitative assessment of the course and participating students, this subsection reflects two of the author's qualitative observational evaluations regarding the course and participating students. The first is based on the sustainable online learning model [32]. At the same time,

the second one is based on Edgar Dale's Cone of Experience [33].

3.1.1. The first observational qualitative assessment

The author's first observational qualitative assessment of the course and participating students is articulated in **Table 1**. In conclusion, exposing students to options (*e.g.*, synchronous online lectures and asynchronous activities) will eventually help their peer learning, learning ability, attitude, motivation, and interpersonal relationships.

Table 1. The author's first observational qualitative assessment of the course.

Sr. No.	Observation	Qualitative Assessment
1	Peer learning enablement and enhancement	As a mini project is incorporated into the said course, the participating students are typically divided into several groups such that each group has about six students. Thus, collaborative peer learning among the participating students will eventually be substantially improved.
2	Learning ability enhancement	As the said course is a blended course, then each of the participating students will be comfortable with at least one of the delivery folds (*e.g.*, synchronous online lectures, asynchronous activities, and others) in terms of enhancing and improving the following aspects of that student: • Their learning ability: some students learn well by self-reading the course material, some others learn well by self-watching the pre-recorded lectures, some others learn well by attending synchronous online lectures, and others • Their learning attitude: providing the students with many options/folds of learning would eventually help improve their attitude toward learning. • Their learning motivation: The instructor's encouragement of students can tremendously help motivate them towards learning.
3	The attitude of learning enhancement	
4	Motivation for learning enhancement	
5	Interpersonal relationships enhancement	Having the students work together towards completing their course project, attending the course's online sessions, and chatting back and forth with the instructor and their colleagues will eventually enhance their interpersonal relationships.

3.1.2. Second observational qualitative assessment

The author's second observational qualitative assessment of the course and its participating students is articulated in **Table 2**. In summary, the author agrees with Dale's Cone of Experience model. However, when it comes to reading, writing, and hearing, Dale's percentages can be much lower when the medium instruction language differs from the participating students' mother-tongue language.

Table 2. The Second Observational qualitative assessment of the course.

Author's Notes	Learning Activities: People Generally Remember:-	Edgar Dale's Cone of Experience	Learning Outcomes: People can: -
Agree[1]	~10% of what they read	Read	Define, List, Describe, and Explain
Agree[2]	~20% of what they hear	Hear	
Agree[3]	~30% of them see	View Images	Demonstrate, Apply, and practice
		Watch Videos	
Agree[4]	~50% of what they see and hear	Attend Exhibits / Sites	
		Watch Demonstrations	
Agree[5]	~70% of what they say and write	practice in Hands-On Workshops	Analyze, Define, Create, and Evaluate
		Design Collaborative Lessons	
Agree[6]	~90% of what they do	Simulate, Model, or Experience a Lesson	
		Design and Perform a presentation (Do the Real Thing)	

3.2. A historical quantitative assessment of the course

3.2.1. First historical quantitative assessment

Statistical indicators were generated by the quality portfolio system of the university's course at the end of eight semesters, starting from the second semester of 2019/20 through the past summer semester of 2021/22, as shown in **Table 3**. From these indicators, the author is mainly concerned with only the ones involving the students' enrollments and overall marks.

Table 3. SE440 statistical indicators starting from the second semester of 2019/20

Counts of Variables	FS2 2019/20	SS3 2019/20	FS1 2020/21	FS2 2020/21	SS3 2020/21	FS1 2021/22	FS2 2021/22	SS3 2021/22
Enrolled students count	71	75	63	78	181	49	52	111
Repeating students count	0	0	0	0	2	0	1	2
Final exam absentees count	2	0	0	0	0	5	2	0
Suspended/withdrawn students count	0	0	0	0	2	1	1	1
Statistically considered enrolled students count	69	75	63	78	179	43	48	110
Highest mark	4.00	4.20	4.00	4.20	4.00	4.20	4.00	4.20
Lowest mark	2.00	0.50	1.75	0.50	1.50	1.50	0.50	0.50
Passing percentage	100%	98.70%	100%	97.40%	100%	100%	95.80%	99.10%
Failing percentage	0%	1.30%	0%	2.60%	0%	0%	4.20%	0.90%
Overall average mark	3.11	3.20	3.15	3.20	3.30	3.40	3.40	3.30
Passing students' average mark	3.11	3.40	3.23	3.34	3.07	2.78	2.48	2.83
Standard deviation	0.65	0.66	0.60	0.65	0.67	0.50	0.52	0.51

Legend: FS1 (first semester); FS2 (second semester); SS3 (summer semester): [1] *This percentage can be much lower when the medium instruction language differs from the participating student's mother tongue language.* [1] *Same as in the above footnote.* [1] *The vision welfare of the participating students highly influences this percentage.* [1] *Same as in the above footnotes 1 and 3.* [1] *Same as in the first footnote above.*

Figures 2 and **3** reflect historical views about students' enrollments and achievements regarding their earned marks at the end of each semester starting from the second semester of the academic year of 2019/20.

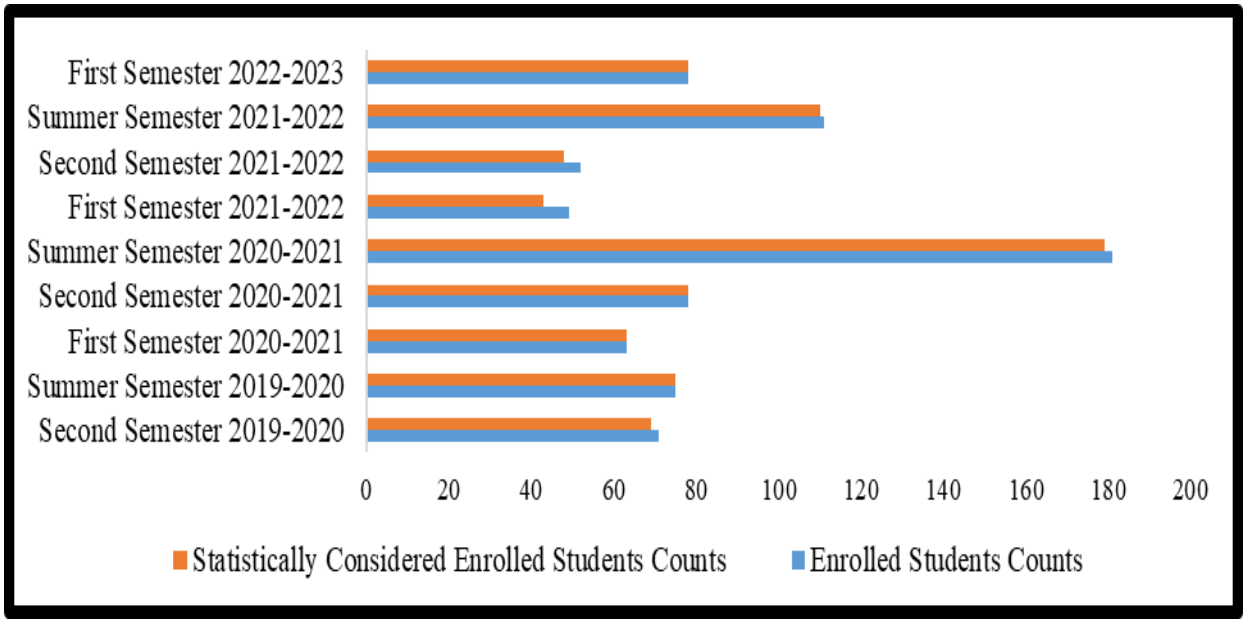

Fig. 2. SE440 students' enrollments starting from the second semester of 2019/20

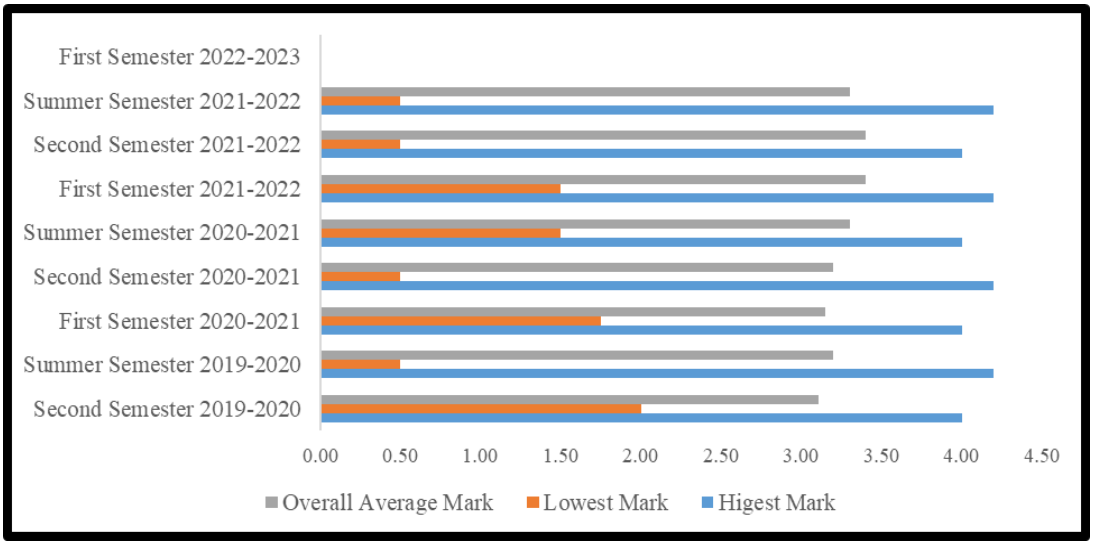

Fig. 3. SE440 students' marks starting from the second semester of 2019/20

It summarized that the student's enrollments were much higher during the summer semesters than during the regular first and second semesters. The SE440 course requires much work from its participating students. Thus, students prefer to take this course during the summer semesters as their academic loads are much lighter than during regular semesters. Students' enrollments during the regular second semesters have been higher than during the first semesters. The passing percentage has been very stable.

3.2.2. **Second historical quantitative assessment Tables 4, 5, and 6** summarize the course learning outcomes (CLOs) reviews starting from the second semester of 2019/20. In summary, it is noticeable that:

(a) The CLOs were restructured at the beginning of the summer semester of the 2020/21 academic year. That was simply due to the addition of the agile project management (Scrum) module into the course (Module #3) and due to reorganizing the original content of the course (*e.g., it was in 4 modules*) into two modules (Module #1, and Module #2).

(b) Generally, the CLOs-related performance improved, particularly in the case of CLO1.

Table 4. SE440 CLOs assessment starting from the second semester of 2019/20

Title:	**Summary of Learning Outcome Performance**
Program	SE
Semester	First Semester 2021/22 throughout First Semester 2022/23
Course Code and Title	SE103 Introduction To Information Technology
Target	60%
Legend	DA: Direct Assessment

Table 5. Direct Assessment above Target%

CLOs	**DA: Above Target %**							
	CLOS: Before Summer Semester 2020/21				**CLOs: Summer Semester 2020/21 Onwards**			
	FS2 2019/20	**SS3 2019/20**	**FS1 2020/21**	**FS2 2020/21**	**SS3 2020/21**	**FS1 2021/22**	**FS2 2021/22**	**SS3 2021/22**
CLO1	100%	91.67%	83.33%	87.50%	82.61%	87.50%	75.00%	90.91%
CLO2	100%	75.00%	100.00%	91.67%	100.00%	87.50%	75.00%	98.18%
CLO3	100%	83.33%	100.00%	91.67%	100.00%	87.50%	75.00%	83.64%
CLO4	84.62%	91.67%	94.44%	95.83%	100.00%	87.50%	83.33%	98.18%
CLO5	92.31%	83.33%	88.89%	100.00%	82.61%	87.50%	83.33%	96.20%
CLO6	100%	83.33%	94.44%	100.00%	82.61%	87.50%	83.33%	95.30%

Table 6. CLOS: Before the summer semester 2020/21 vs. the summer semester 2020/21 onwards

CLOS: Before Summer Semester 2020/21	CLOs: Summer Semester 2020/21 Onwards
CLO1: Apply the basic terms concepts of SPM (weight 10)	CLO1: Understand and demonstrate the basic terms and concepts of SPM (weight 10)
CLO2: Apply the typical software development methodologies such as SDLC (Systems Development Life Cycle) and R.A.D. (Rapid Application Development), J.A.D., Agile software development, and others (weight 5)	CLO2: Understand the typical software development methodologies (SDLC, R.A.D., J.A.D., agile software development, and others). (weight 10)
CLO3: Demonstrate the essential skills that make a project manager effective and successful. (weight 5)	CLO3: Build and demonstrate software project detailed plans. (Weight 20)
CLO4: Build software detailed project plans incorporating project charters, work breakdown structure (WBS), scheduling, dependencies, resource allocations, and others (weight 40)	CLO4: Understand and demonstrate the software project contracts based on their detailed plans. (weight 10)
CLO5: Prepare software project contracts based on their detailed plans. (weight 25)	CLO5: Understand and demonstrate the IEEE SE management knowledge area. (weight 25)
CLO6: Explain how a software project is executed (kick-off project closure). (weight 15)	CLO6: Understand and demonstrate the SCRUM and extreme programming XP agile project management approaches. (weight 25)

Legend: FS1 (First Semester); FS2 (Second Semester); SS3 (Summer Semester)

4. Conclusions:

In conclusion, the "SE440 SPM" course is now a very mature, blended, online, and comprehensive course that elaborates on the various internationally recognized SPM topics, approaches, and methods. Examples are the ones by the Institute of (PMI), the IEEE-CS SWEBOK-V3.0, and the SCRUM). In addition, the author injected his view of SPM. Also, the course elaborates on the international standard for systems and SE life-cycle processes (ISO/IEC 12207). The SE440 course is being delivered as a BOL (e.g., synchronous and asynchronous) course. About 65% of its lectures are delivered synchronously online to the students via the ZOOM platform. At the same time, about 35% of the lectures are recorded and made available asynchronously to the students. All versions of the SE440 course remained compliant with the I.E.T. and the ABET accreditation requirements.

Given that the course is now well-defined and articulated, and its delivery approach is well-defined and applied, the author can claim that this work has carefully addressed and answered the aimed-at research questions. The participants' satisfaction levels continued to increase during the past fifteen semesters. The number of participating students has increased every semester since the course became a BOL. Regardless of what this paper says, there will always be room for improvement to enhance the course context and delivery approach. A future consideration would be transforming all recorded lectures into interactive ones by dividing each lecture into topic-based slots and then inserting a set of interactive questions after each slot.

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