

A Case Study on the Application of Case-Based Learning in Software Testing

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ISEC 2018

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Case-Based Learning in Software Testing

Software Testing Course

This course enables students to examine the adequacy and quality of a developed product.

What is a Case?

A case is like a story, related to a real world situation that sources a number of challenging problems, which have no obvious solutions.

What is Case-Based Learning?

Case-based learning (CBL) is a **teaching methodology** based on discussing and analyzing **real world situations**.

Research Gap & Unique Challenges

No evidence of teaching Software Testing using CBL

- Software Testing is not taught as a separate course in most of the university settings.
- Paucity of effective teaching and learning techniques for Software Testing discipline.
- Traditional lecture-based learning approach is not sufficient.
- Need for interactive learning pedagogy.
- Case-based learning drives active learning sessions as proved in previous literature.

Specific Research Aim

- To **introduce** case-based learning for teaching Software Testing course.
- To **examine the effectiveness** of CBL in teaching Software Testing discipline.
- To **develop software testing cases** and share them publicly through Software Engineering Case-Based Learning Database (SEABED)¹.
- To **examine the impact of gender diversity and change in case problem** on students' responses.

¹<http://seabed.in/>

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Experience Reports on Teaching Software Testing

Fraser et al. [1]

Fraser et al. made software testing education enjoyable by mapping core software testing concepts to the categories of **puzzles** in the framework of a **game**. With each level progress in the game, students grasped better testing skills.

Garousi et al. [4]

Garousi et al. used **industrial tools and projects** for undergraduate software testing labs to demonstrate the real world testing scenario to the students.

Case-based Learning for SE Education

Saini et al. [11]

Saini et al. proposed an open source web-based software engineering case-based learning platform called SEABED. They provided a **case repository** along with a **case template**, that provides guidelines for case writing.

Garg et al. [3]

Garg et al. created a case related to **software architecture** and introduced a Case-Oriented Learning Environment. This helped students to learn better software engineering skills.

Case-based Learning in other Domains

Kundra et al. [5]

Kundra et al. used CBL for teaching the concepts of **Compiler Design**. They observed improvement in the learning, critical thinking, engagement, communication skills, and team work of students.

Peplow et al. [10]

Peplow et al. **compared the responses of female and male medical students** towards a CBL program. They observed that the female students benefited more than the male students from initial **discussions and group activities**.

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Research Contributions

Novel and Unique Contributions

- 1 First implementation of CBL for teaching and practicing the concepts of Software Testing discipline for a **large class of 164 students**.
- 2 Empirical analysis (including **gender-based study**) of CBL execution at Dhirubhai Ambani Institute of Information and Communication Technology (DA-IICT)^a, Gandhinagar, India.
- 3 Writing two original software testing cases *StalwartX Case* and *Browser Case* and submitting them to existing software engineering case repository (SEABED).

^a<http://www.daiict.ac.in>

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Subject:

164, 3rd year under-graduate students taking an elective course on **Software Testing and Quality Analysis** at DAIICT Gandhinagar.

Cases

- **Browser Case:** intends to facilitate the concepts of **responsiveness testing and performance testing** of a web browser (Google Chrome).
- **StalwartX Case:** facilitates the concepts of **security testing and functionality testing** of driver-less vehicles.

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Table: Design of the Experiment

Case-based Learning				
Session	Case	Subject	Group	
Session I	Case I	S1-S41	G1-G7 (5 Subjects)	G8 (6 Subjects)
Session II	Case II	S42- S82	G1-G7 (5 Subjects)	G8 (6 Subjects)
Session III	Case I	S83-S123	G1-G7 (5 Subjects)	G8 (6 Subjects)
Session IV	Case II	S124-S164	G1-G7 (5 Subjects)	G8 (6 Subjects)

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Preparation and Subject Training

- Four lecture sessions were conducted to teach the students about the topics related to the two cases.
- One lecture was conducted to enable them with the basic idea of CBL.
- We chose to teach non-functional aspects of testing (e.g., performance, security, responsiveness, etc.).

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Browser Case

Case A

Suppose you are a Test Manager of Google Chrome. Google Chrome is used by millions of people on various device types of different screen size-smartphone, desktop/laptop, tablets. **Testing Responsiveness** (means the browser adjusting to the screen) is very critical for a browser. Emulating different screen sizes is not easy. Although there are various tools available that check the browser's response on different size viewports, but still manual testing is required to ensure whether all parameter are up to the mark. The browser should support various web languages efficiently. It should effectively support orientation of screens in tablets, mobile phone, etc.....

Browser Case

Questions:

Q.1 Suppose the browser support various platforms. What is your planning strategy to test the responsiveness of the system?

Q.2 How will you ensure that the browser effectiveness will not get affected by the APIs and libraries used by the website? What test strategy will you apply to ensure the browser's performance?

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CBL Execution

- **Case Understanding Phase**
- **Response Gathering Phase**
- **Discussion Phase**

Table: SURVEY QUESTIONS GROUPED BY THE RESPECTIVE TEACHING OBJECTIVE (Part 1)

Teaching Objectives	Questions
Learning	Q1: I feel the use of case was relevant in learning about course concepts.
Learning	Q2: The case allowed for a deeper understanding of course concepts.
Learning	Q3: The case will help me to retain the different aspects of Software Engineering better.

Table: SURVEY QUESTIONS GROUPED BY THE RESPECTIVE TEACHING OBJECTIVE (Part 2)

Critical Thinking	Q4: The case allowed me to view an issue from multiple perspectives.
Critical Thinking	Q5: The case was helpful in synthesizing ideas and information presented in course.
Critical Thinking	Q6: The case added a lot of realism to class.

Table: SURVEY QUESTIONS GROUPED BY THE RESPECTIVE TEACHING OBJECTIVE (Part 3)

Engagement	Q7: I was more engaged in class when using the case.
Engagement	Q8: The case discussion increased my interests in learning about Software Engineering.
Communication Skills	Q9: The case discussion strengthened my communication skills to speak in front of the audience.
Team Work	Q10: The case discussion increased my confidence to work in a team.

Table: PERCENTAGE OF SA, A, D, SD FOR THE 10 QUESTIONS SLICED BY CASE (TO INVESTIGATE IF CASE INFLUENCES THE SATISFACTION LEVEL)

	Case A (Browser)					Case B (StalwartX)				
	SA%	A%	DA%	SD%	IE%	SA%	A%	DA%	SD%	IE%
Q1	76.5	22.2	0.0	1.2	0	42.5	56.3	1.3	0.0	0
Q2	51.9	46.9	0.0	1.2	0	46.3	53.8	0.0	0.0	0
Q3	54.3	44.3	0.0	1.2	0	51.3	47.4	1.3	0.0	2
Q4	51.3	43.8	3.8	1.3	1	41.3	57.5	0.0	1.3	0
Q5	58.0	39.5	1.2	1.2	0	48.8	47.5	3.8	0.0	0
Q6	53.1	43.2	1.2	2.5	0	57.5	40.0	2.5	0.0	0
Q7	55.0	42.5	1.3	1.3	1	47.4	51.3	1.3	0.0	2
Q8	53.8	42.5	2.5	1.3	1	50.0	48.8	1.3	0.0	0
Q9	55.0	40.0	3.8	1.3	1	41.3	47.5	11.3	0.0	0
Q10	37.5	60.0	1.3	1.3	1	48.8	42.5	7.5	1.3	0

Statistical Analysis

- **Null Hypothesis:** “There is no significant difference between the responses for Case A and Case B” .
- Performed t-test on overall agree% (SA+A) for Case A and Case B in Table-5.
- We got a t-value of 0.2863 and p-value of 0.388959. The result is **not statistically significant** at $p > 0.05$.
- Hence, we cannot determine how case difference affects students' responses.

Table: PERCENTAGE OF SA, A, D, SD FOR THE 10 QUESTIONS SLICED BY GENDER. **Note:** OVERALL CLASS SIZE IS: 164 (51 FEMALE, 113 MALE) STUDENTS. NO. OF STUDENTS PARTICIPATED IN THE STUDY: 161 (NO. OF FEMALE: 50, NO. OF MALE: 111)

	Male					Female				
	SA%	A%	DA%	SD%	IE%	SA%	A%	DA%	SD%	IE%
Q1	66.0	32.4	1.9	0	0	66.0	32.0	0.0	2.0	0
Q2	50.5	49.5	0.0	0	0	50.0	48.0	0.0	2.0	0
Q3	55.0	45.0	0.0	0	2	42.0	54.0	2.0	2.0	0
Q4	56.8	42.3	0.9	0	0	36.7	55.1	4.1	4.1	1
Q5	47.7	51.4	0.9	0	0	36.0	56.0	6.0	2.0	0
Q6	60.4	37.8	1.8	0	0	44.0	50.0	2.0	4.0	0
Q7	55.6	43.5	0.9	0	3	48.0	48.0	2.0	2.0	0
Q8	46.4	50.9	2.7	0	1	44.0	54.0	0.0	2.0	0
Q9	38.2	54.5	7.3	0	1	46.0	44.0	8.0	2.0	0
Q10	52.7	44.5	2.7	0	1	48.0	40.0	8.0	4.0	0

Statistical Analysis

- **Null Hypothesis:** “there is no significant difference between the responses from male and female students” .
- Performed t-test on overall agree% (SA+A) responses from male and female students in Table-6.
- We got a t-value of 2.49775 and p-value is 0.011206. The result is statistically significant at $p < 0.05$ and we **reject the null hypothesis**.
- Hence, there is a significant difference in responses from male and female students.

TAs Questionnaire and their responses

Questions	TA Response #1	TA Response #2
Q1.What prior experience did you have with case-based learning as a student and as a TA?	No, I don't have any experience with CBL as a student and as a TA.	No experience as a TA and some experience as a student
Q2. How much and what kind of preparation did you do before the case-based learning sessions?	Before the sessions, the case has been discussed with the instructor to understand the motivation of this exercise. I have also gone through the videos for conducting CBL.	I have gone through many case studies for the session.
Q3. Did you find imbalanced participation or a balanced participation among members of a group? On a scale of 1 to 5, where 1 is imbalance (not everyone equally participating) and 5 is balance.	5	3
Q4.Did you spend equal time on each group? On a scale of 1 to 5 in which 1 is unequal and 5 is equal.	4	2

TAs Questionnaire and their responses

Questions	TA Response #1	TA Response #2
Q5. Did you find facilitating or managing one group easier than other groups (some group dynamics may be poor while some may be good)? On a scale of 1 to 5 where 1 is hard and 5 is easy.	5	5
Q6. In your opinion, was the group size of 5-6 students appropriate or not? What should be the group size?	More. In my opinion, the group size should be 3-4.	Appropriate
Q7. Did you find the time allocated to each group for solving the case is sufficient? On a scale of 1 to 5 in which 1 is less and 5 is sufficient.	4 (If more time was given then it could have benefited more.)	5

Challenges and Suggestions

Challenges

- The cases need to be designed carefully and should not deviate from the scope of course structure.
- Managing **large groups** of students having **different capabilities** with the concepts.

Suggestions

The authors suggest that the **training of TAs** before the CBL sessions is very important as this builds up a relationship of trust between TAs and instructors.

Threats to validity

- Results get affected by students' willingness to give **honest feedback**.
- The **learning potential** of the students of the 4 sessions **differs**.
- Students may have discussed the case problem with other groups prior to their own session.

Conclusion

- We proposed CBL for software testing education with the aim to impart **in-depth and practical knowledge** through a **self-learning** environment.
- Students approved the importance of CBL with an overall agreement of **96.78%**.
- The statistical analysis revealed that there is a **significant effect** observed on students' responses based on **gender difference**.

Future Work

- To identify other topics of Software Testing that can be taught using CBL
- To find the topics of Software Testing that can not be taught using CBL.
- Conduct similar CBL sessions in other universities.

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