Qualitative Analysis: Questionnaire and Results

Evidence-based Control Engineering Education:
Evaluating the LCSD Simulation Tool

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Abstract

This document reports the evaluation conducted on two groups of students, who took an automatic control course at the *Pontifical Catholic University of Valparaiso* (Chile) in 2019-20. To gather students' opinions regarding the usability and usefulness of LCSD and Matlab CST, we asked them to fill a questionnaire in the last laboratory session. Responding to the questionnaire was voluntary. The participation ratio was 42/44 and 52/57 students for the treatment (LCSD) and control (Matlab CST) groups, respectively.

1 Questionnaire

Figure 1 shows the voluntary questionnaire that students from the treatment group answered. Control group students responded to an equivalent questionnaire (i) without question 2, and (ii) where "LCSD" was substituted by "Matlab CST" in items 1.a and 1.b.

2 Students' answers to the closed questions

Figure 2 summarizes the obtained frequencies for items 1.a and 1.b. Responses are rated on a five-point Likert scale.

TREATMENT GROUP QUESTIONNAIRE

1. Please checkmark to what extent do you agree with the following statements:

   (a) *LCSD helps to assimilate the course contents*.

   - ☐ Strongly agree
   - ☐ Agree
   - ☐ Neither agree nor disagree
   - ☐ Disagree
   - ☐ Strongly disagree

   (b) *LCSD is easy to learn and use*.

   - ☐ Strongly agree
   - ☐ Agree
   - ☐ Neither agree nor disagree
   - ☐ Disagree
   - ☐ Strongly disagree

2. Please complete the following sentence in your own words:

   (a) *LCSD strengths to learn the analysis of control systems are...*

   (b) *LCSD weaknesses and my suggestions to improve it are...*

Figure 1: Questionnaire that students from the treatment group answered.

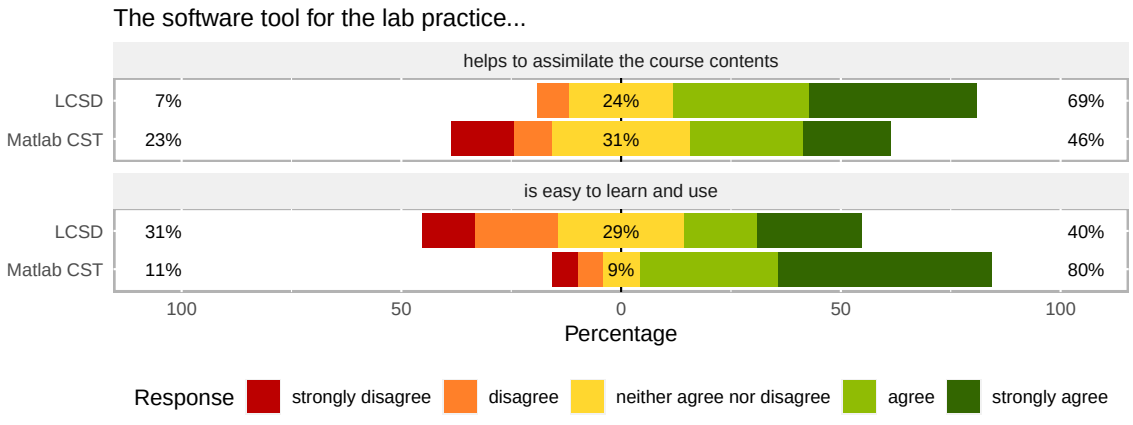

Figure 2: Students' response frequencies to the closed questions.

3 Students' answers to the open-ended questions

3.1 Strengths of LCSD

The following points show the students' responses to the item *2.a LCSD strengths*:

- *Student 1*: I like having a control system global view thanks to visualizing multiple plots simultaneously.
- *Student 2*: You can see at a glance relevant interrelated information: the poles and zeros map, diagrams, and different temporal signals.
- *Student 3*: The variety of the supported plots (BODE, root locus, etc.) for both open and closed loop systems.
- *Student 4*: Its nice to have temporal response and root locus plots in a single tool, which besides, supports open and closed loop systems.
- *Student 5*: The different graphs give complementary perspectives of open and closed loop control system.
- *Student 6*: LCSD is free and runs in almost any computed. Also, the diversity of plots it supports is enough.
- *Student 7*: The interactivity and coordination of all plots helped me a lot.
- *Student 8*: I liked how the instructor illustrated the differences between feedback and non-feedback systems with LCSD.
- *Student 9*: It supports both feedback and non-feedback systems. The user can introduce changes that are propagated to the plots immediately.
- *Student 10*: The coordinated and continuous refreshment of the system dynamics in various graphs helps much.
- *Student 11*: It's easy to interact with the system just using the mouse on the varied plots.
- *Student 12*: It supports important plots studied in the course: Root Locus, Bode, and Nyquist.
- *Student 13*: LCSD provides interesting graphical information, although sometimes it's hard to distinguish all the details on the screen.
- *Student 14*: The tool suits adequately with the course syllabus, showing all studied diagrams for open and closed loop systems.
- *Student 15*: LCSD interactivity is good to understand open and closed control loop systems. I also like visualizing at
- *Student 16*: The instant reaction in all plots when the user makes changes.
- *Student 17*: I appreciate that system dynamic evolution happens in the graphs coordinately.
- *Student 18*: It is free so students can keep learning at home.
- *Student 19*: LCSD is a good simulation tool. It supports important plots (e.g., Nyquist and Bode) and both open/closed systems.
- *Student 20*: It's easy to install, learn, and use.
- *Student 21*: I found interactive plots very useful. I also like LCSD supports open and closed-loop control systems.
- *Student 22*: It visualizes important analysis plots: Bode, Nyquist, etc. Using the mouse, users can easily interact with the system and check its behavior.
- *Student 23*: Having interactive/dynamic diagrams helps understand control systems quickly.
- *Student 24*: It helps to recognize the deficiencies of open-loop systems and how they are overcome with closed-loop systems.

- *Student 25*: The tool is OK. It animates the different diagrams studied in the classroom.
- *Student 26*: It's helpful to observe the various temporal signals of a control system: error, output, etc.
- *Student 27*: LCSD simulates open and closed loop systems with multiple plots.
- *Student 28*: The tool is appropriated for the course since it covers the diagrams studied and supports open and closed-loop control systems.
- *Student 29*: I think graphical simulations complement well the theoretical classes. I liked LCSD interactivity.
- *Student 30*: Although LCSD is simple, it covers all the diagrams and course contents (open and closed loop systems).
- *Student 31*: LCSD helped me to learn that closed-loop systems can improve the open-loop response. Also it is possible to see their operation limits.
- *Student 32*: Visualizing the system behavior with different plots.
- *Student 33*: I don't miss any analysis plots as it supports Root Locus, Bode, and Nyquist. the same time the map of poles and zeros together with the analysis plots and temporal response.
- *Student 34*: LCSD supports the most important diagrams: Bode, Nyquist, Root Locus, etc., and also open and closed loop systems.
- *Student 35*: Non-feedback and feedback systems are well supported.
- *Student 36*: I like that LCSD despite being lightweight (it worked on my old laptop!), it works smoothly (for example, it refreshes the plots on the screen immediately), and it covers all course contents and diagrams.
- *Student 37*: It supports both open/closed loop systems, and provides interactive graphs.
- *Student 38*: LCSD fits the course contents very well. It provides visualizations for all the types of diagrams and systems (open and closed loops) studied in the course.
- *Student 39*: The possibility of comparing open with closed loop control systems. I also found excellent that the opportunity of introducing changes and see what happens.
- *Student 40*: It helps to understand the improvements of closed-loop systems over open-loop systems. You can make little change and experience the consequences instantly.
- *Student 41*: Having the chance to play with a control system, testing changes and disturbances helps a lot learn feedback systems and understand how their complexity compared to open-loop systems pays off.
- *Student 42*: LCSD is adequated to learn non-feedback and feedback systems. Using the mouse, the user can easily interact with the control system and see what happens.

3.2 LCSD weaknesses and suggested improvements

The following points show the students' answers to the item *2.b LCSD weaknesses and suggested improvements*:

- *Student 1*: Though LCSD is easy to use in general, the transfer function handling isn't intuitive enough.
- *Student 2*: Plots are sometimes too small. For example, the process visualization should be larger.
- *Student 3*: LCSD user interface and manual should be improved. I also miss video tutorials.
- *Student 4*: I don't see any weaknesses, so I don't recommend any improvement.
- *Student 5*: Documentation is written in English. It should be improved and translated into Spanish.

- *Student 6*: The user should be able to set how many plots are displayed simultaneously.
- *Student 7*: For high K constants, LCSD crashes.
- *Student 8*: Short videos should guide LCSD learning.
- *Student 9*: The user interface it's not friendly enough because it has too many things.
- *Student 10*: Several bugs caused LCSD to crash.
- *Student 11*: LCSD visual aspect needs to be improved.
- *Student 12*: LCSD should run on Linux.
- *Student 13*: Plots interactivity needs improvement.
- *Student 14*: Some error messages lead to confusion and should be polished.
- *Student 15*: A more complete help menu and documentation are desirable.
- *Student 16*: I don't like the user interface. It's intimidating because it includes too many things in the window.
- *Student 17*: Using LCSD is sometimes tedious. I'd improve the LCSD user interface to make it more flexible and usable.
- *Student 18*: Visual elements should be more re-scalable. I miss a Spanish tutorial video.
- *Student 19*: It'd be great to have multimedia tutorials.
- *Student 20*: The interface is sometimes unnecessarily complex. I'd improve how parameters are specified in the transfer function.
- *Student 21*: I experienced some unexpected bugs.
- *Student 22*: Nothing. LCSD is OK.
- *Student 23*: I'd improve the graphical user interface to make it clean and uncluttered. Also, I'd include some mini video tutorials with examples.
- *Student 24*: The user experience should be enhanced.
- *Student 25*: At first, using LCSD is complicated. Its interface should be improved. For example, by showing hints interactively as the mouse moves through the window.
- *Student 26*: Plots should be larger, particularly the root locus diagram, which should be more detailed, showing asymptotes clearly.
- *Student 27*: I like the tool how it is.
- *Student 28*: LCSD first impression is somehow overwhelming. I think it'd be easier to use.
- *Student 29*: LCSD is easy to learn and use so I wouldn't change anything.
- *Student 30*: I'd improve the user manual.
- *Student 31*: At first contact, LCSD user interface is intimidating. Therefore, it should be simplified. Also, from time to time, LCSD crashes.
- *Student 32*: I couldn't analyze the root locus when there was a zero at -16. It was so far that I couldn't distinguish what happened around that point. I'd also improve how axes are re-scaled because the current LCSD version requires clicking on them too many times.
- *Student 33*: Visualization should be improved.
- *Student 34*: I don't like window size nor plots distribution in the screen.
- *Student 35*: In general, LCSD is a good tool.

- *Student 36:* LCSD interface is complex. I propose to adequate it according to different user profiles.
- *Student 37:* LCSD user interface and manual need improvement.
- *Student 38:* At least one video tutorial should be provided.
- *Student 39:* A couple of times, LCSD malfunctioned/crashed.
- *Student 40:* The transfer function parametrization is tiresome.
- *Student 41:* The user manual doesn't cover all LCSD features.
- *Student 42:* Graphically, LCSD is too rigid. Visual elements should be easily editable. Also, zoom in and out should be improved in the plots.