

# System Usability Scale - SUS Results for perceived usability of ASYMPTOTE by the teachers

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## Contents

1. Introduction.....	2
2. The System Usability Scale .....	2
2.1 Application in case of ASYMPTOTE.....	3
3. Results .....	4
3.1 SUS results .....	4
3.2 SUS results relations to demographic data .....	6
3.3 Open questions answers .....	9
4. Summary.....	13
5. References .....	14

# 1. Introduction

In this report the results of the usability evaluation of the first version of the ASYMPOTOTE system by the end users are presented. For the evaluation, the System Usability Scale (SUS) (Brook 1996) was answered online by 28 trained users from Germany, Italy, Greece, Portugal, and Spain. The results show that the system is perceived as good or excellent by 16/28 (SUS scores [70-100]) of the participants and ok or good [50-70] by the rest 12/28. The results are analyzed in the following sections after the brief presentation of the SUS and the participants sections.

## 2. The System Usability Scale

System Usability Scale (SUS) (Brook 1996) is a standardized questionnaire that is used for the assessment of the usability of websites and of software applications as it is perceived by end-users.

### System Usability Scale

© Digital Equipment Corporation, 1986.

	Strongly disagree				Strongly agree
1. I think that I would like to use this system frequently	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
2. I found the system unnecessarily complex	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
3. I thought the system was easy to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
4. I think that I would need the support of a technical person to be able to use this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
5. I found the various functions in this system were well integrated	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
6. I thought there was too much inconsistency in this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
7. I would imagine that most people would learn to use this system very quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
8. I found the system very cumbersome to use	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
9. I felt very confident using the system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5
10. I needed to learn a lot of things before I could get going with this system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	1	2	3	4	5

Figure 1. SUS items-questions

The ten item - questions of the SUS appear in Figure1. Questions 1, 3, 5, 7, 9 constitute a positive judgment and questions 2, 4, 6, 8 constitute a negative judgment. Users rate on a 5-point scale with the left end indicating 'strongly disagree' and the right end 'strongly agree'.

By assigning 1 to the left end and 5 to the right the scoring is conducted as follows: Questions 1, 3, 5, 7, 9 are scored by subtracting 1, while questions 2, 4, 6, 8, 10 are scored by subtracting from 5 the score of the user so that finally the normalized scores range from 0-4. Finally, the result is multiplied by 2.5 (so that the final score ranges from 0 to  $4 \times 10 \times 2.5 = 100$ ).

In recent years, through extensive testing and validation, an increasing popularity of the SUS questionnaire (Brooke, 1996) has been found for the following reasons:

- Provided free of charge
- Its validity has been established in a series of studies both on websites, distance education systems and on 'conventional' software as well as other devices such as mobile phones etc.
- Produces the same or more reliable results than other questionnaires even with a small sample of participants (12-15 users, Tullis & Stetson, 2004).
- The rating result is a score with a minimum of 0 and a maximum of 100. Bangor, Kortur & Miller (2008, 2009) after extensive studies involving approximately 2300 users found that the median rating value is 70, while the top 25% of scores was measured at 77.8 while Tullis & Albert (2008) found that a score greater than 81.2 implies ranking in the top 10% in the 129 studies they conducted. It was also found that a score greater than 80 implies an increased likelihood of revisiting a website and recommending the service to a friend/acquaintance.

## 2.1 Application in case of ASYMPTOTE

The SUS questionnaire was adapted in case of ASYMPTOTE using the questions of the Table 1.

**Table 1.** Questions of SUS for ASYMPTOTE evaluation

	Questions
1	I think that I would like to use ASYMPTOTE frequently
2	I found ASYMPTOTE unnecessarily complex
3	I thought ASYMPTOTE was easy to use
4	I think that I would need the support of a technical person to be able to use ASYMPTOTE
5	I found the various software operations in ASYMPTOTE were well integrated
6	I thought there was too much inconsistency in ASYMPTOTE
7	I would imagine that most people would learn to use ASYMPTOTE very quickly
8	I found ASYMPTOTE very cumbersome to use
9	I felt very confident using ASYMPTOTE
10	I needed to learn a lot of things before I could get going with ASYMPTOTE

In addition to the questions of SUS some demographics data were gathered, more specifically: *the participant type (In service teacher, Student, etc.), the years of experience, the country of origin, and the gender*. Finally, three open questions were included in the questionnaire to get more data about the opinions of teachers for the ASYMPTOTE system:

11. *Please justify why you think that ASYMPTOTE is very easy/difficult to use.*

12. *Please name three strengths of the ASYMPTOTE system. Justify them briefly.*

13. *Please name three weaknesses of the ASYMPTOTE system. Justify them briefly.*

The questionnaire was delivered online through google forms to the participants of the training programs (LTC & TT) of the project. The training programs were attended by in service

mathematics teachers, student teachers and engineers. The questionnaire is accessible at: <https://cutt.ly/g1U9JyN>.

The 28 answers were gathered during the interval 2 NOV 2022 - 30 NOV 2022. 19 answers were gathered until 19 NOV 2022 and the rest after a kind reminder that was sent in the same date. Since, according to Tullis & Stetson (2004), the SUS produces reliable results even with small set of answers, such as 15 users, the 28 answers will be analyzed to estimate the perceived usability of the ASYMPTOTE system by the teachers-users. The demographic data of the participants in the survey are depicted on Table 2.

**Table 2.** Demographic questions data descriptive summary

Demographic Question	N	Categories	f
Select your profession	28	Engineer	2
		Future Mathematics Teacher (Secondary Education)	10
		Future Teacher (Primary Education)	1
		Future engineer	1
		In Service Mathematics Teacher (Secondary Education)	14
Years of teaching experience	28	1-5	3
		10-15	1
		15+	13
		No previous experience	11
Select your country	28	Germany	8
		Greece	8
		Italy	5
		Portugal	5
		Spain	2
		Select your gender	28
		Male	9

In the following section the SUS application results are presented and analyzed.

## 3. Results

### 3.1 SUS results

The answers of the participants in the SUS questions are summarized on Table 3.

**Table 3.** Summary of the answers to the SUS questions

Part.	SUS SCORE	SUS QUESTIONS									
		1	2	3	4	5	6	7	8	9	10
P1	50.00	3	2	2	2	3	2	2	3	3	4
P2	80.00	4	1	4	2	4	1	4	2	4	2
P3	72.50	4	2	4	1	3	3	4	3	4	1
P4	90.00	4	2	5	2	4	1	5	1	5	1
P5	65.00	3	2	4	2	3	1	4	4	4	3
P6	82.50	4	1	5	2	3	2	5	2	4	1
P7	87.50	3	1	5	1	4	1	4	1	4	1
P8	72.50	4	2	4	2	5	3	3	3	5	2
P9	80.00	4	2	5	1	3	1	5	2	5	4
P10	75.00	4	1	4	2	4	1	3	1	3	3
P11	87.50	4	1	5	1	3	3	5	1	5	1
P12	70.00	4	2	3	2	3	2	4	2	4	2
P13	85.00	2	1	5	1	4	1	5	1	3	1
P14	55.00	4	1	3	4	4	2	2	4	4	4
P15	75.00	4	2	3	2	4	1	4	1	4	3
P16	92.50	3	1	5	1	4	1	5	1	5	1

P17	65.00	3	3	4	2	4	2	4	4	4	2
P18	65.00	2	2	3	1	3	2	4	3	4	2
P19	62.50	3	2	4	2	3	2	3	3	4	3
P20	92.50	4	1	5	1	5	1	4	1	5	2
P21	65.00	4	2	4	2	4	3	4	3	4	4
P22	65.00	3	2	5	3	3	2	4	2	3	3
P23	62.50	5	3	3	2	4	2	3	3	3	3
P24	87.50	4	2	4	1	5	1	4	1	5	2
P25	50.00	3	2	4	5	3	3	4	4	5	5
P26	50.00	5	4	4	4	4	4	3	4	4	4
P27	95.00	5	1	5	1	4	2	5	1	5	1
P28	77.50	5	5	5	2	4	1	4	1	4	2
<b>Mean</b>	<b>73.48</b>	<b>3.71</b>	<b>1.89</b>	<b>4.14</b>	<b>1.93</b>	<b>3.71</b>	<b>1.82</b>	<b>3.93</b>	<b>2.21</b>	<b>4.14</b>	<b>2.39</b>
<b>SD</b>	<b>13.58</b>	<b>0.81</b>	<b>0.96</b>	<b>0.85</b>	<b>1.02</b>	<b>0.66</b>	<b>0.86</b>	<b>0.86</b>	<b>1.17</b>	<b>0.71</b>	<b>1.20</b>
<b>Min</b>	<b>50.00</b>	<b>2.00</b>	<b>1.00</b>	<b>2.00</b>	<b>1.00</b>	<b>3.00</b>	<b>1.00</b>	<b>2.00</b>	<b>1.00</b>	<b>3.00</b>	<b>1.00</b>
<b>Max</b>	<b>95.00</b>	<b>5.00</b>	<b>5.00</b>	<b>5.00</b>	<b>5.00</b>	<b>5.00</b>	<b>4.00</b>	<b>5.00</b>	<b>4.00</b>	<b>5.00</b>	<b>5.00</b>

The answers set of the participants are quite reliable since the Cronbach's alpha=0.801 which is quite high value for social survey data. Table 3 contains the original (non-normalized) answers to the ten SUS questions as well as the SUS score for each participant and the mean total score. The SUS score for each participant is calculated as follows:

$$SUS\ SCORE = 2.5 * (SCORE1 + SCORE2)$$

$$SCORE1 = Q1-1 + Q3-1 + Q5-1 + Q7-1 + Q9-1$$

$$SCORE2 = 5 - Q2 + 5 - Q4 + 5 - Q6 + 5 - Q8 + 5 - Q10$$

SUS score takes values in the interval [0,100]. The SUS scores distribution for the whole group organized in intervals of equal length ten are depicted on the diagram in Figure 2.

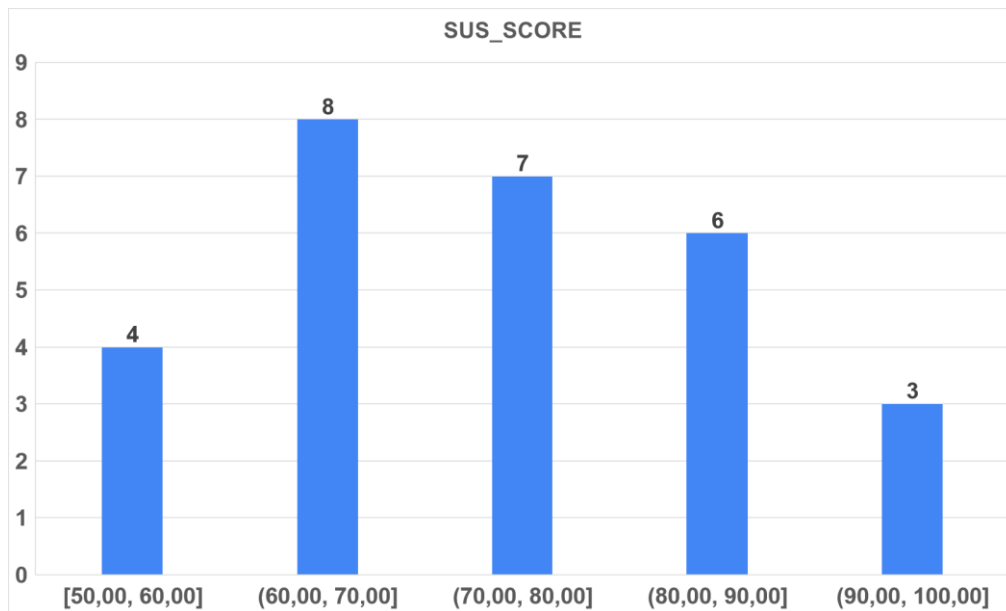
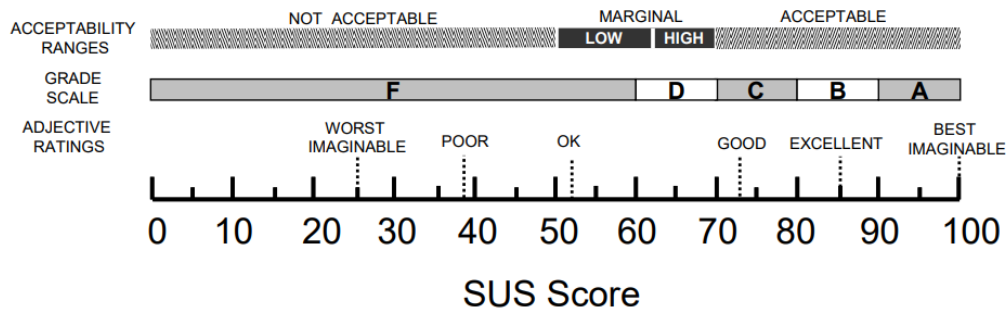


Figure 2. The distribution of the grouped SUS scores in equal intervals of length 10

The mean SUS Score for the answers set is SUS Mean=73.48 and the Standard deviation is SD=13.58. For the comparative interpretation of these values, we can use the rating instruments of Bangor, Kortur & Miller (2008, 2009) and Tullis & Albert (2008). More specifically, Bangor, Kortur & Miller (2008, 2009) after extensive studies involving approximately 2300 users found that the median rating value is 70, while the top 25% of scores was measured at 77.8 while Tullis & Albert (2008) found that a score greater than 81.2

implies ranking in the top 10% in the 129 studies they conducted. In this study the rating scale of Figure 3 is adopted as it is proposed by Bangor, Kortur & Miller (2008, 2009) and it is used widely with SUS.



**Figure 3.** Rating scale for average SUS in comparison to adjective ratings, acceptability scores and school grading scales (Bangor, Kortur & Miller 2008; 2009)

According to the rating scale the average SUS Score 73.48 means that the ASYMPTOTE is perceived in general as a GOOD system quite better than the half of the systems that SUS was used. In addition, as we can see in the distribution of Figure 2, 16/28 (~57,14%) of the participants rate ASYMPTOTE as GOOD or EXCELENT while the rest 12/28 rate it as OK or GOOD.

The low values in questions 2, 4, 6, 8 and 10 show that ASYMPTOTE is quite intuitive and user friendly. The higher mean value (2.39) and SD (1.20) in question 10. *I needed to learn a lot of things before I could get going with ASYMPTOTE* shows that the innovative features of ASYMPTOTE like the learning graph concept, the digital classroom and LATEX based digitization of math symbolism required effort from the teachers in various degrees but in general they are not inhibitor factors for the system acceptance and adoption.

This interpretation is supported by the high mean values in questions 1, 3, 5, 7, & 9. Especially the highest values in questions: 3. *I thought ASYMPTOTE was easy to use* ( $\mu=4.14, \sigma=0.85$ ) and 9. *I felt very confident using ASYMPTOTE* ( $\mu=4.14, \sigma=0.71$ ) are convincing that the system is easy to use for the teachers even though its interface concerns abstract mathematical constructs. The concrete representation of the learning track of students using learning graphs seems to be justified by the teachers. The answer to question 1. *I think that I would like to use ASYMPTOTE frequently* ( $\mu=3.71, \sigma=0.81$ ) is higher than the average and gives the impression that most teachers wish to utilize ASYMPTOTE for their teaching practice in the future. Only two participants (P13 & P18 in service teachers) answered disagree and no one is strongly disagree.

### 3.2 SUS results relations to demographic data

Relations of the demographics data to the answers of each question were examined using Chi-square and Exact Fischer's tests.

No significant relation of the **participant type** (In service teacher, Student, etc) or the **gender** demographics were found to any question of SUS. The participants' answers were homogeneous as far as the participant type or the gender is concerned.

As far as the **years of experience** is concerned it appears a relation to the intention of use that is to SUS question 1. *I think that I would like to use ASYMPTOTE frequently*. Applying the Exact Fischer's test on these table shows that the frequency of the answer "5" for the 15+ group is significantly ( $p=0.035$ ) higher (Tables 5 & 6) than the theoretically expected (Table 7) (4

instead of 1.857). This is a positive finding since the more experienced teachers appreciate the ASYMPOTOTE system with certainty.

**Table 4.** Contingency table: Years of teaching experience \* 1. I think that I would like to use ASYMPOTOTE frequently

Years of teaching experience	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
1-5	0	2	1	0
10-15	0	0	1	0
15+	2	2	5	4
No previous experience	0	4	7	0

**Table 5.** Significance by cell (Fisher's exact test) (Years of teaching experience \* 1. I think that I would like to use ASYMPOTOTE frequently)

Years of teaching experience	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
1-5	<	>	<	<
10-15	<	<	>	<
15+	>	<	<	>
No previous experience	<	>	>	<

**Table 6.** p-values (Fisher's exact test) (Years of teaching experience \* 1. I think that I would like to use ASYMPOTOTE frequently)

Years of teaching experience	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
1-5	1,000	0,188	1,000	1,000
10-15	1,000	1,000	1,000	1,000
15+	0,206	0,221	0,449	<b>0,035</b>
No previous experience	0,505	0,671	0,440	0,132

\*Values displayed in red are significant at the level  $\alpha=0,05$

**Table 7.** Theoretical frequencies (Years of teaching experience \* 1. I think that I would like to use ASYMPOTOTE frequently)

Years of teaching experience	1. I think that I would like to use ASYMPOTOTE frequently				Total
	2	3	4	5	
1-5	0,214	0,857	1,500	0,429	3,000
10-15	0,071	0,286	0,500	0,143	1,000
15+	0,929	3,714	6,500	<b>1,857</b>	13,000
No previous experience	0,786	3,143	5,500	1,571	11,000
<b>Total</b>	2,000	8,000	14,000	4,000	28,000

As far as the **country** of origin is concerned there are two significant findings.

The first concerns the SUS question 1) *1. I think that I would like to use ASYMPOTOTE frequently* where the participants from Germany answer "3" (Table 8) with significantly greater frequency (Tables 9 & 10) than the theoretically expected (Table 11) (5 instead of 2.286). German participants seem to be more frequently not certain if they will use the ASYMPOTOTE in the future. They were math students so their situation may have as a result to doubt if they will use the system in real teaching conditions.

The second concerns the SUS question 8. *I found ASYMPOTOTE very cumbersome to use* where the Greek participants answered "3" (Table 12) with significantly (Tables 13 & 14) higher



frequency than the theoretically expected (Table 15) (5 instead of 2). The Greek participants were trained first with ASYMPOTOTE beta version which had some bugs so the functional problems that appeared are reflected in their answers. The current version of ASYMTOTE is more functional and robust. Trainees testing helped to recover some of the problems. Despite the bugs the trained teachers from Greece evaluate high the system. If they assess the final version of the system, their answers probably will be even better.

**Table 8.** Contingency table (Country \* 1. I think that I would like to use ASYMPOTOTE frequently):

Country	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
Germany	1	5	2	0
Greece	1	2	4	1
Italy	0	1	3	1
Portugal	0	0	4	1
Spain	0	0	1	1

**Table 9.** Significance by cell (Fisher's exact test) (Country \* 1. I think that I would like to use ASYMPOTOTE frequently):

Country	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
Germany	>	>	<	<
Greece	>	<	=	<
Italy	<	<	>	>
Portugal	<	<	>	>
Spain	<	<	=	>

\*Values displayed in red are significant at the level  $\alpha=0,05$

**Table 10.** p-values (Fisher's exact test) (Country \* 1. I think that I would like to use ASYMPOTOTE frequently):

Country	1. I think that I would like to use ASYMPOTOTE frequently			
	2	3	4	5
Germany	0,497	0,022	0,209	0,295
Greece	0,497	1,000	1,000	1,000
Italy	1,000	1,000	1,000	1,000
Portugal	1,000	0,281	0,326	1,000
Spain	1,000	1,000	1,000	0,270

\*Values displayed in red are significant at the level  $\alpha=0,05$

**Table 11.** Theoretical frequencies (Country \* 1. I think that I would like to use ASYMPOTOTE frequently):

Country	1. I think that I would like to use ASYMPOTOTE frequently				Total
	2	3	4	5	
Germany	0,571	2,286	4,000	1,143	8,000
Greece	0,571	2,286	4,000	1,143	8,000
Italy	0,357	1,429	2,500	0,714	5,000
Portugal	0,357	1,429	2,500	0,714	5,000
Spain	0,143	0,571	1,000	0,286	2,000
<b>Total</b>	<b>2,000</b>	<b>8,000</b>	<b>14,000</b>	<b>4,000</b>	<b>28,000</b>

Tables 12, 13, 14 & 15 present the results about Country relation to SUS question 8. I found ASYMPOTOTE very cumbersome to use. The results reflect the functional problems of the beta

version of the system that was used in Greece teachers training as part of its testing. All the problems found are fixed in the current version of the system.

**Table 12.** Contingency table (Country \* 8. I found ASYMPTOTE very cumbersome to use)

	8. I found ASYMPTOTE very cumbersome to use			
Country	1	2	3	4
Germany	3	1	1	3
Greece	1	1	5	1
Italy	4	1	0	0
Portugal	2	2	1	0
Spain	1	0	0	1

**Table 13.** Significance by cell (Fisher's exact test) (Country \* 8. I found ASYMPTOTE very cumbersome to use)

	8. I found ASYMPTOTE very cumbersome to use			
Country	1	2	3	4
Germany	<	<	<	>
Greece	<	<	>	<
Italy	>	>	<	<
Portugal	>	>	<	<
Spain	>	<	<	>

\*Values displayed in red are significant at the level  $\alpha=0,05$

**Table 14.** p-values (Fisher's exact test) (Country \* 8. I found ASYMPTOTE very cumbersome to use)

	8. I found ASYMPTOTE very cumbersome to use			
Country	1	2	3	4
Germany	1,000	1,000	0,633	0,123
Greece	0,099	1,000	0,009	1,000
Italy	0,062	1,000	0,290	0,550
Portugal	1,000	0,207	1,000	0,550
Spain	1,000	1,000	1,000	0,331

\*Values displayed in red are significant at the level  $\alpha=0,05$

**Table 15.** Theoretical frequencies (Country \* 8. I found ASYMPTOTE very cumbersome to use):

	1. I think that I would like to use ASYMPTOTE frequently				
Country	1	2	3	4	Total
Germany	3,143	1,429	2,000	1,429	8,000
Greece	3,143	1,429	2,000	1,429	8,000
Italy	1,964	0,893	1,250	0,893	5,000
Portugal	1,964	0,893	1,250	0,893	5,000
Spain	0,786	0,357	0,500	0,357	2,000
Total	11,000	5,000	7,000	5,000	28,000

### 3.3 Open questions answers

In this section the answers to the open questions 11,12 and 13 are presented. The questions help to understand better why the teachers answered the way they did.

- Answers to question 11. Please justify why you think that ASYMPTOTE is very easy/difficult to use ASYMPTOTE

**Table 16.** Answers to the question 11. Please justify why you think that ASYMPTOTE is very easy/difficult to use.

Part.	11. Please justify why you think that ASYMPTOTE is very easy/difficult to use.
P1	It's easy to use because it have excellent support
P2	I think that Asymptote is very easy to use because its various software operations are rather well integrated, it is quite simple, and, in general, its whole function does not need specific technical adilities.
P3	It is an easy to learn and use program but it has lots of problems regarding the programming code that leed to a cumbersome to use
P4	It's very easy to use because I believe that the app is user-friendly, and the functions are very clearly to the users as well as the instructions
P5	designing graphs is rather difficult, doing them is easy
P6	I think it's a very user friendly app and very easy for the teacher (to program the questions) and for the student to choose his answer.
P7	The creation of tasks is very intuitive and you can implement every kind of exercise you can think of
P8	It has very good software so the use is very easy
P9	It has a simple UI that makes it easy to use but there are some minor inconveniences when making tasks.
P10	It is very easy to use because there is a good scheme to understand step by step where to insert the parts needed to compose the tasks. It is difficult to use if you don't know how to write mathematical expression with LaTeX.
P11	I find that the user interface of asymptote is very friendly.
P12	Good and clear platform's developement
P13	Nach einer Einführung ist es selbsterklärend
P14	it's difficult to use because you must have previous experience in computers, you must understand how it works and you hardly find the exercises you would like to.
P15	There are several variables to consider
P16	the structure is very logical and self explaining
P17	Ist is not very difficult to use. I just need Sonne time to Integration in into my classes. It takes big effort to create tasks for 4 classes that I am teaching right now.
P18	ASYMPTOTE is easy to use because the commands are easy
P19	you make accurated excercises and short ones
P20	intuitive software, nice Grafik design, supports math tasks very well
P21	- übersichtlich - schülerfreundlich - verschiedene Möglichkeiten werden eröffnet
P22	Its easy due to easy access to help
P23	As long as you understand the methodology you intend to use (positive reinforcement), it is quite intuitive. All teachers must be able to indicate prerequisites and developments that the student can and must follow.
P24	I think it is an intuitive app, first time is difficult, but getting easier on the way .
P25	I think it was than easy after the instruction for using the application. But than the buttons for issues was easy to found so you could work easy.
P26	I really think that ASYMPTOTE is easy to use.
P27	It is very intuitive
P28	The portal structure is easily understandable

As the answers show the participants find the ASYMPTOTE user interface intuitive and easy to use. They also mentioned the UI as quite simple and aesthetically attractive. Only a brief introduction to conceptualize the system seems enough to start use the system. The answers justify the high score of SUS and support the belief that ASYMPTOTE is a well-developed end-user friendly system which successfully manipulates abstract mathematical tasks and learning track concepts.

- *Answers to question 12. Please name three strengths of the ASYMPTOTE system. Justify them briefly.*

**Table 17.** Answers to question 12. Please name three strengths of the ASYMPTOTE system. Justify them briefly.

Part.	12. Please name three strengths of the ASYMPTOTE system. Justify them briefly.
P1	1) easy to use because of excellent support 2) simplicity of system 3) download easy for free
P2	Gamification, hints and supportive tasks.
P3	Easy to learn from teachers and students, enables dynamic course planning and enables the student to engage in learning at the time and place he wants since he uses a device that the student almost always has with him
P4	Powerfull, user-friendly and simple
P5	adaptive learning, mobile format
P6	1 User friendly because it is easy to understand 2 Supportive because the app gives you the resolution of the questions with an explanation 3 Challenging because the questions usually give us 3 possible helps and we want to do without using them
P7	Intuitive, complete, flexible. It is intuitive in the sense that it is very easy ti use. It is complete because it offers you a wide range of possibilities in creating tasks. It is flexible because it adapts well to every ideas you can have.
P8	Easy to use Like a game (the look of application is like mobile game Communication teacher student via digital classroom
P9	1. Simple UI: The user interface has a simple design that makes it easy for someone who isn't familiarized with it to use it. 2. Support and challenge tasks: These are useful in that they act as a preparation/broadening for students to have a wider perspective of what they learn. 3. Possibility to create your own tasks: This way, everyone can contribute to the growth of the system.
P10	CLARITY because there is good graphics EFFECTIVENESS because it allows students to prepare well in an alternative way ACCESSIBILITY because you can get the graphs thanks to a single code and a smartphone
P11	Mobile learning, adaptive learning.
P12	Helpful, funny, Useful
P13	Leicht in der Anwendung; Nützlich im Homeschooling, Jeder kann in seinem Tempo lernen
P14	multi language, hints to solve the problems, the App
P15	It can enhance student learning.
P16	easy to use different answer format possibilities
P17	The biggest difficulty is the biggest strength at the same time. It takes time to create some tasks but you can individualize it for your Students.
P18	It is easy to make exercises short ones but accurate
P19	1) the excercises are short and accurate 2)you can use graphs 3)the excercises are flexible to students
P20	see 11
P21	- übersichtlich - schülerfreundlich - verschiedene Möglichkeiten werden eröffnet
P22	futuristic, modern and easy to be used from everywhere
P23	The system allows a good articulation between knowledges. It allows you to review necessary concepts as well as move forward with more elaborate challenges. This should make the student not give up and always try to improve.
P24	Clear - because I´m learning from the beginning Intuitive - because when I don't know, I feel confidente to try Challenger - it is always important to learn new strategies

P25	digitalization graphical support variance of tasks
P26	Understanding ,clarity ,comprehension ,inclusiveness.
P27	Attractive for our students/Involves the use of mobiles or PC/Learn playing
P28	easy to use both fo teachers and students it is a captivating system to learn and tto improve knowledge the system offers different kind of tasks so to create customizable learning graphs

The participants name several advantages of ASYMPTOTE among them the simplicity, the graphical support, the variance of tasks, the gamification, the adaptation, the communication with the students through the digital classroom. Teachers name specific functionality and unique characteristic features of ASYMPTOTE’s system. This justifies its design decisions.

- *Answers to question 13. Please name three weaknesses of the ASYMPTOTE system. Justify them briefly.*

**Table 18.** Answers to question 13. Please name three weaknesses of the ASYMPTOTE system. Justify them briefly.

Part.	13. Please name three weaknesses of the ASYMPTOTE system. Justify them briefly.
P1	1) justification of answers by students due to format of answers 2) not so good graphical representation 3) Math theory is difficult to insert to the system
P2	In my opinion it needs to be improved regarding geometry, symbolic forms of numbers and open-ended questions.
P3	It does not always give the teacher the flexibility to create the exercises in the format he wants (the range of options is not wide) and it does not effectively support the development of a large theoretical background in the hints provided to the student. The students who activate the application away from their usual study area and do not have immediate access to their learning material may need longer and more effective instructions to help them
P4	There are a few bugs, the latex language and the differences of teaching between countries (different points of view and the resolution of the tasks might be different)
P5	no video format
P6	1 Interface (?) I used the application on a tablet (Samsung galaxy tab S6 lite) and the interface was not working properly
P7	Repetitive, weak interface. It can get a little repetitive after a while. The app interface is not the most captivating. I can't really think of a third weakness
P8	Short answers only Strange way of translation Problem with shared tasks, you can't put in line
P9	1. Translation issues: While making translations for a task a simple click outside the translation window completely erases it. 2. Minor glitches: For example, when choosing an answer in the fraction format. 3. Finding graphs can be difficult if you're not specific about their name.
P10	MATHEMATICAL TEXT INSERTION if you do not know LaTeX QUALITY OF IMAGES INSERTED PROBLEMS IN APP WITH LOADING IMAGES/FORMULAS
P11	Lack of contact with the teacher and the schoolmates.
P12	Full of bugs
P13	Es ist viel Arbeit, Lerngraphen zu erstellen, die mathematische Kommunikation miteinander wird unterdrückt
P14	hard to use, hard to find exercises about the topic you need and poor graphics interfaces.
P15	Practice systems have a playful impact that students like. Asymptote can enhance student learning. It contributes to open up new perspectives for further research in order to keep up with technology and exploit its positive role in teaching mathematics.

P16	latex errors (hopefully corrected by now) no answer format to type in an equation as a solution (eg. the student should create an derivative without solving it at a given point)
P17	It takes time to create the tasks.
P18	you must make exercises with accurate and specifically numbers. So the student is obliged to answer in specifically kind of excercises.
P19	1)you must use specifically numbers in the excercises 2)the answers are not always flexible 3)you can't use all of kind of excercises
P20	time consuming to add new tasks, would be good to have a stock of tasks of good quality
P21	- bisher nur auf englisch (für Schüler schwierig)
P22	-
P23	Something even more challenging would be to be able to incorporate other subjects in addition to mathematics and thus achieve interdisciplinarity. For example, physics.
P24	Example of answer - I think it would be great if we can insert more than one image Multiple choice - when write my answers in Latex, in my PC I can't see it written properly (only in code) See the tasks in my phone - I think we can't see the tasks in the app, unless they are part of a learning graph
P25	writing formulas correction of language could be good refresh of website
P26	Lack of control , reduced participation and control of results.
P27	Improved interface to make it friendlier/Possibility to insert GeoGebra applets/Possibility to have an assistant
P28	it is necessary a personal device and in lower secondary school some students don't have one I don't find any other weaknesses

Teachers name specific proposals to improve the system e.g. the use of video, the writing of formulas in digital format, math theory tasks etc. The answers describe some concerns of the teachers and provide a valuable source of information for future development of the system.

## 4. Summary

For the evaluation of the ASYMPTOTE system usability perception by the teachers the SUS questionnaire was used. Twenty-eight trained teachers and student teachers answered the questionnaire, gave some demographic information and their opinion in three open questions. Most of the teachers find the ASYMPTOTE as a good to excellent system. Most of them wish to use it in practice for now on. Especially the most experienced teachers declare more certainly that they will use the system for teaching. Some functional problems in the beta version of the system are reflected in the Greek participants answers, who are not sure about how much cumbersome the system use is. Similarly, the German participants are more frequently than expected not certain if they will use the system in the future, mainly because they are math students yet. The answers in the open question justify the positive reception of the ASYMPTOTE as an intuitive, user friendly, attractive, and effective system as it is reflected in SUS. Moreover, the participants in the evaluation give specific, to the point advantages for the system referring to its functional characteristics e.g., adaptation and digital classroom. This makes its design decisions to seem successful. Finally, teachers name and describe some of their concerns about the system use and propose specific improvements.

The designers and the developers of the system could be pleasant with the evaluation of the teachers of the first version of ASYMPTOTE since it is innovative and quite complex in development.

## 5. References

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