An Evaluation of the Archive of Formal Proofs

Carlin MacKenzie, Jacques Fleuriot and James Vaughan
Artificial Intelligence and its Applications Institute
School of Informatics
University of Edinburgh
{s1724780, jdf, s0952880}@ed.ac.uk

1 Introduction

The Archive of Formal Proofs (AFP) is an online repository of formal proofs for the Isabelle proof assistant[1]. It first appeared on the internet in 2004, hosted as a static site on SourceForge[2] to serve as a central location for publishing, discovering, and viewing libraries of proofs. It subsequently took residence on its own domain[3] however the visuals and functionality of the site have not been significantly updated since.

We conducted an online survey of the AFP in November 2020 to assess the suitability of the website. We first evaluated the questions for clarity and utility with a small pre-study group from the School of Informatics at the University of Edinburgh. The survey was then distributed to the Isabelle Mailing list[4], where it received 30 responses.

Summary of results: We found that long-term users of the website are generally satisfied with the Archive of Formal Proofs but that there are a number of areas, such as navigation, search and script browsing, that need improvement.

2 Pre-study

In order to validate the survey design, it was first distributed to the Artificial Intelligence Modelling Lab[5] in the School of Informatics at the University of Edinburgh. This group was chosen as the members are familiar with Isabelle across a variety of use cases and workflows.

3 Survey Design

The pre-study was completed by 6 members of the Lab. After analysing their answers, we made the following adjustments to the survey, both to address limitations of the initial design and to account for the main audience i.e. the Isabelle mailing list.

- The first question of the survey, “Do you use the Archive of Formal Proofs?”, was replaced with “How often do you access the Archive of Formal Proofs?” as this was a more reliable way to filter out people who do not use the Archive.

- Two questions about submission were added. Although the submission form is separate from the AFP, it was felt that this would provide some further understanding of the responses.

- The final SUS question, “I needed to learn a lot of things before I could get going with the AFP”, was removed as the meaning was deemed to be ambiguous. To account for this in the SUS scoring, the rating of 3 was used for this question as it has no effect on the final score.

Bibliographic information:

[1] https://isabelle.in.tum.de
[2] https://afp.sourceforge.net
[3] https://isa-afp.org
[4] https://lists.cam.ac.uk/mailman/listinfo/cl-isabelle-users
[5] http://aiml.inf.ed.ac.uk
• Two questions about navigation regarding finding specific contents and entries by an author were added.
• Two questions about redesigning the UI and UX were added.
• Four questions changed their format from 5-star ratings to Likert scales \cite{1}, as these were found to be easier to analyse.

The survey was carried out via Microsoft Forms\footnote{https://forms.office.com/} and was organised as follows:

1. **Demographics:** 4 questions to filter users into different groups depending on their experience with the AFP.
2. **Submission:** 2 questions to assess the submission process
3. **System Usability Scale (SUS):** 9 SUS \cite{2} questions to act as an indicator of the usability of the AFP.
4. **Biggest pain point:** 1 long answer question asking users to identify their biggest pain point.
5. **Navigation:** 4 questions related to the ease of finding pages and page visit frequency.
6. **Design:** 2 questions on the user interface and user experience.
7. **Browsing session scripts:** 2 questions about the browsing experience and 1 short answer question about missing features.
8. **Ranking priorities:** 1 question asking users to rank a number areas in order of importance.

The final version of the survey can be found in Appendix \cite{A}.

\section{Participants}

The Isabelle mailing list was chosen as many of its members were likely to be users of the AFP, thereby increasing the likelihood of achieving a comprehensive evaluation of the website. The survey was advertised on the mailing list as *Survey on the AFP* with an estimated time of 10-20 minutes. The time estimate was calculated based upon the average completion time of the pre-study. No compensation was advertised, and the main benefit of the study was to help guide some research on an evaluation of the AFP. The survey was open from 10 to 30 November 2020.
5 Results and Analysis

In this section we look at the results more closely. We break these down to match the survey topics described in the previous section.

1. How often do you access the Archive of Formal Proofs?

```
| Frequency          | Count |
|--------------------|-------|
| Never              | 1     |
| When there is a new submission | 5     |
| When there is a new release o... | 0     |
| Weekly             | 7     |
| Monthly            | 8     |
| Few times per year | 8     |
| Yearly             | 1     |
```

2. How long have you been using the Archive?

```
| Duration          | Count |
|-------------------|-------|
| Three months or less | 1     |
| One year or less   | 3     |
| More than a year   | 25    |
```

3. Have you ever downloaded an Archive entry?

```
| Answer   | Count |
|----------|-------|
| Yes      | 29    |
| No       | 0     |
```

4. Have you ever submitted an entry to the Archive?

```
| Answer   | Count |
|----------|-------|
| Yes      | 20    |
| No       | 9     |
```

Figure 1: Demographics. The demographics of the respondents is skewed towards very active and long-term users.
5. How much do you agree with the following

![Figure 2: Submission](image)

The vast majority of people who have submitted find the process clear and straightforward.

6. What is your biggest pain point when submitting entries to the Archive?

- Sometimes you get some errors from the system after submitting. And if I remember correctly, one time an entry didn’t arrive because of a non-ASCII letter in an author name, but AFAIK this has been fixed now.
- Whether the entry will be accepted or not.
- In 2017, there was no “preview” feature for the entry description.
- Converting apply-style proofs to Isar (not necessarily required by the AFP, but recommended)
- Forgetting to update something about a theorem before submission.
- Compared to a pull request on Github it is a bit more tedious and less transparent.
- Building of submission failing due to LaTeX issues without helpful error messages.
- Need to make sure the LaTeX part compile.
- To bring a submission into format. Sometimes this needs 5-6 times to make a submission attempt and to finally complete it.
- Having to run the new entry with the Isabelle development version if the new entry imports an entry which has been updated since the last release.
- Checking the Isabelle style rules.
- Getting the ROOT file right.

Table 2: Submission. Six of the comments were related to formatting of the ROOT file and script files. The most actionable feedback from this section was that error messages are often unhelpful and that there is no preview for the abstract section. Three participants had no discernible pain point with submission and are not included in the table.
7. For each of the following statements, please mark one box that best describes your reactions to the Archive of Formal Proofs as it is today.

Figure 3: **SUS Questions.** The SUS score for the AFP is 72, which is above the average SUS score of 68 and suggests that the participants are satisfied by the AFP.
8. What is your biggest pain point with the Archive? This could be with browsing entries, browsing scripts within entries, or any other feature of the AFP.

| Pain Point                                                                 |
|---------------------------------------------------------------------------|
| I think the biggest problem is that https://www.isa-afp.org/using.html is not explained well for Microsoft Windows. |
| Use downloaded entries (e.g. integrate in a new development). (This might be more an issue with Isabelle itself than AFP; I do not use Isabelle frequently.) |
| Finding the correct Theory to import in Isabelle for a given Entry.       |
| I cannot online download and integrate the libs of AFP into Isabelle/HOL in the Isabelle/jedit UI.                           |
| A lot of redundant formalizations (like graphs), making it non-obvious which to use.                                       |
| Problems with installing and using the new AFP version with every new Isabelle release.                                    |
| Rather weak HTML presentation.                                            |
| It’s sometimes hard to find what you’re looking for when you’re just in search of “a development that does X”.               |
| Learning what is there. As it grows, I do not know if my contributions are reinventing the wheel or if any theory for an entry in a different topic can help with my developments. |
| The Proof Document contains all the proof, but the research value of the entry is usually in the published paper. A direct link would be useful. |
| The scope could be clearer. In particular: What do I do with work in progress? Are many small libraries or one big library preferred? What about new tools, i.e. new tactics implemented in ML without any new proofs? How do I add a library from the AFP as a dependency to my project? (The method described at https://www.isa-afp.org/using.html lacks basic functionalities like versioning or automatic downloading of dependencies and is a system wide setting instead of a per-project setting.) |
| Searching if a theory already does something I need.                       |

Table 4: **Biggest Pain Point.** The most common response was problems using AFP entries with Isabelle/jEdit [3]. In total, 6 people had this problem, from lacking instructions for Windows to finding the correct theory to import from an entry. The next largest area was search, with 3 respondents describing issues relating to finding whether there is an entry which does what they need. There were four specific asks: one would like a direct link to the corresponding paper about the entry if applicable; another finds the HTML presentation weak; yet another finds it difficult to choose between many similar entries; finally, one user is confused of the scope of the project and what entries are worthy of entering. Finally, 3 respondents had no pain point with the AFP and their responses are not included in the table.
For each of the following, please mark one box that best describes your reaction to the statement.

- **Disagree**
- **Neutral**
- **Agree**

| Statement                                                                 | Disagree | Neutral | Agree |
|---------------------------------------------------------------------------|----------|---------|-------|
| It is easy to find specific entries in the AFP                            | 3        | 9       | 17    |
| It is easy to find entries on a topic                                     | 5        | 13      | 11    |
| It is easy to find entries by an author                                   | 2        | 9       | 18    |
| It is easy to find related entries to a specific entry                    | 4        | 11      | 14    |
| It is easy to find specific content - e.g. lemmas, definitions - in entries| 17       | 7       | 5     |

Figure 4: **Navigating to Specific Content.** Most content is easy to navigate to, except for specific content in entries. Notably, there is no category in which everyone is neutral or agrees implying that navigation can be improved in all areas.
10. How often do you access the following pages:

| Page Description                                                                 | Never | Rarely | Sometimes | Frequently |
|----------------------------------------------------------------------------------|-------|--------|-----------|------------|
| Home – List of entries                                                           | 1     | 3      | 9         | 16         |
| About – Description of the AFP                                                   | 3     | 17     | 7         | 2          |
| Submission – Guidelines for submission                                          | 3     | 15     | 11        | 0          |
| AFP Submission – Form that is used to submit an entry                           | 6     | 12     | 11        | 0          |
| Citing Entries – Citation style for AFP entries                                  | 4     | 11     | 11        | 3          |
| Updating Entries – How authors should update their entries                     | 9     | 11     | 8         | 1          |
| Using Entries – How to use entries                                              | 4     | 12     | 12        | 1          |
| Search – Find entries in the archive                                            | 6     | 7      | 9         | 7          |
| Statistics – Statistics about the archive                                        | 6     | 12     | 7         | 4          |
| Index – A list of entries and topics                                            | 2     | 5      | 10        | 12         |
| Download – A link to download the Archive                                       | 4     | 7      | 13        | 5          |

Figure 5: **Navigating to Pages.** There are very different access requirements for pages of the AFP even though all but two of the eleven pages feature in the sidebar.
11. For an entry of the AFP, how often do you access the following:

| Service                                      | Never | Rarely | Sometimes | Frequently |
|----------------------------------------------|-------|--------|-----------|------------|
| Proof Outline – PDF of the lemmas of the entry in mathematical notation | 5     | 9      | 8         | 7          |
| Proof Document – PDF of the Isabelle script of the entry | 4     | 10     | 4         | 11         |
| Browse Theories – HTML directory which allows you to browse the theories script | 1     | 3      | 8         | 17         |
| View theory dependencies – A PDF of the dependencies graph | 4     | 14     | 8         | 3          |
| Download this entry – Downloads the entry | 5     | 6      | 14        | 4          |
| Older Releases – Previous releases of that entry in different AFP versions | 13    | 12     | 4         | 0          |

Figure 6: Navigating to Pages Related to the Entry. Each entry of the AFP has several links to pages related to it. “Browse Theories” and “Download” are the most accessed while “Older Releases” is rarely accessed.

12. How often do you mis-click when navigating between pages?

| Frequency     | Percentage |
|---------------|------------|
| Frequently    | 0          |
| Sometimes     | 4          |
| Rarely        | 13         |
| Never         | 12         |

Figure 7: Clarity of Link Text. Over half the participants mis-click rarely or sometimes.
13. **For each of the following, please mark the box that best describes your reaction to the statement**

- I am satisfied with the look and feel of the AFP
- The layout of the AFP is intuitive
- The user interface - e.g. colours, icons, etc - of the AFP should be redesigned
- The user experience - e.g. placement of menus, etc - of the AFP should be redesigned

![Survey Results]

Figure 8: **Design and User Experience.** Most users are satisfied with the UI and UX but are neutral towards a redesign of either.

14. **Do you browse theories within entries?**

- Yes: 28
- No: 1

![Survey Results]

15. **How satisfied are you with:**

- Browsing the theories
- Finding specific contents - e.g. lemmas, constants - in a theory

![Survey Results]

Figure 9: **Browsing Theories.** Almost all participants browse theories and are mostly satisfied with the experience. However, they are largely unsatisfied with finding contents within theories.
16. What feature would improve browsing theory scripts?

| Feature                                                                 | Description                                                                                       |
|-------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------|
| The ctrl-click/cmd-click option of JEdit | to find theorems and constants available in the online version.                                  |
| If I could navigate to the definition of a type or a constant by clicking on it. |                                                                                                 |
| Summary/Outline Feature. Goto Definition/Usage Statistics about frequently used theorems. |                                                                                                 |
| Search for a lemma and a definition. Click & jump like in jEdit when navigating theory. |                                                                                                 |
| Linking https://search.isabelle.in.tum.de/ | would improve the search experience.                                                             |
| More structure and links in the HTML output. |                                                                                                 |
| Links from entities to where they are defined or proved. |                                                                                                 |
| Index of lemmas. |                                                                                                 |
| A proper search function. |                                                                                                 |
| A Sidekick of the theory. |                                                                                                 |
| Semantic search. |                                                                                                 |
| Ontology and ontology based search. |                                                                                                 |
| I don’t know |                                                                                                 |
| Maybe something like “sidekick” from Isabelle/jEdit. Maybe a better search. |                                                                                                 |
| Clickable terms with a link that leads to the definition!!! | that would be awesome! | Crossreferences; overlays that show information about terms. |                                                                 |
| Add some features from JEdit: highlighting of inner syntax, go to definition hyperlinks, search theorems and search constants functionality, text search across all files. Also: option to find all uses of a constant or lemma. |                                                                                                 |

Table 6: **Browsing Theory Scripts.** 16 people responded to this question and half of them requested the ability to be able to click on links to definitions, as available in Isabelle/jEdit. Following this was 7 requests for better search capabilities and 5 requests for SideKick functionality (an outline of the sections, lemmas, etc). One respondent suggested usage statistics of frequently used theorems.
Figure 10: **Ranking Priorities.** The ordering of priorities is consistent across the participants. Look and feel is a low priority which is congruous with the neutrality towards a redesign.
6 Summary

It is likely that people who are subscribed to the Isabelle mailing list and willing to answer the survey are active AFP users. This is reflected in the demographics and the familiarity of the audience should be kept in mind when interpreting the results.

The survey was taken by 30 participants and 29 of them answered all the parts. From Fleuriot et al. [4], there were around 600 contributing users on the mailing list in the seven year period of 2008 to 2015. We cannot tell whether the mailing list has grown or shrunk in the years since, but the number of responses seems adequate for the order of magnitude of the mailing list.

As the participants are mostly contributors to the AFP, their opinions are highly valued. The SUS score of 72 implies that they are generally satisfied with the AFP, which is a testament to the design decisions that have lasted almost 20 years. The pre-study score was much lower, 46, which seems to imply that non-contributors of entries to the AFP might be less satisfied. However a further study with a larger group would be needed to confirm this.

Three respondents described difficulty in finding existing functionalities and seven requested improvements to script search capabilities. Additionally, a majority of the participants struggle to find specific content in the AFP. As it is the second highest priority for users, it is clear that the AFP would be more useful if the search capabilities were improved.

The most important thing for participants was navigation and the results of the survey imply that it does not currently meet their needs. The sidebar is the main navigation area and it is not ordered in terms of frequency of use (Figure 5), audience (contributor vs non-contributor) or content (i.e. “Home” and “Index” are the only pages which list entries and they are separate). Participants also report mis-clicking, which could suggest link labelling is not clear or links are too small. It is also hard to find many different types of content as shown in Figure 4. Navigation is closely related to search, however, and many of these issues could be solved in other ways.

Finally, navigation improvements to script browsing were requested frequently – over half the respondents requested in-place links to entity definitions, i.e. to directly navigate to specific content. Similarly having an outline of the theory file, as SideKick provides in Isabelle/jEdit, was highly requested.

7 Conclusion and Further Work

Whilst a significant minority of responses hold that redesign is unnecessary, there are many specific criticisms with the current design as well as a general sentiment that several core features (specifically navigation, search, and theory browsing) could be improved.

Future work could broaden the evaluation to users who are unfamiliar with the AFP, to understand how first-time users understand the functionality of the website. This would be important to understand as it is crucial to the longevity of the project that new people can be on-boarded successfully.

Acknowledgement

We would like to thank all those who took part in this survey of the Archive of Formal Proofs. Our thanks also go to the developers and maintainers of the AFP for providing such a valuable resource to the theorem proving community.

References

[1] R. Likert, A technique for the measurement of attitudes, vol. 140 of Archives of psychology. New York: The Science Press, 1932.

[2] J. Brooke, “SUS: a quick and dirty usability scale,” Usability evaluation in industry, p. 189, 1996.
[3] M. Wenzel, “Isabelle/jEdit–a prover IDE within the PIDE framework,” in *International Conference on Intelligent Computer Mathematics*, pp. 468–471, Springer, 2012.

[4] J. D. Fleuriot, S. Obua, and P. Scott, “Social network processes in the Isabelle and Coq theorem proving communities,” *CoRR*, vol. abs/1609.07127, 2016.

A Survey Script

![Survey Image]

*Required

1. How often do you access the Archive of Formal Proofs? *
   - Select your answer

2. How long have you been using the Archive? *
   - Select your answer

3. Have you ever downloaded an Archive entry? *
   - Yes
   - No

4. Have you ever submitted an entry to the Archive? *
   - Yes
   - No

Next

Never give out your password. Report abuse
### Submitting entries

5. How much do you agree with the following *

| Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-------------------|----------|---------|-------|----------------|
| The submission instructions are clear | ☐ | ☐ | ☐ | ☐ | ☐ |
| The submission process is straightforward | ☐ | ☐ | ☐ | ☐ | ☐ |

6. What is your biggest pain point when submitting entries to the Archive?

Enter your answer

Never give out your password. Report abuse
7. For each of the following statements, please mark one box that best describes your reactions to the Archive of Formal Proofs as it is today. *

| Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-------------------|----------|---------|-------|---------------|
| I think that I would like to use the AFP frequently | ☐        | ☐       | ☐     | ☐             |
| I found the AFP unnecessarily complex | ☐        | ☐       | ☐     | ☐             |
| I thought the AFP was easy to use | ☐        | ☐       | ☐     | ☐             |
| I think that I would need the support of a technical person to be able to use the AFP | ☐        | ☐       | ☐     | ☐             |
| I found the various functions in the AFP were well integrated | ☐        | ☐       | ☐     | ☐             |
| I thought there was too much inconsistency in the AFP | ☐        | ☐       | ☐     | ☐             |
| I would imagine that most people would learn to use the AFP very quickly | ☐        | ☐       | ☐     | ☐             |
| I found the AFP very cumbersome to use | ☐        | ☐       | ☐     | ☐             |
| I felt very confident using the AFP | ☐        | ☐       | ☐     | ☐             |

8. What is your biggest pain point with the Archive? This could be with browsing entries, browsing scripts within entries, or any other feature of the AFP.

Enter your answer

Never give out your password. Report abuse
### Archive of Formal Proofs Survey

**Navigation**

9. For each of the following, please mark one box that best describes your reaction to the statement:

| Statement                                                                 | Disagree | Neutral | Agree |
|---------------------------------------------------------------------------|----------|---------|-------|
| It is easy to find specific entries in the AFP                          |          |         |       |
| It is easy to find entries on a topic                                   |          |         |       |
| It is easy to find entries by an author                                 |          |         |       |
| It is easy to find related entries to a specific entity                 |          |         |       |
| It is easy to find specific content - e.g. lemmas, definitions - in entries |          |         |       |

10. How often do you access the following pages:

| Page Description                        | Never | Rarely | Sometimes | Frequently |
|-----------------------------------------|-------|--------|-----------|------------|
| Home – List of entries                  |       |        |           |            |
| About – Description of the AFP          |       |        |           |            |
| Submission – Guidelines for submission |       |        |           |            |
| AFP Submission – Form that is used to submit an entry                    |       |        |           |            |
| Citing Entries – Citation style for AFP entries                           |       |        |           |            |
| Updating Entries – How authors should update their entries               |       |        |           |            |
| Using Entries – How to use entries                                          |       |        |           |            |
| Search – Find entries in the archive                                        |       |        |           |            |
| Statistics – Statistics about the archive                                   |       |        |           |            |
| Index – A list of entries and topics                                        |       |        |           |            |
| Download – A link to download the Archive                                   |       |        |           |            |
11. For an entry of the AFP, how often do you access the following: *

| Service                                                                 | Never | Rarely | Sometimes | Frequently |
|-------------------------------------------------------------------------|-------|--------|-----------|------------|
| Proof Outline – PDF of the lemmas of the entry in mathematical notation | ☐     | ☐      | ☐         | ☐          |
| Proof Document – PDF of the Isabelle script of the entry                | ☐     | ☐      | ☐         | ☐          |
| Browse Theories – HTML directory which allows you to browse the theories script | ☐     | ☐      | ☐         | ☐          |
| View theory dependencies – A PDF of the dependencies graph             | ☐     | ☐      | ☐         | ☐          |
| Download this entry – Downloads the entry                              | ☐     | ☐      | ☐         | ☐          |
| Older Releases – Previous releases of that entry in different AFP versions | ☐     | ☐      | ☐         | ☐          |

12. How often do you mis-click when navigating between pages? *

Select your answer

[Back] [Next]

Never give out your password. Report abuse
### Design

13. For each of the following, please mark the box that best describes your reaction to the statement.

| Statement | Strongly disagree | Disagree | Neutral | Agree | Strongly agree |
|-----------|-------------------|----------|---------|-------|----------------|
| I am satisfied with the look and feel of the AFP | ○ | ○ | ○ | ○ | ○ |
| The layout of the AFP is intuitive | ○ | ○ | ○ | ○ | ○ |
| The user interface - e.g. colours, icons, etc - of the AFP should be redesigned | ○ | ○ | ○ | ○ | ○ |
| The user experience - e.g. placement of menus, etc - of the AFP should be redesigned | ○ | ○ | ○ | ○ | ○ |

14. Do you browse theories within entries? *

- ○ Yes
- ○ No
Archive of Formal Proofs Survey

Required

Browsing theories within entries

Please visit the following link: https://www.isa-afo.org/browser.info/current/AFTP\Syntax_Independent_Logic\index.html

15. How satisfied are you with: *

|                                | Very dissatisfied | Somewhat dissatisfied | Neither satisfied nor dissatisfied | Somewhat satisfied | Very satisfied |
|--------------------------------|-------------------|-----------------------|-----------------------------------|-------------------|---------------|
| Browsing the theories          | ○                 | ○                     | ○                                 | ○                 | ○             |
| Finding specific contents - e.g. lemmas, constants - in a theory | ○                 | ○                     | ○                                 | ○                 | ○             |

16. What feature would improve browsing theory scripts?

Enter your answer

Never give out your password. Report abuse

This content is created by the owner of the form. The data you submit will be sent to the form owner. Microsoft is not responsible for the privacy, security, or accuracy of data you submit through this form.

Released: 5th April 2021
Final section

17. Please rank the following in order of importance to you *

- Navigation, like finding related entries on a topic
- Browsing scripts within theories
- Look and feel
- Searching the archive
- Statistics about the archive
- Submitting entries to the archive

Back Next

* Required

Never give out your password. Report abuse