A Semantically-Enriched Digital Portal for the Digital Preservation of Cultural Heritage with Community Participation

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Abstract. Understanding our past can determine our ability to understand the present. Many people associate cultural heritage with the ancient past and history; however, cultural heritage should be seen as a continuous tradition that lives through daily practices. In this paper, we present the details of our research dealing with one aspect of Balinese culture, the Balinese traditional communication system (*kulkul*), undertaken in the Indonesian island of Bali. The central aim of our project was to document, organize, and preserve the relevant *kulkul* knowledge for the benefit of the Balinese community, and the younger generations in particular by designing and developing a digital portal as a dynamic repository. A basic ontology of key *kulkul*-related concepts and terms and their interrelationships that as part of our digital portal was developed to support the semantic searching and browsing of the online portal and related resources. Much of the content for the digital portal was acquired through community-based crowdsourcing and the informants came from the different geographical areas in Bali. Members from the community were invited to contribute their knowledge to enable the online digital portal to evolve into a living repository of Balinese cultural knowledge. The significant number of digital cultural resources uploaded and the substantial growth of the *kulkul* ontology by the community are indicators of the success of this research project. The prototype digital portal is implemented on the cloud to facilitate elastic growth and easy user access to the resources both to read and to add content. Finally, the digital portal was made available online and extensive evaluation was carried out based on responses from selected users drawn from community by letting them use and experience the digital portal in order to evaluate the ease of use and usefulness. The evaluation results suggest that, for the most part, the users perceived the digital portal to be relatively useful and easy to use.

Keywords: Digital portal · Balinese culture · Balinese *kulkul*
Ontology

1 Introduction

The loss of cultural knowledge is not just a process that has occurred in the past; it is still happening today when access to traditional resources and traditional ways of life are limited and restricted for the younger generation. Traditional cultural knowledge is the knowledge that has accumulated from the contributions and historical experiences of many generations. It is clear that understanding the traditions of the past in the right context, depth, complexity, and diversity, is to re-affirm cultural identity in the present.

Today, the rapid development and adoption of digital technology such as the Internet and mobile technology have created an opportunity for cultural heritage preservation to be facilitated by these technologies. The digital preservation of cultural heritage offers new and innovative means of digital heritage knowledge representation and to link both the people who possess the heritage knowledge and others who want to acquire that cultural knowledge. Moreover, digital cultural heritage resources open new pathways for scholars, members of the community, and younger generation in particular, to represent, store, refine, maintain, share and continue to contribute to further development of cultural heritage knowledge.

Cultural heritage is an aspect of past experiences that carry important value for a society, and continues to change dynamically with time [1, 2]. Heritage is the opposite of nature, in that heritage is something that has been trained and learnt, while nature refers to the 'original' [3]. It is a form of a man-made heritage that is often context-rich and therefore evolves through a long and complex process rather than by a single action or creation [1, 4].

The tangible objects of cultural heritage are maintained by the material form in which they are encoded, stored, and replicated. A problem encountered in cultural digitisation projects is the preserving of information beyond the actual physical object, such as contextual and cultural practice-related information. Cultural heritage knowledge – specifically, cultural practices and traditions – are changing over time and evolving.

The central goal of this project is to digitally document and share information regarding one aspect of the Balinese cultural heritage – *kulkul*. The *kulkul* system is part of the Balinese traditional communication systems that varies from one Balinese village to another and remain being used in the Balinese community. We transformed the cultural knowledge and related practices into an explicit and digital form, in order for the public to add, refine, and share this knowledge. In this paper, we discuss the methods we employed to design, develop, implement, and to evaluate the semantically enriched digital portal for documenting and sharing one important aspect of Balinese cultural heritage.

2 Digital Portal Design, Development and Implementation

In our previous research, we have gathered a significant amount of information and that has contributed to a detailed understanding of the Balinese *kulkul* system and its diversity through in-depth interview with selected Balinese cultural experts. We have

proposed a knowledge classification framework based on the key Balinese cultural principal (*Tri Hita Karana* and *Desa Kala Patra*) to capture, classify, and organise the richness of *kulkul* related knowledge [5]. Drawing from the in-depth interview approach, we came out with the detailed *kulkul* specifications and features. Furthermore, we modelled the *kulkul* domain and developed the *kulkul* ontology in order to provide an abstract representation of the *kulkul* domain knowledge that can assist the users to engage with the computer systems in a meaningful manner [6]. Much of the *kulkul* digital content available in our digital portal was acquired, populated, and organised by the community-based crowdsourcing that came across different regency in Bali [6].

Our digital portal development employed a prototyping method that focused on the full functionality of the key aspects of the final IT artefact. We used the freely available open source tools and integrated them into our digital portal architecture [6]. We developed our platform from scratch with the aim of maximizing the integration between the modules that we prepared in of the each stages of the prototype development. We can break down our application into three main modules that support the following services:

1. Populating content: allows multiple online users to contribute their knowledge by populating detailed content on Balinese *kulkul*.
2. Browsing: allows users to browse through different parts of the ontology by navigating through *kulkul* classification hierarchies.
3. Searching: lets users construct a query relating to one or more attributes of the *kulkul* artefact or practices as inputs, and displays a selected attribute for the output.

It is important that the appearance and level of fidelity of the prototype is accepted by the potential users. During the early stages of the digital portal development, we focused on developing a mid-fidelity prototype with a mock-up graphical user interface (GUI) to demonstrate and communicate the idea, and to provide a draft functionality of the artefact. The medium-fidelity prototyping tools and methods focus on the ease of production as well as the supporting detail of the design for direct manipulation. Also, the detailed information about functionality, navigation, and the layout of the content is presented without involving detail on programming [7]. To realise our artefact, the JustInMind[1] prototyping tools were used to enabled us to simulate and present the prototype either offline (without the Internet connection) or, by uploading the object to the cloud services, users could try and experience it using a web browser over the Internet. In developing the digital portal mid-fidelity prototype using the JustInMind tools, we adopted the steps and method proposed by Engelberg and Seffah [7] (see Fig. 1).

After all the steps and iterations of the prototype design process were completed, we demonstrated the artefact to the researchers for feedback and approval. This was followed by the systematic development of the actual IT artefact.

The digital portal, which has been made available online at http://ccbp.oss.web.id, was developed to ease the task of recording and preserving cultural heritage,

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[1] https://www.justinmind.com.

specifically of the Balinese *kulkul*, and to enable people to access, share, and contribute to this knowledge. This semantic-enriched digital portal relies heavily on the *kulkul* ontology. The *kulkul* ontology was populated in the previous study through community-based crowdsourcing [6].
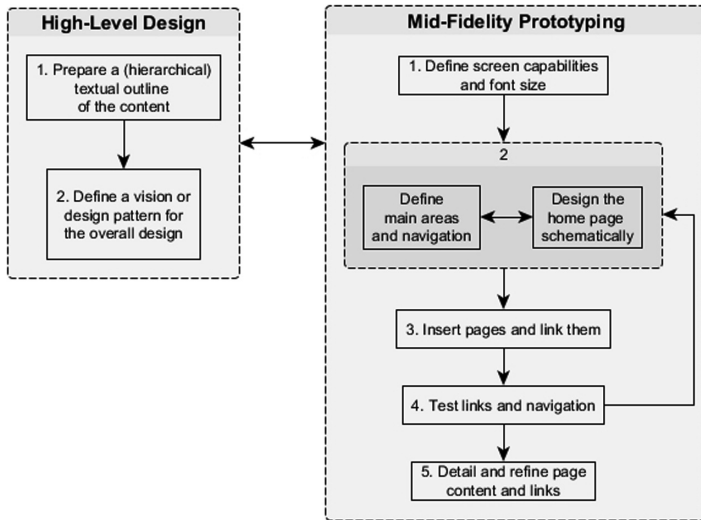
Fig. 1. Mid-fidelity prototyping steps. Adopted from "A framework for rapid mid-fidelity prototyping of web sites" by Engelberg and Seffah [7].

2.1   Browsing Facility

The browsing module that we developed allows the user to explore the *kulkul* information available at the digital portal by following one interesting link to another, usually with a definite objective but without a planned search strategy. Furthermore, using this module allows the user to navigate the browsing activity to a different part of the *kulkul* classification hierarchies.

The front page of this module, as shown in Fig. 2, provides users a summary on the districts, villages and *banjar* in each regency for which content data were inserted and updated by the Community-Based Crowdsourcing we conducted in our previous study [6]. The calculation process calculates the transitive path of object properties in the OWL (thk:isPartOf) and the number of instances in each district (*kecamatan*), village (*desa*) and *banjar* class. Further, the number of instances is classified and organised by regency (*kabupaten*) see the SPARQL query against the RDF triple store below.

```
$result1 = $sparql->query(
  "SELECT ?kabupaten (SUM (?total) AS ?totaldesa)
  {SELECT ?kabupaten (COUNT (?desa) AS ?total)
  WHERE
  {?kabupaten a thk:Kabupaten .
  ?desa a thk:Desa;
  thk:isPartOf* ?kabupaten .}
  GROUP BY ?kabupaten ?desa }
  GROUP BY ?kabupaten
  ORDER BY ?kabupaten ");
$result2 = $sparql->query(
  "SELECT ?kabupaten (SUM (?total) AS ?totalbanjar)
  {SELECT ?kabupaten (COUNT (?banjar) AS ?total)
  WHERE
  {?kabupaten a thk:Kabupaten .
  ?banjar a thk:Banjar;
  thk:isPartOf* ?kabupaten .}
  GROUP BY ?kabupaten ?banjar}
  GROUP BY ?kabupaten
  ORDER BY ?kabupaten ");
```
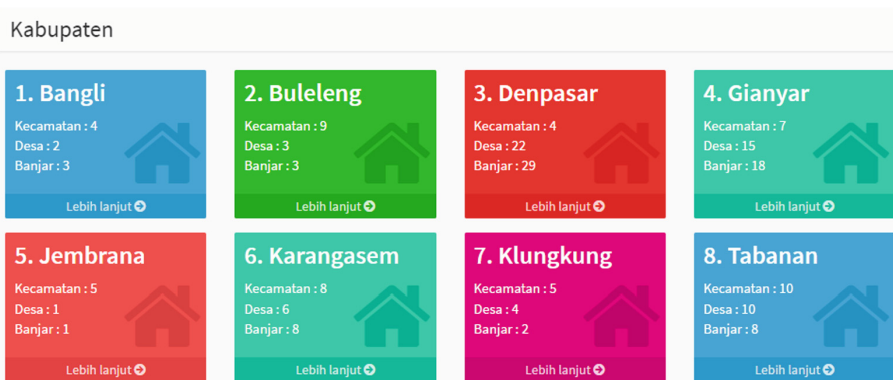

Fig. 2. Counting the number of district, village, and *banjar*.

2.2   Search Facility

The search facility was developed to give the user flexibility to find the relevant digital resources by constructing multiple criteria for the query. First, the user should select one output query: in other words, what are they looking for. For instance, the user may like to know the location of the *kulkul*, the number of *kulkul* installed at the particular

location, the raw material of *kulkul*, and so forth. Second, the user should select at least one input query filter, so the digital portal can search the available resources using the semantic relationships of the constructed query. For example, finding a *kulkul* that is used for *manusa yadnya* activity, installed in Gianyar regency, with has a height of between 150 and 170 cm, and so forth. By giving more criteria for the search, the systems will try to follow the semantic link for each criterion (class, object property, data property and instance) that is available in the digital portal (see program code below for a query example and Fig. 3 shows the graphic user interface of the search facility).

```
SELECT DISTINCT (?tempat as ?output)
{ ?kulkulName thk:numberKulkul 1 .
?tempat thk:hasKulkul ?kulkulName .
?kulkulName thk:isUsedFor ?aktivitas .
?aktivitas a thk:ManusaYadnya .
?tempat thk:hasKulkul ?kulkulName . }
ORDER BY ?output
```

As shown in Fig. 3, the user should select at least one output filter query and can select more than one input filter query in order to construct the semantic query in the digital portal. At the right side of the interface, we print the SPARQL query when the system executes the user query. This output is used for the purpose of research, to check whether the system performs the right query.

Fig. 3. *Kulkul* used for *manusa yadnya* activity where one *kulkul* is installed, in any location.

3   Digital Portal Demonstration and Evaluation

The aim of this evaluation was to understand whether the users found the digital portal useful and helpful from the perspective of learning about the Balinese *kulkul* artefact and related practices. This evaluation was designed to assess users' perceptions of the usefulness and ease of use of the digital portal. Perceived usefulness is defined as "the degree to which a person believes that using a particular system would enhance his or

her job performance" [8, p. 320]. Perceived ease of use refers to "the degree to which a person believes that using a particular system would be free of effort" [8, p. 320]. The following sections describe in detail the process of evaluation and analysis.

3.1   Participants and Data Collection

This study was carried out over three months. Participation in the study was voluntary. None of the participants had been involved in any of our previous data acquisition surveys related to this project. Participants were recruited from the student and staff networks of three universities in Bali (Universitas Udayana, UNDIKNAS University and Universitas Pendidikan Ganesha), and other communities in Bali. The Universitas Udayana was chosen for the research because of its reputation as a repository of Balinese cultural knowledge and expertise. The UNDIKNAS was selected because this university is recognised as one of the best private universities in eastern Indonesia, and currently there are more 3,000 students enrolled in this university. The Universitas Pendidikan Ganesha (Undiksha) was chosen because it is the second largest university in Bali and is located on the north island of Bali (Buleleng Regency). Currently, the Undiksha employs around 700 staff and 11,400 active students. Our study intended to involve participants from a variety of backgrounds.

The participant recruitment and evaluation process is shown in Fig. 4. Once the participants agreed to take part in the study, they were put through a short training session using the tutorial video that we provided on the digital portal. The tutorial video outlined the steps required for this study. After viewing the tutorial video, all participants were required to provide their online consent and then conduct a range of browsing and searching tasks using the features and facilities available in the digital portal. Finally, all participants were invited to respond to a small set of questions regarding the usefulness and ease of use of the digital portal.
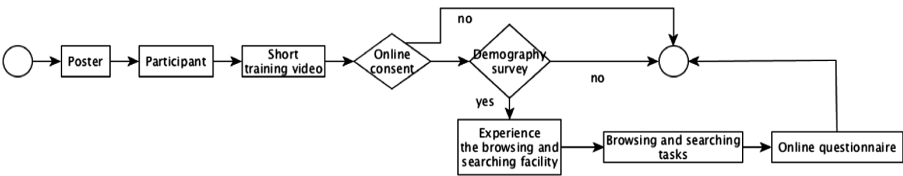

Fig. 4. Evaluation process

The data used in this research was collected using an online questionnaire that we developed, and the data gathered was logged at the portal. The study was carried out over several sessions or days to enable us to improve the performance of the system when the participants reported bugs in the digital portal. Before the evaluation started, all the participants were asked to watch an eight-minute tutorial video provided on our digital portal. The tutorial video informed participants about how the system works and what the participants should do during the study. The tutorial video explained how to use the semantic browsing and semantic searching facilities in the digital portal. The operation of a semantic search is significantly different to the text- and keyword-based search service that is commonly available in many Web applications. For a text-based

search, the user types any text string and the system will match it with the available data. However, in our semantic search, the user selects only the available classes and instances that are part of the ontology and the RDF data store

After the above steps were completed, participants were asked to perform two sets of tasks. Firstly, participants were asked to undertake five browsing tasks (exploration of the World Wide Web by following one interesting link to another) on the browsing module (Fig. 5). In each browsing task, participants were required to answer a question by constructing two elements of the query using the digital portal browsing module. Here is an example of the browsing question:

– List two (2) name of villages (*desa adat* or *desa pakraman*) that use *kulkul* for *manusa yadnya* activities.
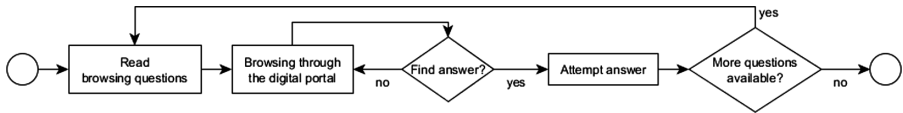

Fig. 5. Browsing task flowchart

Secondly, participants were expected to perform five searching tasks (request for a piece of information from a database) using the digital portal searching module. In order to be able to answer the questions using the searching facility, the participants were required to construct two or more elements of the query as input filters and form one category query from the *kulkul* ontology hierarchy as the output filter (Fig. 6), and follow up by clicking the search button. Here is an example of the searching question:

– List two (2) name of the raw material that uses for *kulkul*, where are *kulkul* installed two (2) in each location, the direction of installing is face to face, and has height 160 cm
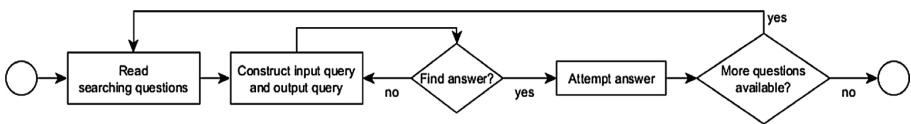

Fig. 6. Searching task flowchart

In the first stage of the evaluation, we performed a pilot study with only 15 participants to see whether the users could successfully complete the task using the digital portal. Based on this small sample of participants, we examined whether significant errors were due to bugs in the system. Using this data, we performed debugging and made some adjustments to the digital portal before inviting more participants to undertake the evaluation.

After performing the browsing and searching tasks, all participants were invited to answer a small set of questions regarding the ease of use and usefulness of the digital portal. We adopted the questionnaire constructed by Davis [8], in which we focused on two dimensions: perceived usefulness (PU) and perceived ease of use (PE). The perceived usefulness (PU) comprised of five items:

1. Using the digital portal would enable me to accomplish tasks more quickly.
2. Using the digital portal would improve my task performance.
3. Using the digital portal would enhance my effectiveness in performing my tasks.
4. Using the digital portal would make it easier to do my tasks.
5. I would find the digital portal useful to finish my tasks.

The perceived ease of use (PE) comprised of three items:

1. I would find it easy to get the digital portal to do what I want it to do.
2. I would find the digital portal to be flexible to interact with.
3. I would be easy for me to become skillful at using the digital portal.

The items are measured using 7-point Likert scale (strongly agree = 7, agree = 6, somewhat agree = 5, neither agree nor disagree = 4, somewhat disagree = 3, disagree = 2, and strongly disagree = 1). Moreover, participants were invited to add further comments and suggestions if they wished.

Aside from two constructs (PU and PE), we added additional questions to determine whether the video tutorial (VT) that we provided helped the participants to understand and perform their tasks:

1. The video tutorial provided is useful for me to understand the use of digital portals.
2. It is easy for me to understand the tutorial video material provided.

The back-translation method [9] was adopted to ensure the reliability of the instrument in different source languages. Thus, all questions in the questionnaires were given in Bahasa as the targeted participants were fluent in Bahasa.

3.2   Data Analysis and Results

A total of 90 participants responded to our invitation. However, we were only able to use 68 usable responses because some of them completed the questionnaires without performing the tasks or did not respond to all the questions. Also, some of the participants did not complete the semantic browsing or semantic searching tasks. Such incomplete data could not be included in the analysis.

Among the 68 participants in our study, 75% were male and 25% female; 91% were Balinese Hindu, 66% part of a Balinese community (*sekaa banjar, sekaa truna truni* and *sekaa gong*) and 94% were university students or had a university degree.

Browsing Tasks
All activities and interactions of the participants with the digital portal, such as the times at which the online user started and finished the tasks, were recorded automatically in the log file. The log file was used to analyse the efficacy of the digital portal and the perceived levels of ease of use and usefulness of the portal information by the participants. On average, participants spent 86 min to complete the given tasks, with a minimum of 15 min and a maximum of 260 min. After the participants finished performing the browsing tasks, we marked each one of the submissions. We classified the marking skim into three categories:

1. Wrong. This score was given when the participant did not give the correct answer to the given task.
2. Partially correct. This score was given when the answer matched any required criteria.
3. Fully correct. This score was given if the participant gave an entirely correct answer to the question.

Using these criteria above, 71% of the participants answered the question correctly, and 11% did not give an answer that was close to the requirement.

Search Task
Similar to the browsing tasks, we marked each of the answers attempted by the participants. We used the same scale (wrong, partially correct and fully correct) as that used for the browsing task to evaluate the answers. On average, 68% of the answers given by participants to the questions using the semantic searching modules were entirely correct, and 15% of the answers were wrong.

Perceived Usefulness and Perceived Ease of Use
After all the participants had completed the browsing and searching tasks, they were invited to answer a small set of questions related to the perceived usefulness and perceived ease of use of the digital portal. To analyse the questionnaire outcomes, the following statistical analyses were conducted using SPSS:

– Kaiser-Meyer-Olkin (KMO) Measure of Sampling Adequacy analysis was conducted to ensure that there was adequate and high variability in the collected data for factor analysis.
– Bartlett Test of Sphericity was conducted to ensure that the items of the instrument were sufficiently correlated.
– Reliability test (Cronbach's alpha) was conducted to find internal consistency among the items.
– One-sample t-test was conducted to determine whether the system is perceived as easy to use and useful.
– Principal component analysis with varimax rotation was conducted on the collected data. This method was used to determine the number of factors or principal components to retain.

Kaiser-Meyer-Olkin Measure of Sampling (KMO) and Bartlett's Test of Sphericity are measures of sampling adequacy that are recommended to check the case-to-variable ratio for the analysis being conducted. The collected data were inspected through KMO with a value of 0.853. High values close to 1.0 indicate that conducting a factor analysis on the data will be suitable. Also, as a rule of thumb, KMO values between 0.8 and 1 indicate the sampling is adequate. The results of the Bartlett Test of Sphericity (approximate chi-square = 358.458, df = 28, sig. = 0.005) with a small value of significance level (less than 0.05) indicated that a factor analysis may be useful and was suitable for the collected data.

The reliability of the items was assessed with Cronbach's alpha. The calculated alpha was 0.922 for perceived usefulness (PU) and 0.833 for perceived ease of use (PE) which is above the minimum threshold of 0.7 [10]. Hence, the reliabilities are deemed sufficient.

For ease of interpretation and to assess users' perception of the portal, we averaged participants' raw scores on each of the above two component items (PU and PE). Also, due to the exploratory nature of this research element, we treated the above scores with the equal weights [11]. The results indicate that the users' perceived usefulness (PU) and the users' perceived ease of use (PE) of the digital portal score was statistically significantly higher than the middle point of 4.0 (see Table 1). Additionally, with more than 91% of the total users responding on the agree scale point the results suggest that generally, the users perceived the usefulness and ease of use with of the digital portal to be positive.

Table 1. One-sample t-test

Constructs	t	df	p	SD	mean
PU	19.605	67	0.005	0.82	5.95
PE	21.493	67	0.005	0.71	5.85
VT	22.491	67	0.005	0.80	6.18

Multimedia Tutorial Resources

As previously noted, we added two additional questions apart from the perceived usefulness and perceived ease of use. These additional questions aimed to assess whether the given video tutorial (VT) helps the user to finish the browsing and searching tasks. Similar to the PU and PE, the reliability of the items was assessed with Cronbach's alpha to find internal consistency between the items. The calculated alpha was 0.835 which is above the minimum threshold of 0.7. Therefore, the reliabilities are deemed sufficient to be used for evaluation.

The result indicates that the users' perceived usefulness of the tutorial video (VT) score was statistically significantly higher than the middle point of 4.0 (see Table 1). Therefore, with more than 95% of the total users responding on the agree scale point, and none of them responding on the disagree scale point, the result suggests that generally the users perceived the video tutorial to be helpful in finishing the given tasks.

Apart from the questions on perceived ease of use, usefulness and multimedia tutorial resources, we added additional questions to capture the individual users' comments and suggestions for further improvements.

The suggestions of the users after they evaluated the digital portal gave us positive feedback that was helpful for making improvements, which we have since made. Furthermore, three participants contacted us to ask whether they could have access to the portal to populate the *kulkul* details for their village, because they saw that some of the *kulkul* details of their village or *banjar* were not entirely populated. They were aware that doing so would help to capture and document their traditions over time, and also to help the next generation to learn more about their heritage.

4 Conclusion

We have presented the details of our research dealing with one aspect of the Balinese cultural heritage, the Balinese traditional communication system (*kulkul*). Our contributions include the development, implementation, and evaluation of the community-

based and semantic-enriched digital portal that enable the public to add, refine, and share previously fragmented knowledge about one aspect of the Balinese cultural heritage.

Our study involved 68 participants from three universities and communities in Bali to evaluate the main features of our digital portal (semantic browsing and semantic searching) in term of ease of use and usefulness. The results suggest that, for the most part, the users perceived the usefulness and ease of use of the digital portal to be positive. Furthermore, the requests by some participants of this study to be contributors to add content to the digital portal based on their knowledge of aspects of *kulkul* indicates a positive commentary on the project. Work is ongoing to develop the prototype further and to populate it fully before it can be installed in one of the memory institutions in Bali (e.g. Bali Museum).

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