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Improvement of identification keys by user-tracking

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Abstract — Identifications keys are indispensable tools for identifying organisms and understanding biodiversity. It is therefore advantageous to give a broad public access to these tools. Due to the fact that these tools are used by very different target groups – pupils, students, researchers, etc. – customisation and quality enhancement are crucial for effective and appealing identification keys. The evaluation of key software by inquiring users is always influenced by various, often subjective impressions and is usually restricted to a small number of them. The identification keys developed in the framework the *KeyToNature* project are available on electronic devices and allow registering the actions of single users during the identification process. By transferring user actions to an Learning Management System (LMS) like ILIAS OpenSource, where they can be correlated to user-data like experience in the field of identification, courses visited, age etc., it is not only possible to identify the problems a individual user did encounter and the mistakes he made, but also to conduct statistical evaluations to review and substantially improve the keys, to solve problems with single questions, and to optimise customisation to the different user groups.

Index Terms — identification keys, user-tracking, eLearning, Rich Internet Application, customisation, evaluation.

1 Introduction

Identification keys (id-keys) are indispensable tools to identify organisms, which is a basic process for understanding nature and preserving biodiversity. The European project *KeyToNature* aims at developing and improving identification keys for all media, including electronic devices such as smartphones and all types of computers. [1]. This form of electronic keys permits – as a fundamental new possibility – to record every action performed by users of a key, which is named here “tracking-feature”. Every wrong alternative chosen by the user, every achieved species name, accepted as right or rejected as wrong, can be registered. Gathering these information in a Learning Management Software (LMS) [2], where it can be related to all user-

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specific data (pre-knowledge, courses taken, age) enables a new benchmarking of identification software and keys.

Therefore an add-on for the LMS ILIAS [3] was developed, that consists of a *logging service* to record every action a user performs in an id-key, and an *evaluation service* that performs basic statistical analysis for continuous monitoring and quality enhancement.

The "*logging service*" in connection with the "*tracking feature*" inside the *Flex Player* [4] or the *Open Key Player* [5, 6] enables us to track user behaviour for continuous improvement of id-keys, to correlate the results with user groups: age, education, previous experiences etc., and to gather an enormous amount of information about how users use the key.

The "evaluation service" with filtering and exporting features offers automated-evaluation processing at low efforts, testing the eligibility of keys for user groups (e.g. age) by the filtering feature and exporting all information for further and more detailed analysis.

2 What we want to know exactly

The above described services aim at continuously providing updated user requirements for the further development and customisation of the id-keys. More concretely, information such as: How long users need to orient themselves in the key (especially true for multi-access id-keys)? How does the user navigate in the key (choose an alternative, undo a choice, and restart because of feeling lost)? How long does a user need to answer every single question? How much time does a user need for one identification run? Does she or he reach the correct result at the first attempt? Does she or he feel satisfied or certain to have correctly identified the organism? How long does she or he use the key at all?

Additionally it is also extremely interesting to analyse the influence of pre-knowledge and use of the id-key, as well as the specific pedagogical settings. Furthermore, it is most interesting to investigate further factors that influence the results, such as age, gender, school type, etc.

To answer these questions, it is necessary to get information about every single event within the usage of a key, and its duration. All data are gathered by the logging service, and a first automatic analysis is performed by the evaluation service that was first developed for ILIAS and in the Open Key Player (single-access keys) and the Flex Player (multi-access keys).

3 How does the process work

3.1 Integration Overview

The information flow in the collaboration between the LMS (ILIAS) and the key software is shown in Fig. 1.

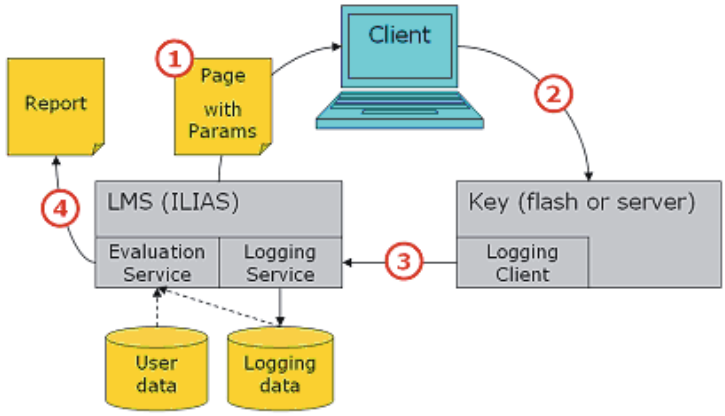

Fig. 1 – Information flow LMS - User - Key-Software - LMS - Outside.

3.2 Data transmitted to the Key (Step 1 and 2)

The information transmitted to the Open Key Player software consists of the name of database to be used by the Player, a reference-id to specify the ILIAS object representing the key, and a user-specific session-id to correlate the tracking of data to the individual user when they are sent back to the LMS.

3.3 Logging of User Interactions (Step 3)

The key sends back every user action to the LMS by appending them to the URL of the logging service, together with the reference-id and the session-id. The log entry is written by ILIAS only if the session_id is valid. The logging service is responsible to add a time stamp to every action recorded.

3.4 Evaluation Service (Step 4)

The evaluation service inside the LMS performs the tasks of filtering and exporting the log events by user profile data (age range, education, precognition, e.g., lessons or courses attended before the key was used). It is also able to perform a first analysis of data such as a count of the total number of key sessions (how often the key was used at all), the average time of a key session (is the key exciting or boring to the users?) or the average time to answer a question (is it simple or difficult?). It can also count how often an answer was revised, etc.

4 Logging events provided by the key respectively by the key-player software

The information sent back by the key and logged by the LMS was designed to serve a broad list of types of keys, and should be open for future developments. Therefore it was decided to log four parameters that can be freely filled with text-

strings or numeric values.

4.1 Example for tracking a multi-access key

Multi-access keys were the first type for which user-tracking was established. In this type of keys, users can select the question they want to answer first, so that they need some time to orient themselves in the key. At the end of the identification they can decide if they are confident with the result or if they want to restart the determination process. With the sorting and filtering feature of the logging service the log-events can be filtered and exported for further evaluation.

USER	TIME	EVENT TYPE	EVENT SUBTYPE	VA	EVENT TEXT
user, root	2009-09-25 11:11:36	Flex Key Player Start	Application First Load	0	
user, root	2009-09-25 11:12:16	Identification Step	Character Selected	0	Does it have legs?
user, root	2009-09-25 11:12:20	Identification Step	State Selected	0	Yes, it has legs
user, root	2009-09-25 11:12:20	Identification Step	First Step Taken	0	Character: Heeft het dier poten?; State: Ja, di
user, root	2009-09-25 11:13:00	Identification Step	Character Selected	0	What is the colour on the back?
user, root	2009-09-25 11:13:05	Identification Step	State Selected	0	Black and yellow
user, root	2009-09-25 11:13:05	Identification Step	New Step Taken	0	Character: Wat voor kleur kun je zien op de ru
user, root	2009-09-25 11:13:05	Identification End	Success	0	Identification ended with result: Salamandra s
user, root	2009-09-25 11:13:11	Identification End	User is satisfied with result	0	Identification ended with result: Salamandra s
user, root	2009-09-25 11:13:21	Application Reset	Reset	0	Reset caused either by user pushing Reset b
user, root	2009-09-25 11:13:21	Flex Key Player Start	Application First Load	0	
user, root	2009-09-25 11:13:28	Identification Step	Character Selected	0	Does it have a tail?
user, root	2009-09-25 11:13:31	Identification Step	State Selected	0	Yes, it has a tail
user, root	2009-09-25 11:13:31	Identification Step	First Step Taken	0	Character: Heeft het dier een staart?; State: J
Pupil, 1	2009-09-25 11:20:30	Flex Key Player Start	Application First Load	0	
Pupil, 1	2009-09-25 11:28:43	Identification Step	Character Selected	0	Does it have legs?
Pupil, 1	2009-09-25 11:28:45	Identification Step	First Step Taken	0	Character: Heeft het dier poten?; State: Ja, di
Pupil, 1	2009-09-25 11:28:45	Identification Step	State Selected	0	Yes, it has legs
Pupil, 1	2009-09-25 11:28:55	Identification Step	Character Selected	0	Does it have a carapace?
Pupil, 1	2009-09-25 11:28:57	Identification Step	New Step Taken	0	Character: Heeft het dier een schild op zijn ru
Pupil, 1	2009-09-25 11:28:57	Identification Step	State Selected	0	Yes, it has a carapace
Pupil, 1	2009-09-25 11:28:57	Identification End	Success	0	Identification ended with result: Trachemys sc
Pupil, 1	2009-09-25 11:29:06	Identification End	User is NOT satisfied with result	0	Identification ended with result: Trachemys sc
Pupil, 1	2009-09-25 11:29:14	Application Reset	Reset	0	Reset caused either by user pushing Reset b
Pupil, 1	2009-09-25 11:29:14	Flex Key Player Start	Application First Load	0	
Pupil, 1	2009-09-25 11:29:17	Identification Step	Character Selected	0	Does it have legs?
Pupil, 1	2009-09-25 11:29:22	Identification Step	State Selected	0	Yes, it has legs
Pupil, 1	2009-09-25 11:29:22	Identification Step	First Step Taken	0	Character: Heeft het dier poten?; State: Ja, di
Pupil, 1	2009-09-25 11:29:36	Identification Step	Character Selected	0	What is the colour on the back?
Pupil, 1	2009-09-25 11:29:39	Identification Step	New Step Taken	0	Character: Wat voor kleur kun je zien op de ru
Pupil, 1	2009-09-25 11:29:39	Identification Step	State Selected	0	Black and yellow
Pupil, 1	2009-09-25 11:29:39	Identification End	Success	0	Identification ended with result: Salamandra s
Pupil, 1	2009-09-25 11:29:42	Identification End	User is satisfied with result	0	Identification ended with result: Salamandra s

Fig. 2 – Tracking example for a multi-access key
(the lines have been coloured manually).

Data are sorted by user and time, so that the actions of single users within the key can be easily observed. For example, pupil 1 performs an identification step but is “NOT satisfied with the result” reached in the first step of the identification. Thus, he does an “Application Reset” and finishes with the correct result. Statistical analysis of large amounts of tracking data can identify certain questions that often lead to wrong results, or are re-visited many times. Accordingly, these specific questions are improved and closely evaluated in further testing events.

4.2 Example for the tracking of a single-access key

The following table was extracted from the log file of a determination of trees and shrubs in a Romanian school. The “History revision” (marked in yellow) represents selections that have been revised. The option number 198 was independently re-visited by more pupils, which indicates that this alternative is not clear enough.

User	Time stamp	event_type	event_subtype	event_integer	event_text
				question number	selected alternative
keytopm14	09:50:04	Identification Step	Character Selected	182	Plante cu diferite caractere
keytopm14	09:50:08	Identification Step	Character Selected	185	Plante nepungente, f?r? spini
keytopm14	09:50:20	Identification Step	Character Selected	198	Frunze cu contur mai mult sau mai pu?in t
keytopm14	09:50:25	Hystory Revision	Character Selected for Revsion	198	Frunze cu contur mai mult sau mai pu?in t
keytopm14	09:50:27	Identification Step	Character Selected	198	Frunzele nu au contur triunghiular sau rom
keytopm14	09:50:36	Identification Step	Character Selected	205	Frunze truncate, cordate sau hastate la ba
keytopm14	09:50:39	Identification Step	Character Selected	206	Marginea frunzei din?at?
keytopm14	09:50:41	Identification Step	Character Selected	207	Frunze verzi pe ambele fe?e, nu sunt puter
keytopm14	09:50:50	Identification Step	Character Selected	209	Fruct diferit
keytopm14	09:50:53	Hystory Revision	Character Selected for Revsion	209	Fruct diferit
keytopm14	09:50:54	Identification Step	Character Selected	209	Fruct uscat ?i dezvoltat pe pedicel lung, cu
keytopm14	09:50:59	Identification Step	Character Selected	210	Fa?a inferioar? a frunzei cu peri ruginii la b
keytopm14	09:50:59	Identification End	Success	0	Identification ended with result: Tilia cordat
keytopm14	09:51:09	Identification End	User is satisfied with result	0	Identification ended with result: Tilia cordat
keytopm15	09:35:17	Application Start	Start	0	Identification started
keytopm15	09:35:34	Identification Step	Character Selected	1	Plante înr?d?cinate în sol
keytopm15	09:36:13	Identification Step	Character Selected	185	Plante nepungente, f?r? spini
keytopm15	09:36:16	Identification Step	Character Selected	198	Frunzele nu au contur triunghiular sau rom
keytopm15	09:36:23	Identification Step	Character Selected	205	Frunze rotunjite sau îngustate la baz?
keytopm15	09:36:28	Hystory Revision	Character Selected for Revsion	198	Frunzele nu au contur triunghiular sau rom
keytopm15	09:36:30	Identification Step	Character Selected	198	Frunze cu contur mai mult sau mai pu?in t
keytopm15	09:36:42	Hystory Revision	Character Selected for Revsion	185	Plante nepungente, f?r? spini
keytopm15	09:36:51	Identification Step	Character Selected	185	Plante nepungente, f?r? spini
keytopm15	09:36:56	Identification Step	Character Selected	198	Frunzele nu au contur triunghiular sau rom
keytopm15	09:37:42	Identification Step	Character Selected	209	Fruct uscat ?i dezvoltat pe pedicel lung, cu
keytopm15	09:37:49	Identification Step	Character Selected	210	Fa?a inferioar? a frunzelor cu peri albicio?i
keytopm15	09:37:52	Hystory Revision	Character Selected for Revsion	210	Fa?a inferioar? a frunzelor cu peri albicio?i
keytopm15	09:38:18	Identification Step	Character Selected	210	Fa?a inferioar? a frunzei cu peri ruginii la b
keytopm15	09:38:18	Identification End	Success	0	Identification ended with result: Tilia cordat
keytopm15	09:39:27	Identification End	User is satisfied with result	0	Identification ended with result: Tilia cordat

Fig. 3 – Tracking example for a multi-access key (Grey lines represent tracking events that have been removed to restrict the length of the table).

5 Feedback from the user tracking to the key builders by analysis of the logfile

Without any explicit analysis, simply by sorting and filtering functions, the logfile provides insight into how single users move in the key, how many times they reached a result, rated it as right or wrong. It also provides a list of the species they found with the key or how many organisms they tried to identify. The logfile of the user tracking can be statistically analysed, basically in the LMS with the evaluation service itself, and in a more extended and detailed way when exported as an Excel-sheet for further analysis.

The following calculations may be used as feedback to improve the key and are directly provided by the logging service in the LMS:

1. Key starts / Results assumed as correct or wrong
2. Time to select a question (multi-access keys only)
3. Time to answer a question
4. Time to successfully identify a species
5. Most selected questions (multi-access keys only)

To get additional, statistical information, the log-file can be exported for more detailed analysing.

school 1	Species given	Species found	Identification ended	Not satisfied	Satisfied
	Abies alba	Abies alba Mill.	7		7
		Abies nordmanniana (Steven) Spa	3		2
		Actinidia chinensis Planch.	1		
	Aesculus hippocastanum	Aesculus hippocastanum L.	7		6
		Bruckenthalia spiculifolia (Salisb.)	1		1
	Buxus sempervirens	Buxus sempervirens L.	1		
		Campsis radicans (L.) Seem.	1		1
		Cupressus sempervirens L.	1		
	Ginkgo biloba	Ginkgo biloba L.	10		10
		Hippophaë rhamnoides L.	2	1	
		Juniperus communis L.	1		
		Juniperus communis L. subsp. na	4		1
		Loranthus europaeus Jacq.	3		2
		Maclura pomifera (Raf.) C.K. Schr	2	1	1
		Myricaria germanica (L.) Desv.	1	1	
	Picea abies	Picea abies (L.) H. Karst.	2		1
		Picea pungens Engelm.	1		
		Populus alba L.	1		
	Populus nigra	Populus nigra L.	6		5
		Satureja montana L.	1		
		Taxodium distichum (L.) Richard	1		
		Taxus baccata L.	2		1
	Thuja occidentalis	Thuja occidentalis L.	6	1	5
	Thuja orientalis	Thuja orientalis L.	7		5
	Viscum album	Viscum album L.	11		10

Pupils:	18
Identifcation total	83
Identifications minus "not satisfied"	4
Identifications affirmed with "satisfied with result"	58
Events	841
Events / Pupils	47

Fig. 4 – Log-File of class A after second level analysis. “Species found” refers to the result the identification.

6 Reliability and Performance

The testing events that took place in a Romanian school have been conducted with two classes, concurrently using the Open Key Player software that was fed by a Dutch database, sending the log data to a LMS hosted in Germany. Nearly 4000 datasets were recorded without problems and without significant load to the servers. The logging service is estimated to be reliable and scalable, and able to gather large amounts of information about the usability of keys in Europe.

7 Conclusions

The combination of identification tools with tracking features and a logging and evaluation service in an LMS can give objective information about user behaviour and the quality of identification keys. The filtering features allow differentiating the appropriateness of keys for different user groups and enable the authors of keys to improve them over time, adapting them to the needs of different target groups. The application is robust and reliable, and can handle a high number of concurrent users. As the actual evaluation of a single key can be conducted by hundreds of LMS-Systems, the next step will be to hand back user-specific quality indicators to the key or the key-database by means of the key-player software.

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