Computer Aided Archaeology

03 - Database 1

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Database then

source: https://www.ssa.gov

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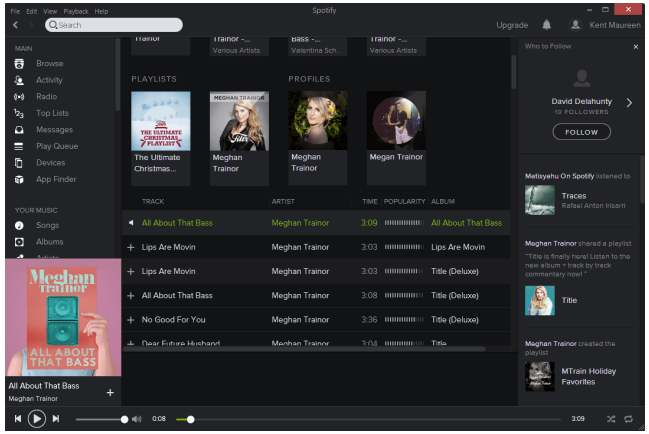
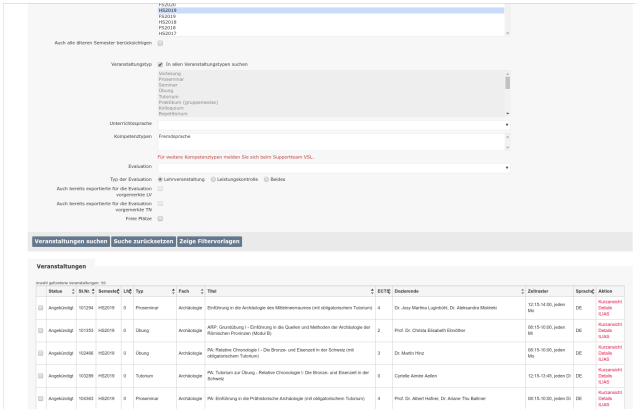
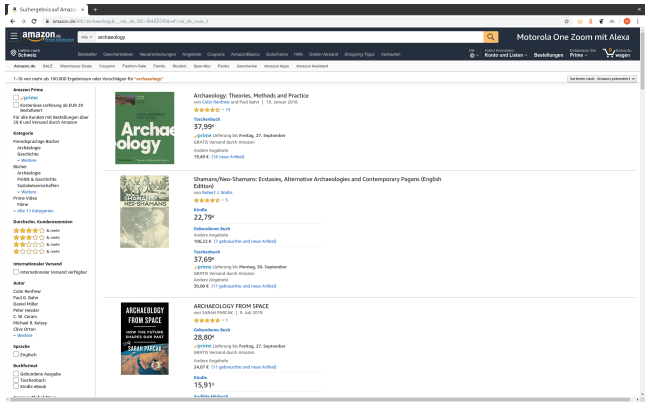
Database now



source: https://lifewire.com



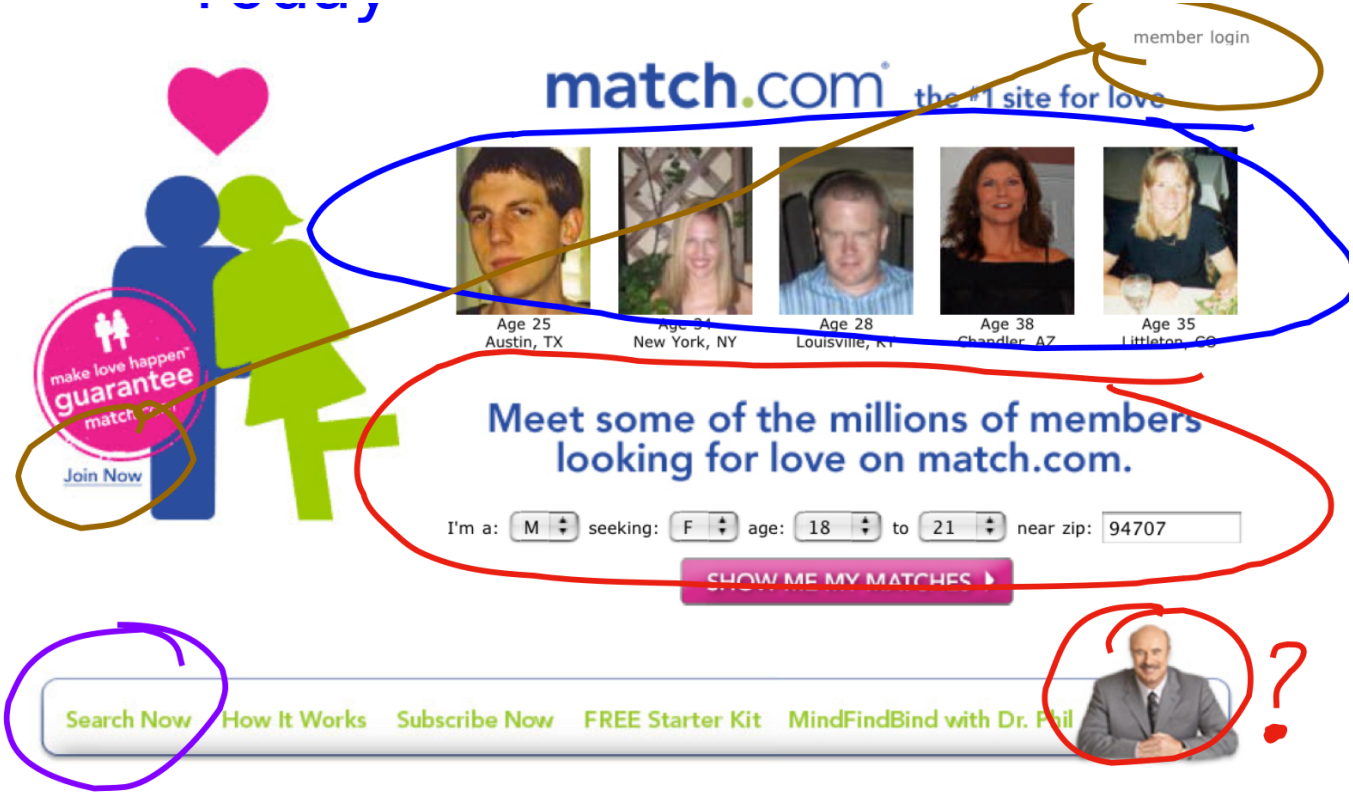
source: https://www.ksl.unibe.ch



source: https://amazon.de

source: http://www.fmis.raa.se

Database now



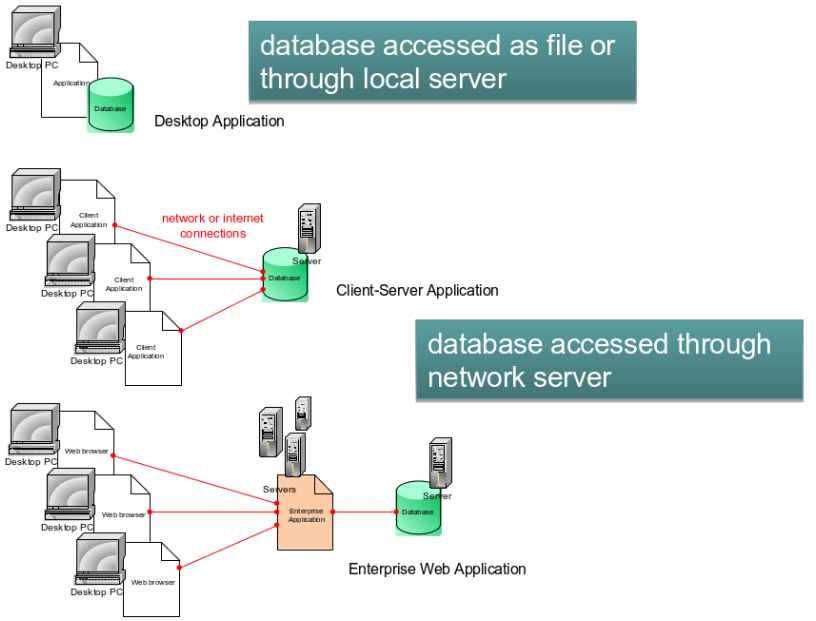
source: Hellerstein/Olston 2005, Introduction to Database Systems

What is a Database?

- A (typically very large) integrated collection of data.
- Typically models a real-world situation:
  - Entities (e.g., teams, games)
  - Relationships (e.g. YB is playing in the Champions League)
- Computerised database systems are now very commonplace
- Information is stored in a database every time we:
  - use a bank account
  - book a travel ticket
  - make an appointment with a doctor
  - etc.
- To actually store the data, and to do anything useful with it, you need a Database Management System (DBMS)

DBMS

- Microsoft Access
  - aimed at small businesses, and useful for desktop applications and systems with a small number of users
- Microsoft SQL Server, Oracle, IDM DB2
  - scalable and professional, and widely used by large organisations
- MySQL, PostgreSQL
  - open-source and quite powerful, widely used in web sites
- JavaDB, SQLite
  - compact DBMSs, suitable for mobile devices in particular
- ...and many more

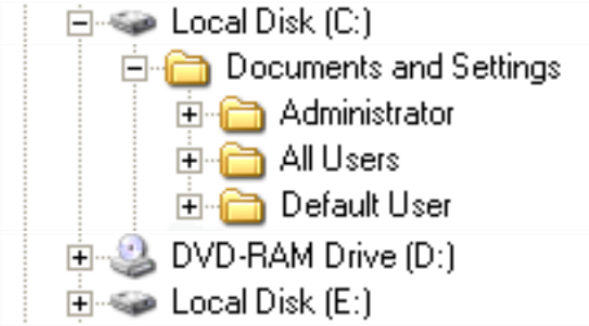


source: Paterson, Introduction to Database Development

Data models

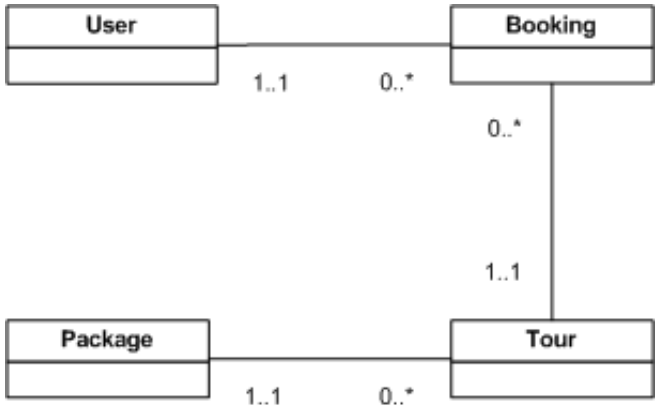
- The way in which data is organised for storage in a database is known as the data model
- Early computer databases developed in the 1960's used a hierarchical model, similar to the way files and folders are still organised in computer file systems
- Most data does not fit very well into a simple hierarchy

Hierarchical data



source: Paterson, Introduction to Database Development

"Real-world" data – no clear hierarchy



source: Paterson, Introduction to Database Development

- Relatively complex data like this is better handled with the relational model
- Most databases nowadays are relational databases
  - although there are others: object databases, XML databases, "NoSQL" databases

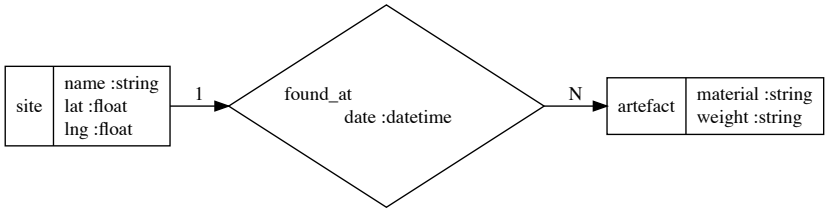
Designing a data model

Entity - Relationship (ER)

Entity:* Real-world object, distinguishable from other objects. An entity is described using a set of attributes.

Relationship:* Association among two or more entities. E.g., a fibula was found at Münsingen.

- relationships can have their own attributes.



***Entity Set:** A collection of similar entities. E.g., all employees.

- All entities in an entity set have the same set of attributes. (Basically)
- Each entity set has a key (!).
- Each attribute has a domain, that means, a range of possible values.

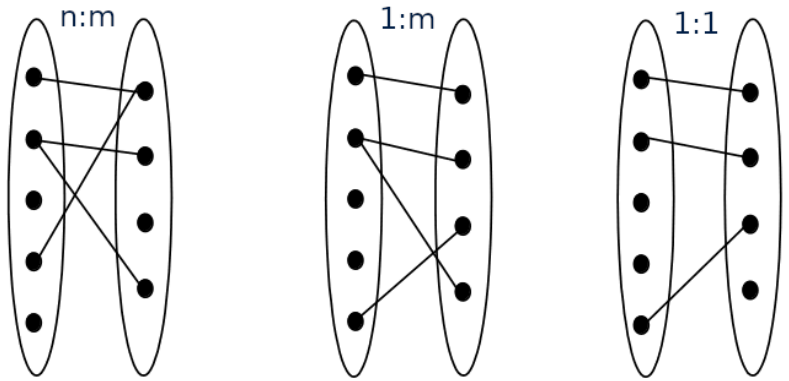
***Relationship Set:** Collection of similar relationships.

Types of Relationships

1:1, 1:m, n:m

Examples

- potsherds and features (n:m)
  - the sherds of one pot can be found at 1:n features
  - a feature can contain 1:n potsherds
- sample and measurements (1:m)
  - 1 sample has 1:n measurements
- artefact and find lable (1:1)
  - 1 Artefact has 1 find label



(primary) keys

Each record must be uniquely identifiable.

Primary key!

either

- a set of attributes that are already there and make the record unique
  - example: Lab Code and Lab Number identify a radiocarbon date

or

- is an explicit (artificial) attribute that is a sequential number
  - example: an id number from 1...∞

The latter is not pure dogma, but most of the time more pratical

(primary & foreign) keys

If a record is uniquely identifiable, this can be used in relation to other entities:

sites
Münsingen
Worb

burials
Burial 1
Burial 2
Burial 3
Burial 1
Burial 2
Burial 3

id	site
1	Münsingen
2	Worb

id	burial	site_id
1	Burial 1	1
2	Burial 2	1
3	Burial 3	1
4	Burial 1	2
5	Burial 2	2
6	Burial 3	2

The identifier of a record is the **primary key**.

The identifier of another record in relation to this one is the **foreign key**.

Normalisation

> **Database normalization** is the process of structuring a relational database in accordance with a series of so-called normal forms in order **to reduce data redundancy** and **improve data integrity**. -- wikipedia

site_id	site_name	lat	lng	Kanton	Country	burial_name	artefact_name	literature
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Halsring	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Bernsteinkette	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Fibel LTA	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Arm-/Fussring gerippt vollguss	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Schwert	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 3	Fibel LTB	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 3	Schwert	Hodson 1960, Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 1	Arm-/Fussring gerippt vollguss	Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 1	Fibel LTB	Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 2	Bernsteinkette	Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 2	Fibel LTB	Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 3	Halsring	Schaff 1976
2	Worb	46.9	7.5	Bern	Switzerland	Grab 3	Fibel LTA	Schaff 1976

First Normal Form (1NF), problem

To satisfy 1NF, the values in each column of a table must be **atomic**. (Meaning one information at the time)

Problem here: literature:

site_id	site_name	lat	lng	Kanton	Country	burial_name	artefact_name	literature
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Halsring	Hodson 1960, Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA	Hodson 1960, Schaff 1976

possible solution:

site_id	site_name	lat	lng	Kanton	Country	burial_name	artefact_name	literature1	literature2
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Halsring	Hodson 1960	Schaff 1976
1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA	Hodson 1960	Schaff 1976

But do you all the time know, how many citations to expect?

First Normal Form (1NF), better solution

separation into multiple tables, using primary and foreign keys, and a n:m relationship.

id	site_id	site_name	lat	lng	Kanton	Country	burial_name	artefact_na
1	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Halsring
2	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA
3	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA
4	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Bernsteinkette
5	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Fibel LTA
6	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Arm-/Fussring gerippt vollguss
7	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 2	Schwert
8	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 3	Fibel LTB
9	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 3	Schwert
10	2	Worb	46.9	7.5	Bern	Switzerland	Grab 1	Arm-/Fussring gerippt vollguss
11	2	Worb	46.9	7.5	Bern	Switzerland	Grab 1	Fibel LTB
12	2	Worb	46.9	7.5	Bern	Switzerland	Grab 2	Bernsteinkette
13	2	Worb	46.9	7.5	Bern	Switzerland	Grab 2	Fibel LTB
14	2	Worb	46.9	7.5	Bern	Switzerland	Grab 3	Halsring
15	2	Worb	46.9	7.5	Bern	Switzerland	Grab 3	Fibel LTA

id	literature
1	Hodson 1960
2	Schaff 1976

artefact_id	literature_id
1	1
1	2
2	1
2	2
3	1
3	2
4	1
4	2
5	1
5	2
6	1
6	2
7	1
7	2
8	1
8	2
9	1
9	2

First Normal Form (1NF), reason

Queries of the database are eased by the 1NF or only possible when the attribute value ranges are atomic. For example, in a field containing an entire name string consisting of title, first name and surname, it is difficult to impossible to sort by surname.

2NF, problem

Each data record represents only one fact. If there is data in a table that does not represent only 1 fact, this data is subdivided into individual thematic tables.

or more formal:

It does not have any non-prime attribute that is functionally dependent on any proper subset of any candidate key of the relation. A non-prime attribute of a relation is an attribute that is not a part of any candidate key of the relation.

Problem here:

id	site_id	site_name	lat	lng	Kanton	Country	burial_name	artefact_name
1	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Halsring
2	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA
3	1	Münsingen	46.8	7.6	Bern	Switzerland	Grab 1	Fibel LTA

Mixed informations about sites, burials and artefacts

2NF, solution

separation into multiple tables, using primary and foreign keys, and a 1:m relationship.

id	site_id	burial_name	artefact_name
1	1	Grab 1	Halsring
2	1	Grab 1	Fibel LTA
3	1	Grab 1	Fibel LTA
4	1	Grab 1	Bernsteinkette
5	1	Grab 2	Fibel LTA
6	1	Grab 2	Arm-/Fussring gerippt vollguss
7	1	Grab 2	Schwert
8	1	Grab 3	Fibel LTB
9	1	Grab 3	Schwert
10	2	Grab 1	Arm-/Fussring gerippt vollguss
11	2	Grab 1	Fibel LTB
12	2	Grab 2	Bernsteinkette
13	2	Grab 2	Fibel LTB
14	2	Grab 3	Halsring
15	2	Grab 3	Fibel LTA

id	site_name	lat	lng	Kanton	Country
1	Münsingen	46.8	7.6	Bern	Switzerland
2	Worb	46.9	7.5	Bern	Switzerland

2NF, reason

Consider this:

id	site_name	lat	lng	burial_name	artefact_name
1	Münsingen	46.8	7.6	Grab 1	Halsring
2	Münsingen	50	14	Grab 1	Fibel LTA
3	Münsingen	35	3	Grab 1	Fibel LTA

Where, exactly is Münsingen now??? Data Inconsistency!!!

The 2NF forces essentially "monothematic" relations in the scheme: each relation models only one fact.

This reduces redundancy and the associated risk of inconsistencies. Only logically/objectively related information can be found in a relation. This makes it easier to understand the data structures.

3NF, problem

No data in a record should automatically follow from other data in the same record.

id	site_name	lat	lng	Kanton	Country
1	Münsingen	46.8	7.6	Bern	Switzerland
2	Worb	46.9	7.5	Bern	Switzerland

From that Münsingen is in Kanton Bern, it automatically follows that it is in Switzerland!

Same reason as before, consider this:

id	site_name	lat	lng	Kanton	Country
1	Münsingen	46.8	7.6	Bern	Switzerland
2	Worb	46.9	7.5	Bern	Uganda

??? Data Inconsistency!!!

3NF, problem

separation into multiple tables, using primary and foreign keys, and a 1:m relationship.

id	site_name	lat	lng	kanton_id
1	Münsingen	46.8	7.6	1
2	Worb	46.9	7.5	1

id	kanton_name	Country
1	Bern	Switzerland

3NF, benefits

- Transitive dependencies are immediately apparent, without the need to know the relationships between the data. They are represented by the structure of the relations.
- In addition, any remaining thematic intermixtures in the relation are eliminated: according to the 3NF, the relations of the schema are reliably monothematic.

That's enought

There also exists the 4th, 5th and 6th Normal Form (not to mention the Boyce–Codd normal form (BCNF))...

In practise, normalising to the 3th Normal Form is absolutely enough.

> Informally, a relational database relation is often described as "normalized" if it meets third normal form. Most 3NF relations are free of insertion, update, and deletion anomalies. -- wikipedia

Most of that comes naturally if you think about your relations as objects in the 'Real World'[tm].

Let's get practical

We want to design a data base for finds of your site.

What **Informations** do we like to record?

What **Entities** and **Relations** do we have?

What **Attributes** will the **Entities** have?

How can we transform that into tables (this usually comes naturally than)?

Table:

site	literature	link
Birmensdorf-Rameren	Mäder, Andreas, Die mittelbronzezeitlichen Gräber von Birmensdorf-Rameren. Zürcher Archäologie, Heft 24. 2008	link
Chables	Leyla Duvanel, Henri Vigneau, Michel Guélat et Michel Mauvilly, La nécropole de l'âge du Bronze de Châbles/Les Biolleyres 1. Fribourg 2018	link
Singen	Rüdiger Krause: Die endneolithischen und frühbronzezeitlichen Grabfunde auf der Nordstadtterrasse von Singen am Hohentwiel (= Forschungen und Berichte zur Vor- und Frühgeschichte in Baden-Württemberg. Bd. 32 = Die Grabfunde von Singen. Bd. 1)	link
Murten/Löwenberg	Archäologie und Autobahn A1 : 25 Jahre Ausgrabungen im Murtenbiet	link
Prag-Miškovice	Ernée , Michal. Prag-Miskovice Archäologische und naturwissenschaftliche Untersuchungen zu Grabbau, Bestattungssitten und Inventaren einer frühbronzezeitlichen Nekropole Römisch-Germanische Forschungen Band 72 2016	link
Spiez, Einigen, Holleeweg 3	Gubler, Regula, Spiez-Einigen, Holleeweg 3. Gräber am Übergang zwischen Früh- und Mittelbronzezeit . Archäologie Bern/Archéologie bernoise – 2010, 147	link

Any questions?

You might find the course material (including the presentations) at

https://berncodalab.github.io/caa

You can contact me at

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