DEKXTROSE: An Education 4.0 Mobile Learning Approach and Object-Aware App Based on a Knowledge Nexus

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Background: Higher Education 4.0

- A correlating concept to Industry 4.0
- Aims to better align humans and technology in the area of tertiary education
- Involves various aspects that are values of a digital native culture, including:
  - Student-centric approaches instead of traditional lectures, individualistic (customized) learning
  - Internet and multimedia usage
  - Collaborative peer emphasis
  - Mobile device usage
  - Leveraging learning analytics to customize experiences

Problem

- Knowledge-doubling curve articulated by Buckminster Fuller
  - IBM extrapolated that by 2020 knowledge would be doubling in a matter of hours.
  - Factors fueling this trend include: digital and interconnected global access to knowledge, the transition from industrial to knowledge- and service-based societies, the advancement of science and invention, collaborating teams, computer-based data analysis of big data and that generated by sensors and devices, etc.
- Knowledge decay or obsolence
  - Not all knowledge remains stable, valuable, useful, and accurate for long
  - Some knowledge subset can be viewed as having a "half-life" as articulated by Fritz Machlup
  - Exacerbated in high-technology fields and related education and training

Motivation for research

Our solution concept and investigation were motivated by several questions and factors:

- To what extent is object recognition currently practical for didactic applications?
  - Is the recognition rate good enough for real usage?
- Can digital learning and knowledge content be connected to physical objects and triggered by users in context?
- How can knowledge and practice (from research and professional practice) be efficiently and effectively modularized into digital units, reused, and linked in a nexus-like way?
- How can digital long-lived sequential learning trails (routes through knowledge) be technically realized?
- How can complex learning flow templates (to actively support methods such as research learning, problem-based learning, project learning, experiential learning with assistance and navigation suggestions ("guidance") be technically implemented?
- To what extent can technically supported learning flows support creative thought processes?
- Is gamification motivating for all users, or are some primarily intrinsically motivated?
- Can we easily reuse digitally available information material in a way that:
  - Leverages intrinsic curiosity and motivation
  - Visually shows how one knowledge granule relates to another - and helps users find the next interesting knowledge granule
  - Enables users to add and share their own knowledge or opinions onto a knowledge node
  - Facilitates individual customized learning and flipped classroom approaches that put the student in the driver's seat

Underlying presuppositions of our solution

Individualized (no single one-size-fits-all)
- For certain courses or training - especially higher-semester courses, a one-size-fits-all didactic model is not effective nor efficient with regard to the post-course relevance of transferred knowledge. Each individual has personal preferences, pre-existing knowledge, competencies, learning styles, etc.

- Disparate, unpackaged knowledge
  - Much of the knowledge that "should" be distributed to an individual is not exclusively available from the mind of the expert, but also digital sources, especially in the SE domain. However, the knowledge has typically not been fashioned in a way that lends itself to efficient learning. Web search engines, while designed to quickly find relevant web pages, are not designed to support efficient learning.

- Networked-knowledge
  - knowledge is not isolated and (mostly) not immutable, but rather relevant or connected to other knowledge to some degree. Certain knowledge objects have multiple possible representations and ways they can be consumed (e.g., media formats). Digitally accessible resources should be reused if possible.

DEKXTROSE

(Didactic-Enhancing Knowledge-neXus TRail-enabled Object-aware Software for Education)

A knowledge nexus-based multimedia approach for creating mobile learning (mLearning) apps with the following capabilities:

- Augmented reality object identification
- Multiple didactic models
- Leverage intrinsic curiosity and motivation
- Support gamification
- Enable digital collaboration
- Object recognition triggers learning paths
- Learning Flows support
- Various didactic methods support group or team-based learning

DEKXTROSE = a sweetener for education and training

DEKXTROSE mLearning Approach

- Knowledge Nexus
- Object recognition
- Analytics
- Gamification
- Learning Paths
- Learning Flows
- Peer Collaboration
- Tagging
- Multimedia content

DEKXTROSE LearningPaths

- Are *trails* that explain knowledge in a predetermined sequential order using multimedia offers (e.g., about certain technologies that users do not yet know)
  - Contains a quiz at the end
- Can be started by object recognition
  - To acquire knowledge by curiosity about possibly unknown objects, or by choosing a LearningPath directly from the menu.
- Users can acquire requisite knowledge and skills

DEKXTROSE LearningFlows

- Are learning workflows/processes/methods to utilize different didactic methods in a practical way (research learning, problem-based learning, project learning, experience-based learning)
  - Alone or as a team
  - Can be quickly understood and self-directed
  - Use new, unfamiliar methods easily
- Provides students a goal and a process (LearningFlow)
  - A team of students is provided with a framework with which they can achieve some goal

DEKXTROSE: Motivational aspects

Leverages inherent curiosity:
- Links digital knowledge and questions with real objects in the immediate environment using the device's camera together with an object recognition service.
- Objects in the environment can be recognized, parts of a knowledge nexus can be triggered and visualized, and curiosity can be aroused.
- Passive LearningPaths provide sequential learning of expertise in these objects leveraging curiosity-triggered self-motivation

Goal-oriented collaboration:
- More complex LearningFlows support various goal-oriented knowledge processes via self- or team-directed didactic methods

Gamification:
- Badges provide achievement feedback

Realization: Knowledge Nodes

- A cross-platform tablet app for iOS/Android using Flutter
- Knowledge nodes can be browsed, searched, and viewed as a list (top) or nexus (bottom, network overview)
- Graph of knowledge nodes implemented as JSON documents containing:
  - Links to other related knowledge nodes
 - Contains detailed information and media pertaining to that node
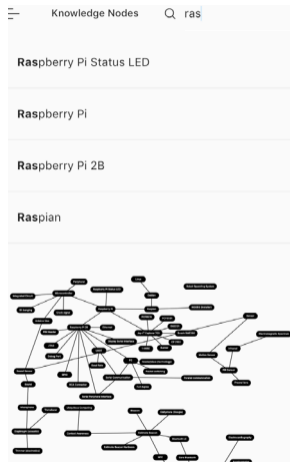
Realization: Object recognition

- Google Firebase ML Kit service for machine-learning-based object recognition
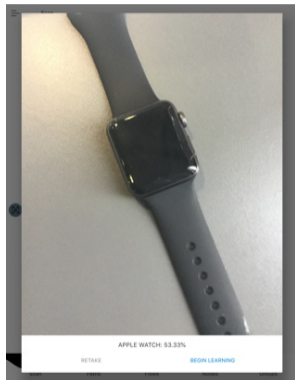
Realization: Tagging

- easily add information (e.g., comments, links to external site or photos, etc.), the concept of tags are used. From a technical perspective, our use of cloud storage as a backend for the app permits us to easily add to or adapt the knowledge nexus at any time without requiring the app software to be updated. This supports longer-term sustainability of the knowledge network. Furthermore, moderators, analogous to Wikipedia, can be utilized for certain areas of expertise to validate entries, add new knowledge, and maintain the network.
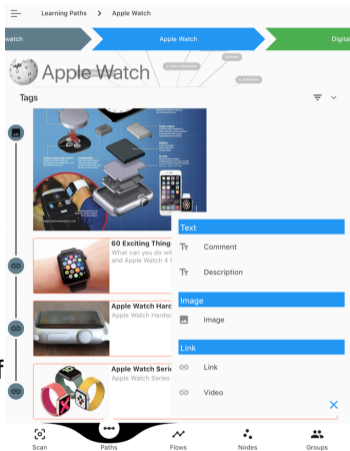
Evaluation

- Our qualitative evaluation focused on the subjective impressions of participants in three areas:
  - LearningPaths,
  - LearningFlows,
  - General impressions
- Convenience sample of 13 Computer Science students
  - Average semester = 5.8 (range 3 to 8)
- Using iPads or Sony Android tablets.
- Due to data privacy concerns, we did not utilize data analytics capabilities

Evaluation of LearningPath Feature

- For the LearningPaths feature, participants only chose paths about topics they had no significant knowledge of.
    - The available topics were:
    - Beacon technology
    - Raspberry Pi
    - Raspberry Pi Internet-of-Things extension board
    - Android
    - Apple Watch
    - Various hardware sensors (light, temperature, motion, sound, moisture)

Without our App:
- They selected an unknown topic, received a random list of topic-related URLs in a text file for use in their Web browser, and had 15 minutes before taking a quiz on the topic

With LearningPath in App:
- They selected another unknown topic and used our LearningPath, and then answered the built-in quiz after 15 minutes.

Evaluation of LearningFlows feature

- Participants self-formed groups of 2-3 people and were directed to apply the learning flow "Experiential learning" with our app, going through all the steps at least once, in order to optimize a simple paper-based product within 15 minutes.

- Only one of the participants had prior knowledge of experiential learning.

Evaluation

Area	Question	Average[a]
Learning Path	How helpful was the LP in learning?	4.00
	How much fun was using a LP?	4.08
	Were the quizzes motivating?	3.69
	Did quizzes provide helpful feedback when learning?	4.23
	Was earning badges motivating?	2.69
	How better/worse was the learning experience with app vs. without an app? (worse=-1, 0, better=+1)	0.85
Learning Flow	How helpful was the LF in learning?	3.15
	How much fun was it to use the LF?	3.69
General	Did you learn things you wouldn't have learned otherwise?	92% Yes
	Intuitiveness?	3.54
	How efficient was learning something new w/ app?	2.23
	Curiosity aroused about new technical knowledge?	3.15
	What was more fun?	100% app
	What would be your preference?	100% app
	What was the overall learning experience like?	4.00

a. Unless indicated, scale 1-5 where 5=Very & 1=Little

A selection of participants comments included:

- Can easily & quickly dive into new topics; greater depth of information is available when needed
- App summarizes knowledge compactly & very well; mostly intuitive to use.
- Topic overview via nodes was good and encouraged dig further into the topics of interest
- Learning path is very useful/helpful for unknown topics
- Prepared content is very good
- Graph view of knowledge nodes useful

The evaluation showed DEKXTROSE to be a viable approach.

Conclusion on DEKXTROSE

- Education 4.0 mLearning approach
  - Relevant and related knowledge can be conveyed in a mobile digital form
  - Provides digital natives a multimedia self-directed learning experience including:
    - Flipped classroom, internet-connected multimedia, internet-based collaboration, and student data analytics that can be used to further customize the user learning experience.
- Reuses digitally available knowledge –organized/accessible as a **knowledge nexus**:
  - Knowledge nexus can be explored/browsed for inquisitive self-directed learners
  - Objects in the environment can be used to trigger a **LearningPath**
  - **LearningPaths**: guided journeys through knowledge; quizzes for instant feedback; gamified with badges
  - **LearningFlows**: support applying didactic methods by individuals/teams; steps explained; state tracked
- Prototype and evaluation showed DEKXTROSE and its principles to be viable
  - Evaluation showed strong approval and interest by students and shows its potential
- Can be used to support aspects of Education 4.0, including:
- Approach generalizable to various other domains
  - E.g., art, science, etc., and would be beneficial for education and training in business/industry

Thank you!