Learning Styles and Cognitive Traits – their Relationship and its Benefits in Computer-Based Educational Systems

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Outline

- Motivation of incorporating learning styles and cognitive traits
- Felder-Silverman Learning Styles Model (FSLSM)
  - Description of learning style dimensions
  - How to detect learning styles
  - Adaptivity based on learning styles
- Cognitive Trait Model (CTM)
  - Description of CTM
  - Implementation
  - Adaptivity based on cognitive traits
- Relationship between FSLSM and CTM
  - Motivation/Benefits of the relationship
  - Relationship between each dimension of FSLSM and WMC
  - Results
Why shall we incorporate LS & CT?

- Learners have different needs
  - Knowledge
  - Learning goals
  - Learning styles
  - Cognitive traits
  - ...

- Incorporating these needs improves the learning progress

→ adaptive systems
Student Modelling

- Knowledge
- Goals
- Cognitive Traits
- Learning Style
- Motivation
- General Preferences

- How to get this information?
  - Ask the students
  - Initial questionnaires or test
  - Track the behavior of the students
Felder-Silverman Learning Style Model

Richard M. Felder and Linda K. Silverman, 1988

Each learner has a preference on each of the dimensions

Dimensions:

- Active – Reflective
  - learning by doing – learning by thinking things through
  - group work – work alone

- Sensing – Intuitive
  - concrete material – abstract material
  - more practical – more innovative and creative
  - better in single answer-tests – better in open-end tests
  - patient / not patient with details
  - standard procedures – challenges

- Visual – Verbal
  - learning from pictures – learning from words

- Sequential – Global
  - learn in linear steps – learn in large leaps
  - good in using partial knowledge – need ”big picture“
  - serial – holistic
FSLSM – How to find out the learning style?

- Index of Learning Style (Felder & Soloman, 1997)
  - 44-item questionnaire (11 questions per dimension)

- Track learners behavior and infer the learning style from it
  - Using Bayesian networks to detect learning styles (García et al., 2006)
  - Detecting learning styles in learning management systems (Graf and Kinshuk, 2006)
Adaptivity based on learning styles

Some examples:

- Number of exercises (active, sensing)
- Number of examples (reflective, sensing)
- Incorporating discussions (active, verbal)
- Sequencing of LOs in a course
  - Examples first (sensing)
  - Exercises/tests at the end of a course (global)
- Use of overviews (global)
- ...

Cognitive Trait Model (CTM)

- Lin, Kinshuk and Patel, 2003
- Includes cognitive traits such as
  - Working Memory Capacity
  - Inductive Reasoning Ability
  - Information Processing Speed
  - ...
- Cognitive traits are more or less persistent
  - CTM can still be valid after a long period of time
  - CTM is domain independent and can be used in different learning environments, thus supporting life long learning
Cognitive Trait Model (CTM)

Implementation of CTM:
Adaptivity according to cognitive traits

- Number of links
- Relevance of links
- Amount/detail of content
- Concreteness of content
- Structureness of content
- Number of information resources
Different types of adaptivity

- Learning styles
- Cognitive traits

Adaptivity based on learning styles
Adaptivity based on cognitive traits

Course
Benefits

Why relate cognitive traits (CT) and learning styles (LS)?

- Case 1: Only one kind of information (CT and LS) is included
  - Get some hints about the other one
  
  \[ \text{CT} \rightarrow \sim \text{LS} \quad \text{or} \quad \text{LS} \rightarrow \sim \text{CT} \]

- Case 2: Both kinds of information are included
  - The information about the one can be included in the identification process of the other and vice versa
  - The student model becomes more reliable

\[ \text{Detection of CT} \quad \text{and} \quad \text{Detection of LS} \]

... ... ...
\[ \text{LS} \]

... ... ...
\[ \text{CT} \]
Relationship between FSLSM and WMC

Felder-Silverman Learning Style Model

- Sensing
- Intuitive
- Active
- Reflective
- Visual
- Verbal
- Sequential
- Global

Working Memory Capacity

- High
- Low
Sensing and intuitive learners have similar characteristics to convergent and divergent learners

- Hudson, 1966 (thinking style)
  - Convergent:
    - Good in seeing information leading to a restricted answer or solution
    - Score better in single answer tests
  - Divergent:
    - More creative
    - Good in finding a greater variety of answers to a problem
    - Score better in open end tests
Sensing-Intuitive Dimension and WMC

- Convergent/Divergent and High/Low WMC
  - Study by Bahar and Hansell, 2000
    - About 400 students
    - Tests on convergency/divergency and WMC
    - Results:
      - convergent ↔ low WMC
      - divergent ↔ high WMC

→ Sensing ↔ convergent ↔ low WMC
→ Intuitive ↔ divergent ↔ high WMC
Sensing-Intuitive Dimension and WMC

- Concreteness / Abstractness
  - Field-dependency (FD) and field-independency (FI) proposed by Witkin et al., 1977
    - Field dependent learners learn best when given a larger context, or "field," in which to embed new learning
    - Field independent learners can learn material that is separated from its context
  - Several experiments about FD/FI and preferences for concrete/abstract learning material
    - Ford and Chen, 2000
    - Davis, 1991
    - FD ↔ concrete material (= sensing)
    - FI ↔ abstract material (= intuitive)
Sensing-Intuitive Dimension and WMC

- Several experiments about FD/FI and high/low WMC
  - Al-Naeme, 1991
  - Bahar and Hansell, 2000
  - El-Banna, 1987
  → FD ↔ low WMC
  → FI ↔ high WMC

→ Sensing ↔ field dependent ↔ low WMC
→ Intuitive ↔ field independent ↔ high WMC
Active-Reflective Dimension and WMC

- Kolb’s learning style theory (1984)
  - Convergers
    - More practical
    - Finding one solution to a problem
    - More attracted to technical problems than to social or interpersonal issues
    - Active experimentation
  - Divergers
    - Perform well in idea-generation
    - Reflective observations

→ similar to Hudson’s definition
→ Relation to active and reflective dimension
  - Convergers tend to be more active – by doing something
  - Divergers tend to be more reflective – by watching

→ Active ↔ convergers ↔ low WMC
→ Reflective ↔ divergers ↔ high WMC
Active-Reflective Dimension and WMC

- Relation to field-dependency and field-independency
  - According to Witkin et al., 1977
    FD learners are more socially oriented and prefer interaction as well as communication

  - Active $\leftrightarrow$ field-dependent $\leftrightarrow$ low WMC
  - Reflective $\leftrightarrow$ field-independent $\leftrightarrow$ high WMC

- Note-taking in lectures
  - Study by Hadwin et al. (1999)
    High WMC $\Rightarrow$ perform better when notes are given

  - Reflective $\leftrightarrow$ high WMC
Study by Beacham, Szumko, and Alty, 2003 about dyslexia
- Dyslexia refers to a specific learning difficulty regarding written language
- Effect of different presentation modes in e-learning courses for dyslexic students
- 30 students
- Performed Index of Learning Styles
  - 97% have a visual learning style
  - 3% have a verbal learning style (mild-verbal)

Studies about dyslexia and working memory capacity
- Study by Simmons and Singleton, 2000
  - Dyslexic students had done very poor in inferential questions
  - Working Memory deficiency was identified as a cognitive cause
- Study by Beacham, Szumko, and Alty, 2003
  - Weakness in working memory, sound processing, and co-ordination and motor skill

→ Visual ← dyslexic ← low WMC
→ Verbal/Visual ← high WMC
Study by Wey and Waugh (1993)

- Instructions based on text-only or text and graphics
- Results:
  - Text-only: field-independent learners perform better
  - Text & graphics: no significant differences
    - field-dependent learners have difficulties with text-only instructions

Visual ← Field-dependent ↔ low WMC
Verbal/Visual ↔ high WMC
Sequential–Global Dimension and WMC

- **Study by Huai, 2000**
  - Relationship between working memory capacity and long-term memory capacity to serial and holistic learning style
  - Serial learning style is strongly related to a sequential one
  - Holistic learning style is strongly related to a global one
  - About 140 students
  - Results:
    - Serial $\leftrightarrow$ high WMC (but poor results in the long run)
    - Holistic $\leftrightarrow$ low WMC (but good results in the long run)

$\Rightarrow$ Sequential $\leftrightarrow$ serial $\leftrightarrow$ high WMC
$\Rightarrow$ Global $\leftrightarrow$ holistic $\leftrightarrow$ low WMC
Sequential–Global Dimension and WMC

- Relation to field-dependency and field-independency
  - FI learners can learn material that is separated from its context and perceives information analytically \(\Rightarrow\) sequential
  - FD learners learn best when given a larger context, in which to embed new learning and perceives information globally \(\Rightarrow\) global

  \(\Rightarrow\) Sequential \(\leftrightarrow\) field-independent \(\leftrightarrow\) high WMC
  \(\Rightarrow\) Global \(\leftrightarrow\) field-dependent \(\leftrightarrow\) low WMC

- Study by Beacham, Szumko and Alty, 2003 (dyslexia)
  - Higher preference (14 % higher) of global learning style among dyslexic learners (low WMC)

  \(\Rightarrow\) Sequential \(\leftrightarrow\) high WMC
  \(\Rightarrow\) Global \(\leftrightarrow\) low WMC
Relationship between FSLSM and WMC

Felder-Silverman Learning Style Model

- Sensing
- Intuitive
- Active
- Reflective
- Visual
- Verbal
- Sequential
- Global

Working Memory Capacity

- High
- Low
Conclusion & Future Work

- Introduced Felder-Silverman Learning Style Model and Cognitive Trait Model
- Relationship between Felder-Silverman Learning Style Model and Working Memory Capacity
- Benefits
  - Additional information → more adaptivity
  - Improving the detection process of CT and LS → more reliable student model
- Ongoing/Future work
  - Study aiming at comparing data about LS and CT
    - Verifying the results
    - Investigating how strong the influences are
  - Use the relationship in a web-based educational system to make the student model more reliable
  - Further investigations concerning other cognitive traits (e.g. inductive reasoning ability, associative learning skills, ...