Using sensor-based technology to capture expert performance and to support expertise development

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“The trick to sound like an expert, is to make sure nobody understands you.”
Problem statement

• Experts struggle to explain their performance (Feldon, 2007)
  Explanation ability $\propto \frac{1}{\text{Expertise}}$

• Shortage of experts
So Who is an expert?

• Accepted by others as an expert.

• Consistently display superior performance in Representative task. (Ericson, 2006)

*Of course i talk to myself,
Because sometimes i need expert advice.*
Representative Task

“If you can’t measure it, you can’t improve it.” Lord Kelvin

• **Controlled scenario (Lab)**
• structured and managed drills where essential attributes of expert performance naturally occur.
But, How can I be an expert?

1. Practice for 10 years (Malcom Gladwell)?
   
   Only partially true (Hoffman, 1992)

Deliberate practice (Ericson, 2006)
Okay, Let's all practice deliberately then....

- Hambrick et al. (2014) found that deliberate practice accounted for only 12% of performance increment.
- Deliberate practice due to the fact that it is cognitively demanding (Rikers et al., 2004).
Okay!!...so what are we supposed to do?

SuperExpert Ericsson in his reply “the effect of deliberate practice as measured in my past studies relied on the one-to-one scenario where an expert continuously provided guidance and feedback to the apprentice” (Carey., 2014).
1st commandment: Thou shall not practice alone!

Deliberate practice
- Appropriate difficulty level,
- Provides informative feedback to the learner,
- Provides opportunities for repetition, and
- Provides room to make and to correct errors.

Ericsson et al. (2007) stressed the importance of a mentor for deliberate practice, stating that the apprentice does not engage in deliberate practice spontaneously.
But, but..there aren't enough experts!

Also experts have more knowledge than they can verbalize

Therefore,

In this project, we aim to explore how we can exploit the potential of Augmented Reality and Sensors to capture expert’s performance and Use it to train the apprentice.
Theoretical approach
4C/ID: 4 Component Instructional Design

Learning tasks
- concrete, authentic whole-task experiences
- organized in simple-to-complex task classes, i.e., categories of equivalent learning tasks
- learning tasks within the same task class start with high build-in learner support, which disappears at the end of the task class (i.e., a process of “scaffolding”).
- learning tasks within the same task class show high variability

Part-task practice
- provides additional practice for selected recurrent constituent skill in order to reach required level of automaticity
- organized in part-task practice sessions, which are best intermixed with learning tasks
- snowballing and REP-sequences might be applied for complex rule sets
- practice items are divergent for all situations that underlying rules can deal with

Supportive information
- supports the learning and performance of non-recurrent aspects of learning tasks
- consists of mental models, cognitive strategies and cognitive feedback
- is specified per task class
- is always available to the learners

JIT information
- prerequisite to the learning and performance of recurrent aspects of learning tasks or practice items
- consists of information displays, demonstrations and instances and corrective feedback
- is specified per recurrent constituent skill
- presented when needed and quickly fades away as learners acquire expertise

Welten Institute
Research Centre for Learning, Teaching and Technology

Figure: 4C/ID Model (van Merrienboer, Clark, & de Croock, 2002)
Where does the expert come in?

Modeling the Expert (not: aka. Observational learning)

1. Guidance (and feedback) by capturing expert performance (Collins, 1991)
   - Capturing of the expert performance with physical attributes and
   - Capturing of the process in the world (making invisible aspects visible)
Research Questions

• RQ1. How can sensor-based Augmented Reality capture expert performance, in particular, domain specific skills?
  – How can we identify aspects of expert performance (Lego Expert) which must be captured?
Our approach to operationalizing RQ1

We use the term “Transfer Mechanisms” to describe the instructional strategies or methods that exploit AR and sensor-based technology for training purposes.

<table>
<thead>
<tr>
<th>Transfer Mechanism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Attributes</strong></td>
</tr>
<tr>
<td>How can the features be described?</td>
</tr>
<tr>
<td>What skills is being addressed?...</td>
</tr>
<tr>
<td><strong>Requirements for recording</strong></td>
</tr>
<tr>
<td>How is the mechanism enabled during the recording?</td>
</tr>
<tr>
<td>What types of sensors are required?...</td>
</tr>
<tr>
<td><strong>Requirements for enactment</strong></td>
</tr>
<tr>
<td>How is this feature enabled by/for the learner?</td>
</tr>
<tr>
<td>Which conditions need to be me to allow this feature to be present?</td>
</tr>
<tr>
<td>Which interaction means does the learner have?</td>
</tr>
<tr>
<td>What type of sensor/display technology does the learner require?</td>
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</tbody>
</table>
## Transfer Mechanisms that support Learning task component

<table>
<thead>
<tr>
<th>Learning Task</th>
<th>Performance attributes</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Transfer mechanism</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Augmented path</td>
<td>1,2,12,18</td>
<td>1. Juanes et al. 2015</td>
</tr>
<tr>
<td>Augmented Mirror</td>
<td>14</td>
<td>2. Hahn et al. 2015</td>
</tr>
<tr>
<td>Interactive Virtual Objects</td>
<td>15</td>
<td>3. Meleiro et al. 2014</td>
</tr>
<tr>
<td>Directed focus</td>
<td>7,33</td>
<td>5. Lok et al. 2014</td>
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<thead>
<tr>
<th>Performance attributes</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fine motor Skills</td>
<td>Cognitive motor skills</td>
<td>Collaborative skills</td>
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Taken from Limbu et al. 2017
## Transfer Mechanisms that support Supportive Information component

<table>
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<tr>
<th>Supportive Information</th>
<th>Performance attributes</th>
<th>Literature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transfer mechanism</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Object Enrichments</td>
<td>Perceptual motor skills</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Cognitive motor skills</td>
<td>1,25, 26</td>
</tr>
<tr>
<td></td>
<td>Collaborative skills</td>
<td>16,28</td>
</tr>
<tr>
<td>3D models and animation</td>
<td></td>
<td>22</td>
</tr>
<tr>
<td>Xray vision</td>
<td></td>
<td>23</td>
</tr>
<tr>
<td>Setting Cues and Clues</td>
<td></td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>Cognitive motor skills</td>
<td>32,19</td>
</tr>
</tbody>
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Taken from Limbu et al. 2017
Research Questions

• RQ2. How can we support training of the expert performance?
  – How can the captured expert performance be used for mentoring with help of AR & WT?
  – What is the effect of expert modelling as compared to the standard 4CID on the cognitive load of the apprentice?
The Lego Predicament

Design based study/experiments to identify attributes of expert performance
• Identify dominant skills involved in Lego building
• How can the learner be guided?

• No Lego Experts (Attributes of expert vs attributes of novice?)
• Not a well defined domain
Thank you!

Future Steps:
• Explore attributes of expert guidance(LEGO)
• Updating the literature Review
• Try not to have a mental break down
• Envision how we can contribute to attainment of expertise
• Be a Lego expert
Questions and Thoughts

Questions
Bibliography


