

Understanding the Learners' Actions when using Mathematics Learning Tools



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The Problems

- a teacher explains concepts in a lecture
- he *assigns* exercises
- students can try...
- how are they checked?
 - paper corrections
 - self-corrections, peer-corrections
 - ...intelligent tutoring systems

Interactive Exercises: Risks

- cognitive load (technical & conceptual)
- tiniest bugs become huge
- irrelevant parts
- frustration of unachieved exercises

- they need to be managed by teacher!

Interactive Exercises: Risks

*It didn't accept my answer as correct, despite clear syntax (checked by the syntax checker) and my answer being correct.
(LeActiveMath evaluation 2007)*

- irrelevant parts
- frustration of unachieved exercises
- they need to be managed by teacher!

Interactive Exercises: Risks

*It didn't accept my answer as correct, despite clear syntax (checked by the syntax checker) and my answer being correct.
(LeActiveMath evaluation 2007)*

- irrelevant parts

- frustration

*I am going round in circle in this exercise. Should I have set up things differently?
(SAiL-M evaluation 2011)*

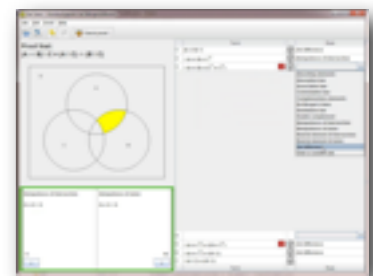
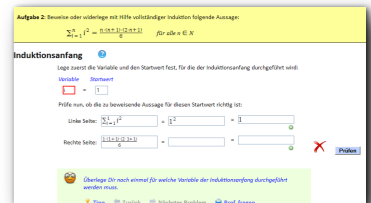
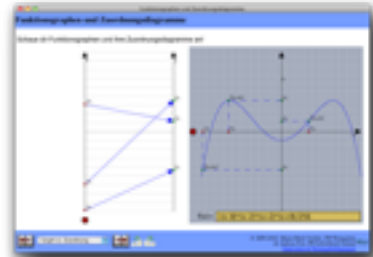
- they need to be managed by teacher!

Outline

- problem statement
- learning tools
- proposed solution
- techniques
- demo
- related works
- open avenues

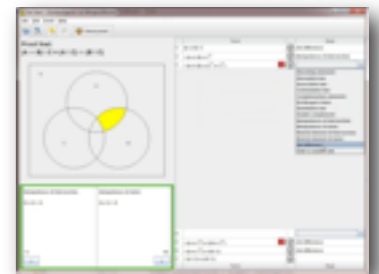
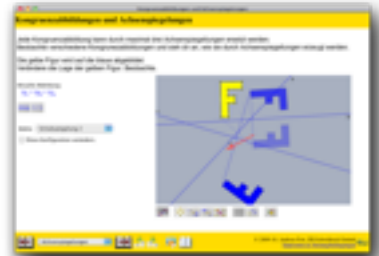
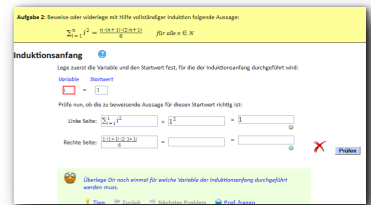
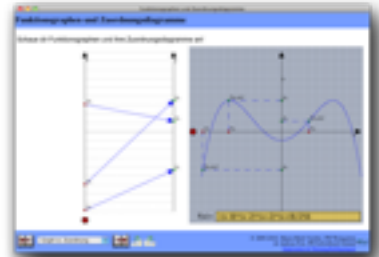
Learning Tools

- for undergraduate mathematics teachers
- SquiggleM: relations, bijection, ...
- ComInM: induction
- MoveltM: isometries, composition
- SetSails: boolean algebra



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Learning Tools

- f
- S
- C
- T
- S

Funktionsgraphen und Zuordnungsdiagramme

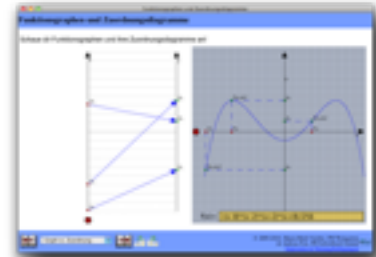
Schaue dir Funktionsgraphen und ihre Zuordnungsdiagramme an!

$f(x) = -(x-8) \cdot (x-2) \cdot (x+2) \cdot (x+8) / 256$

Graph vs. Zuordnung

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Learning Tools



- for undergraduate mathematics teachers

Aufgabe 2: Beweise oder widerlege mit Hilfe vollständiger Induktion folgende Aussage:

$$\sum_{i=1}^n i^2 = \frac{n \cdot (n+1) \cdot (2n+1)}{6} \quad \text{für alle } n \in \mathbb{N}$$


Induktionsanfang

Lege zuerst die Variable und den Startwert fest, für die der Induktionsanfang durchgeführt wird:

Variable Startwert

=

Prüfe nun, ob die zu beweisende Aussage für diesen Startwert richtig ist:

Linke Seite: = = 

Rechte Seite: = = 



Prüfen



Überlege Dir noch einmal für welche Variable der Induktionsanfang durchgeführt werden muss.

 Tipp

 Zurück

 Nächstes Problem

 Prof. fragen

intro • tools • solution • techniques • demo • outlook

Kongruenzabbildungen und Achsenspiegelungen

Kongruenzabbildungen und Achsenspiegelungen

Jede Kongruenzabbildung kann durch maximal drei Achsenspiegelungen ersetzt werden.
 Beobachte verschiedene Kongruenzabbildungen und sieh dir an, wie sie durch Achsenspiegelungen erzeugt werden.

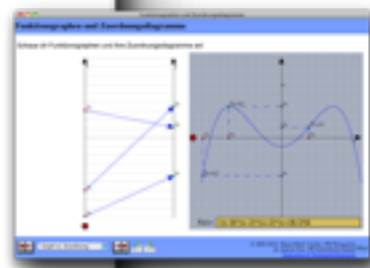
Die gelbe Figur wird auf die blaue abgebildet.
 Verändere die Lage der gelben Figur. Beobachte.

Aktuelle Abbildung:
 $Y_c \circ Y_b \circ Y_a$

Wähle:

Diese Konfiguration verändern.

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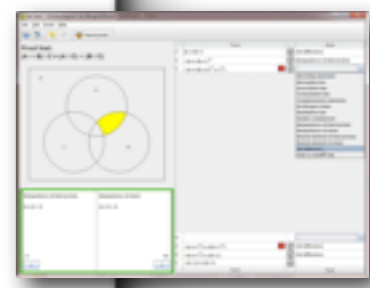


Aufgabe 2: Beweise oder widerlege mit Hilfe vollständiger Induktion folgende Aussage:
 $\sum_{k=1}^n k^2 = \frac{n(n+1)(2n+1)}{6}$ für alle $n \in \mathbb{N}$

Induktionsanfang
 liegt bereit die Variable und den Startwert fest, für die der Induktionsanfang durchgeführt wird.
 Variable: Startwert:

Bitte nun, ob die zu beweisende Aussage für diesen Startwert richtig ist!
 Richtig falsch:

Richtige Werte:

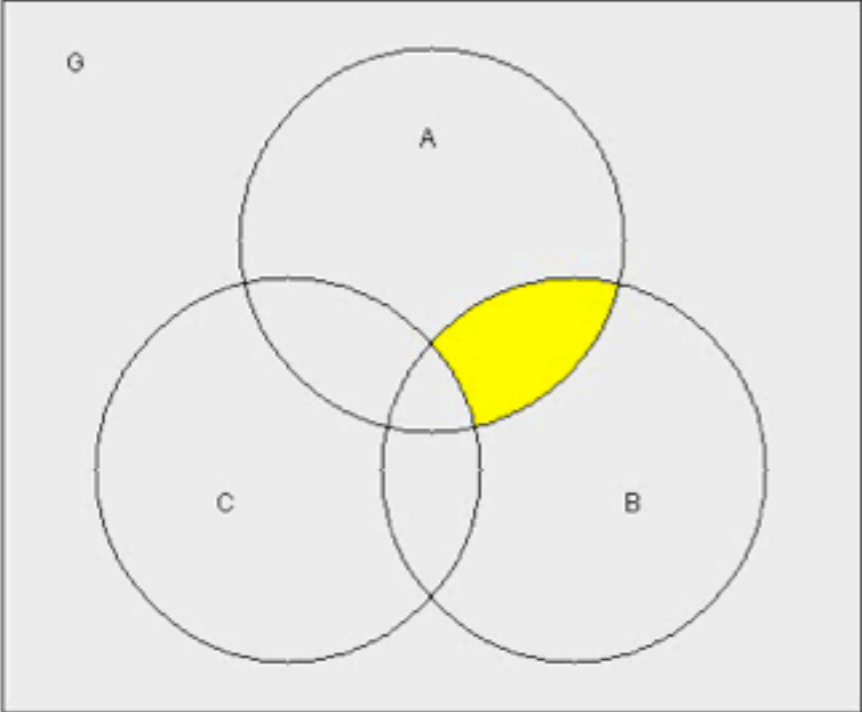


Set Sails! - Distributivgesetz bei Mengendifferenz

File Edit Proof Help

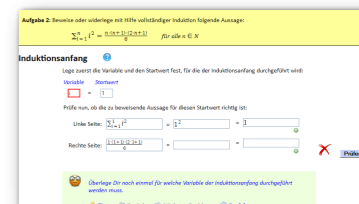
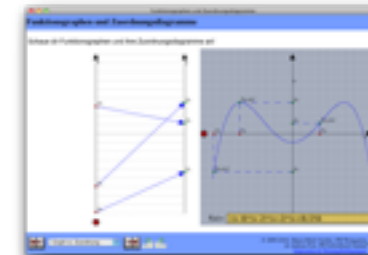
Check proof ...

Proof that:
 $(A \cap B) \setminus C = (A \setminus C) \cap (B \setminus C)$



	Term		Rule
1	$(A \cap B) \setminus C$		Set difference
2	$= (A \cap B) \cap C^c$		Idempotence of intersection
3	$= (A \cap B) \cap (C^c \cap C^c)$		X
<ul style="list-style-type: none"> Absorbing elements Absorption law Associative law Commutative law Complementary elements De Morgan's laws Distributive law Double complement Idempotence of intersection Idempotence of union Neutral element of intersection Neutral element of union Set difference Enter a custom rule 			
4			
5	$= (A \cap C^c) \cap (B \cap C^c)$		X Set difference
6	$= (A \cap C^c) \cap (B \setminus C)$		Set difference
7	$= (A \setminus C) \cap (B \setminus C)$		

<p>Idempotence of intersection</p> <p>$A \cap A = A$</p>	<p>Idempotence of union</p> <p>$A \cup A = A$</p>
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S

SAIL-M

our approach:

Integrated Play, Learning Analytics

- start at the LMS
- collect tracks of the usage
- present tracks to teachers:
 - in summary form
 - in individual form
- as much as needed so that the teacher understands what happened

our approach:

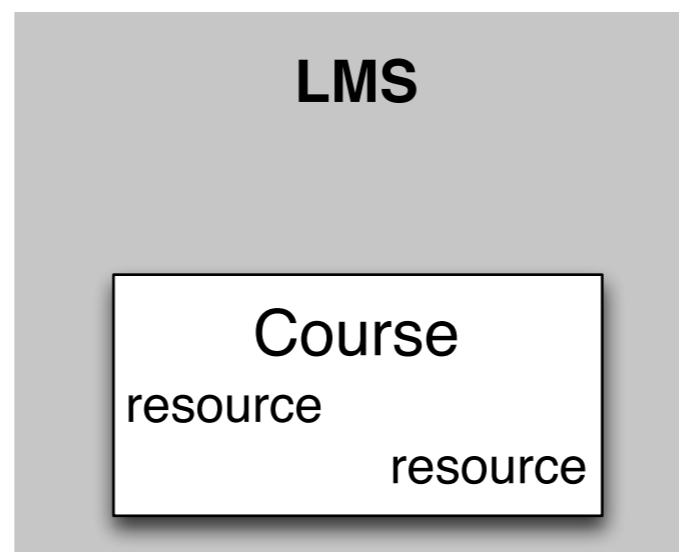
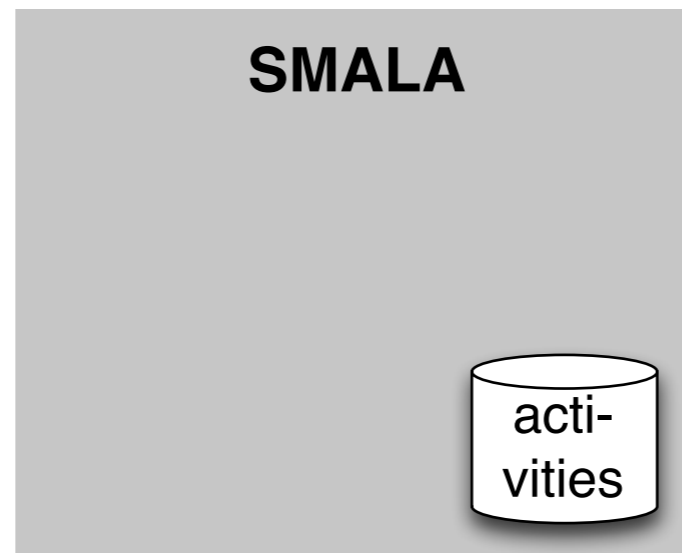
Integrated Play, Learning Analytics

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SMALA

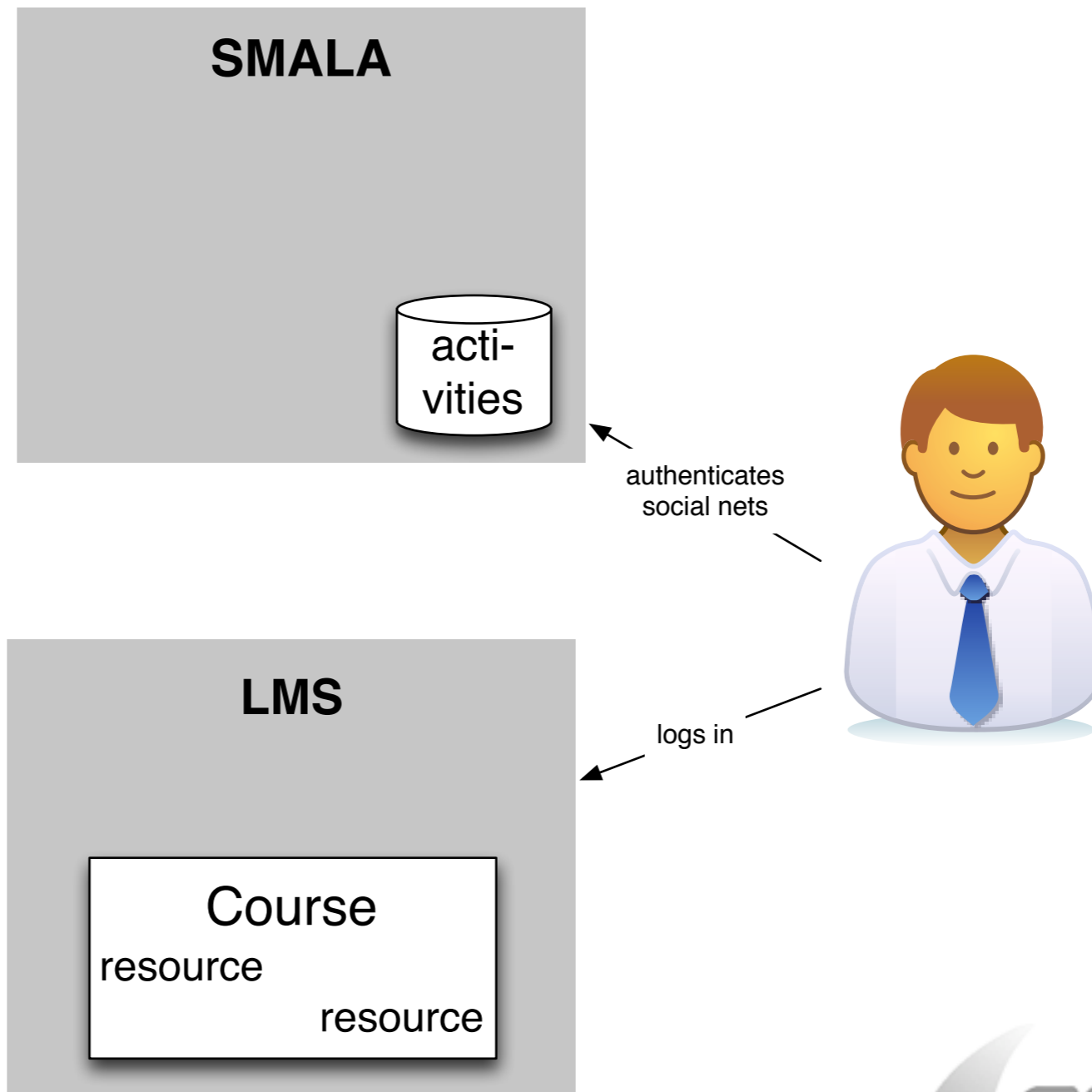
SMALA Architecture

intro • tools • solution • techniques • demo • outlook

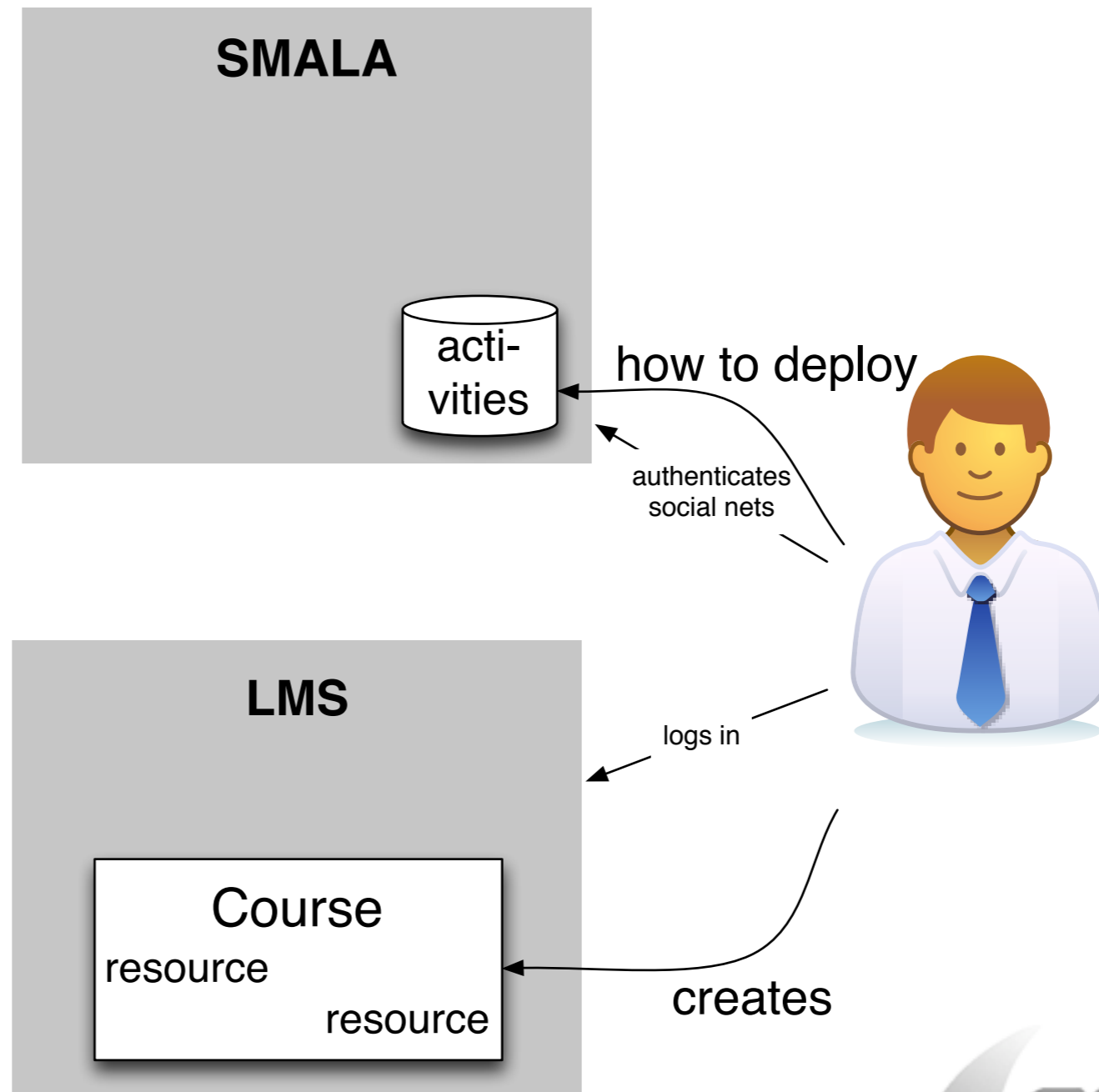


SMALA Architecture

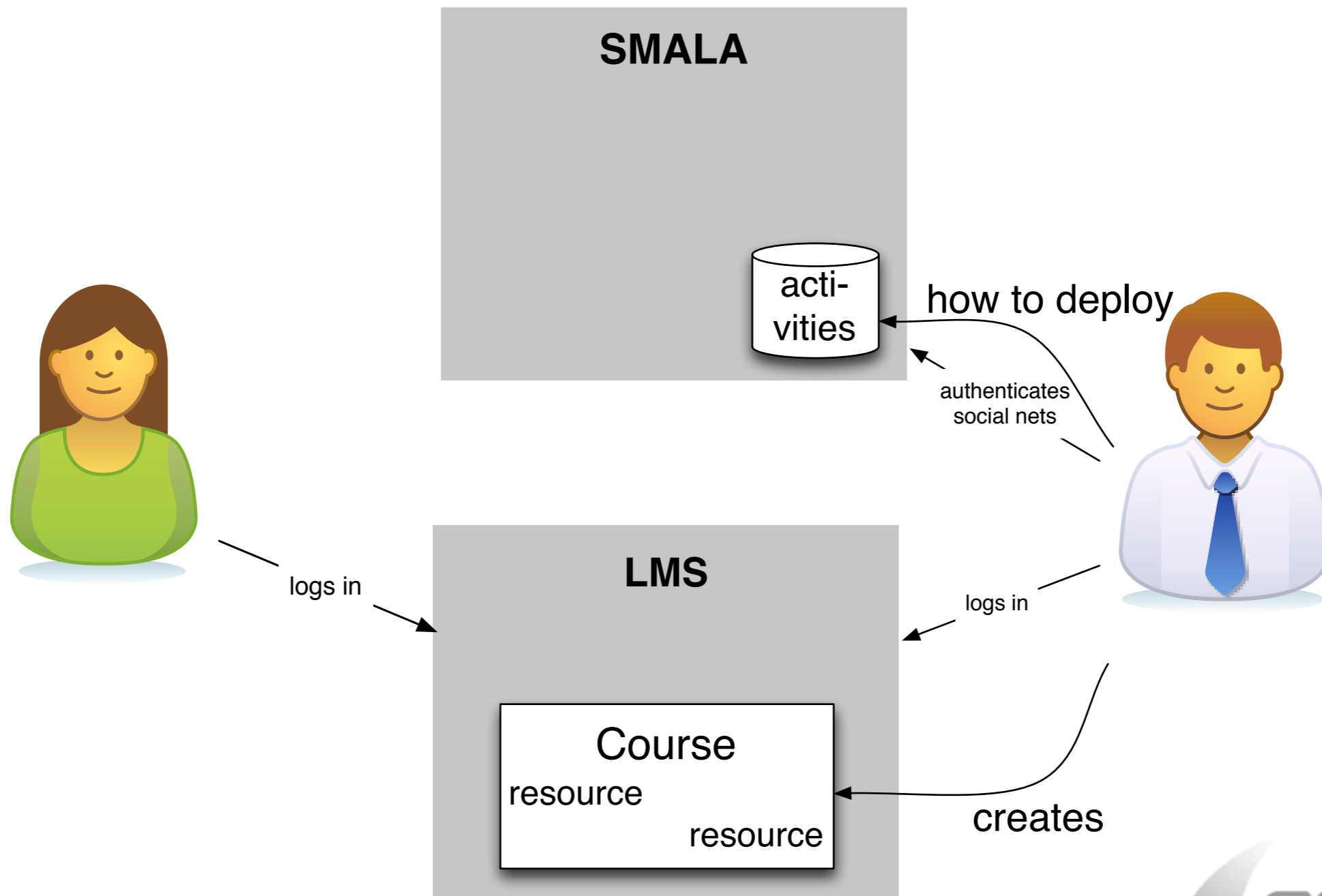
intro • tools • solution • SMALA • techniques • demo • outlook



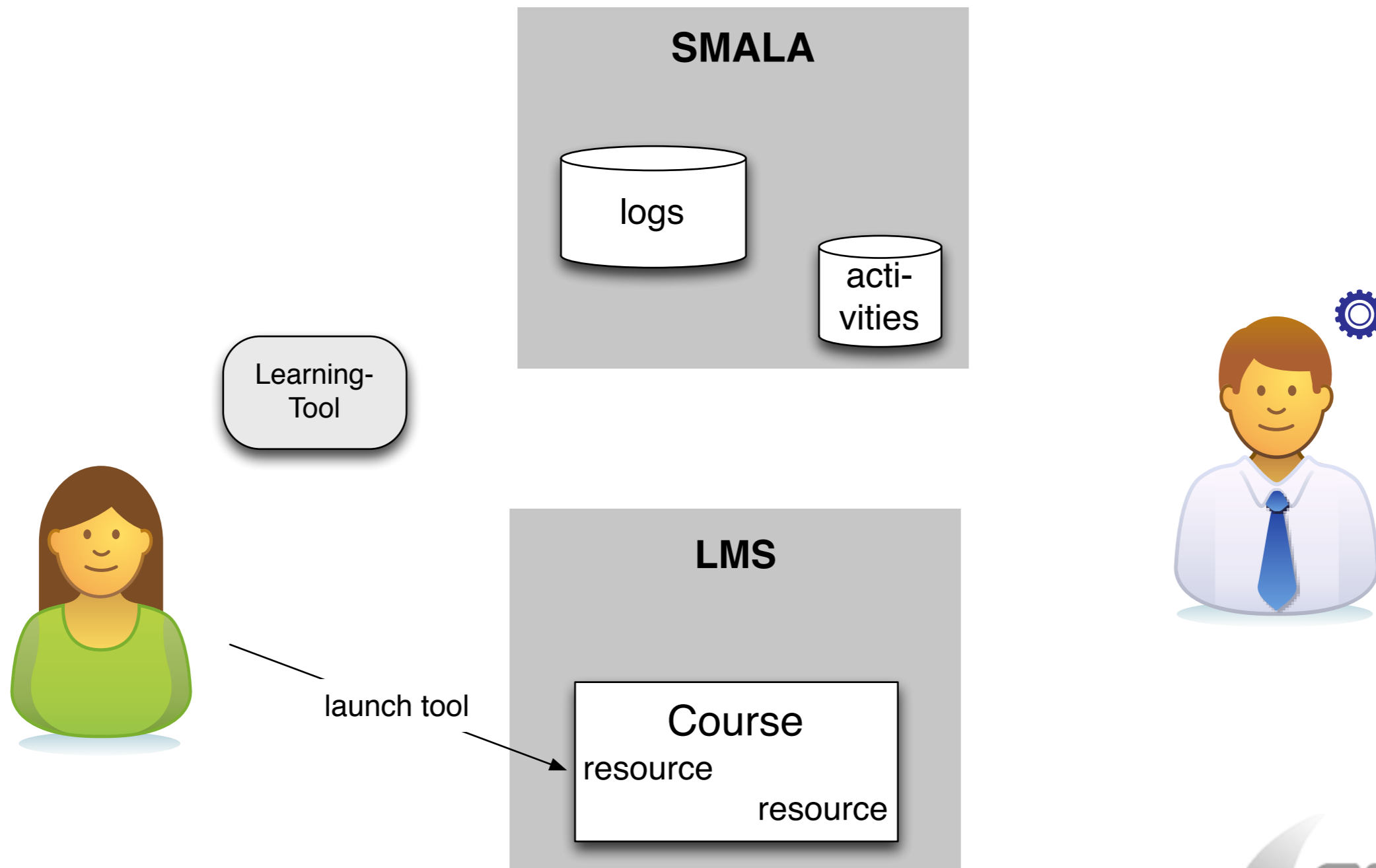
SMALA Architecture



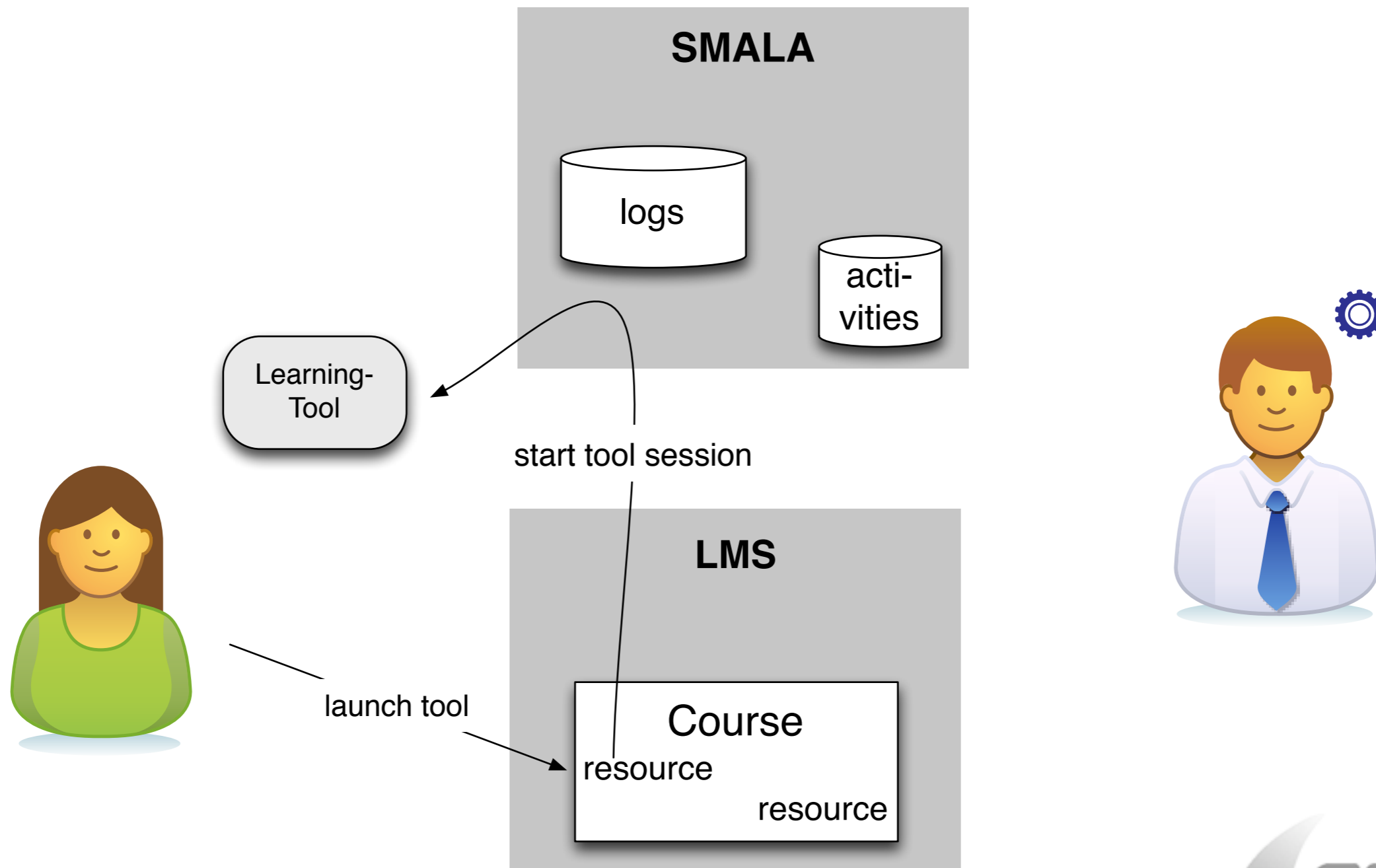
SMALA Architecture



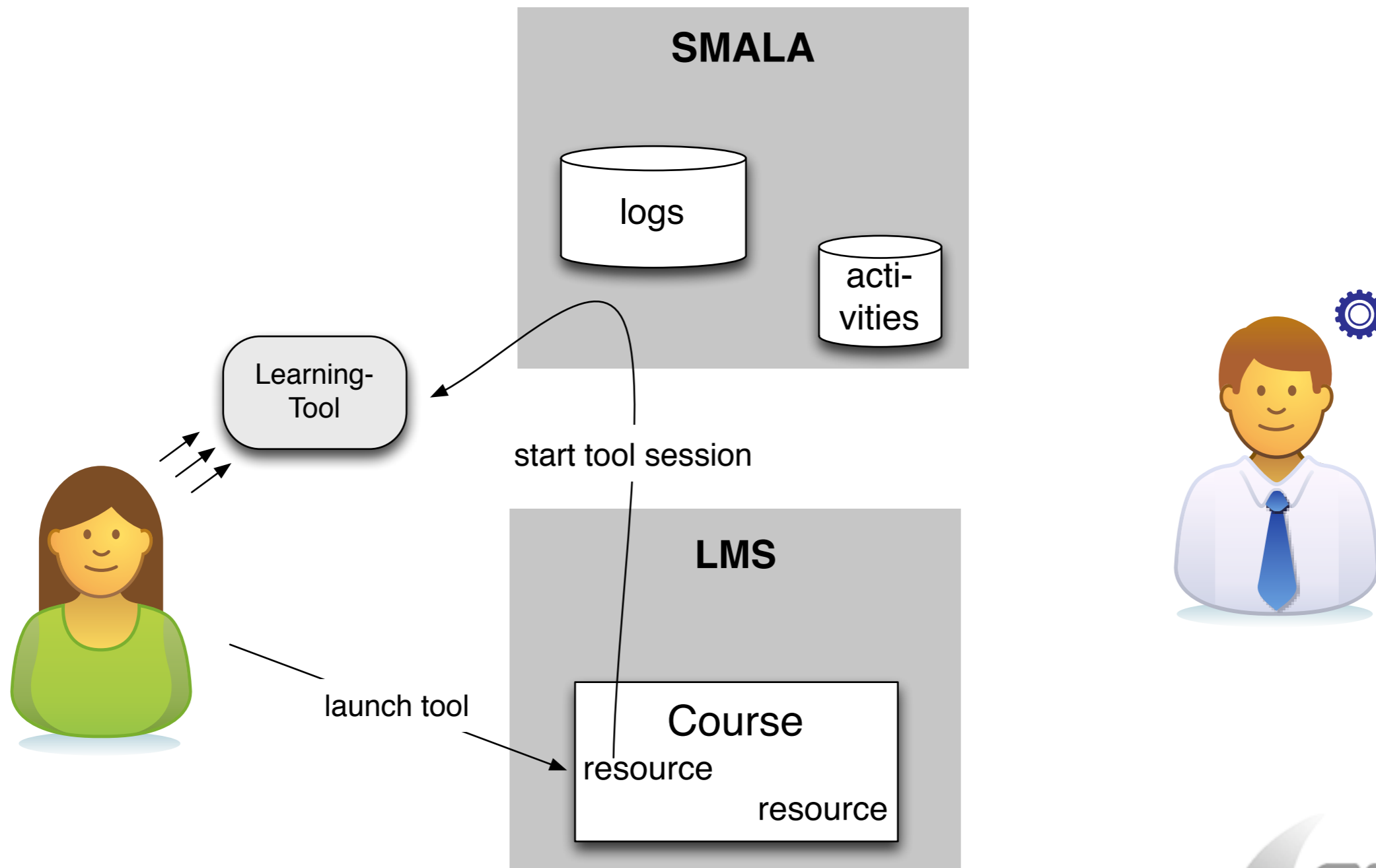
SMALA Architecture



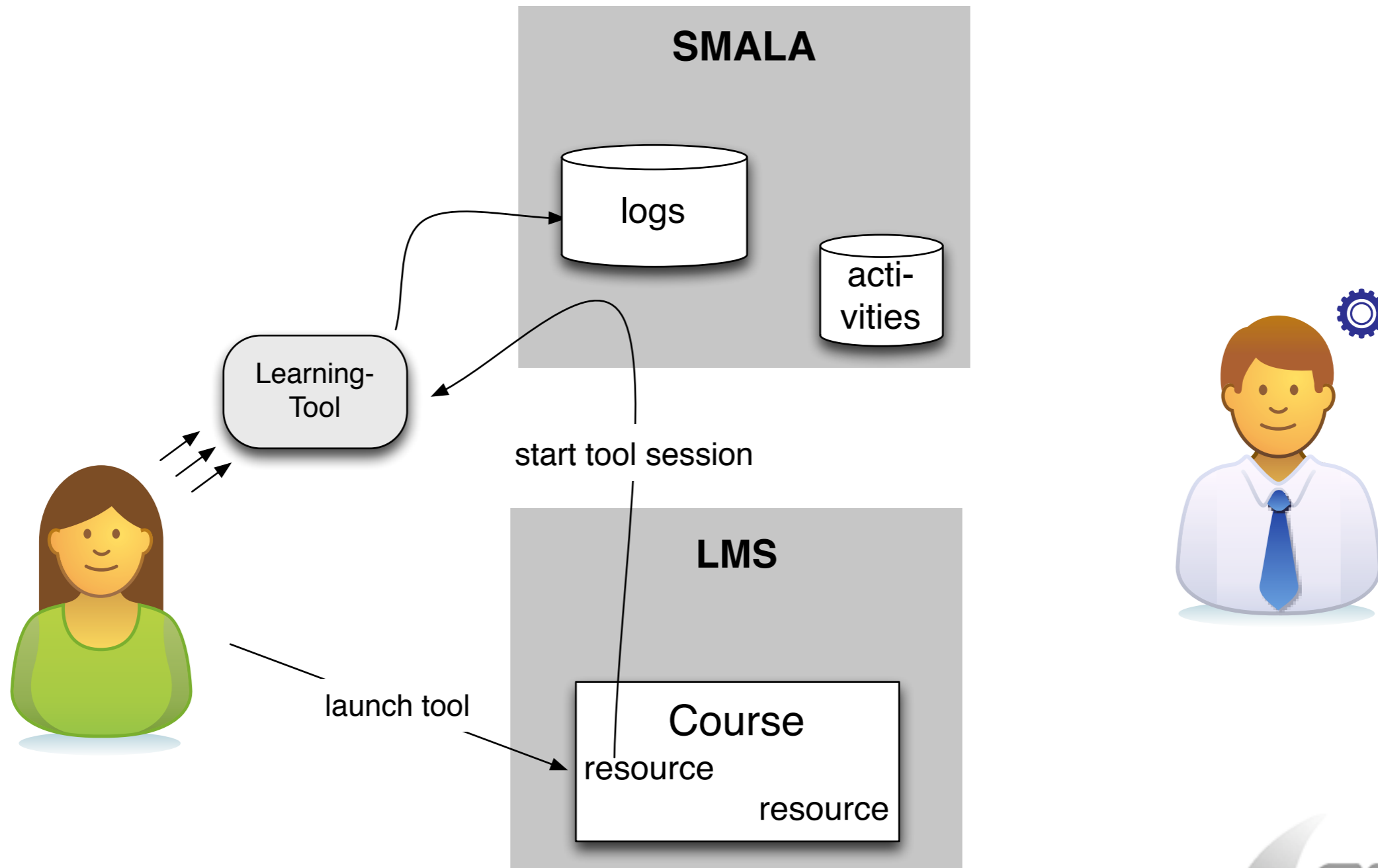
SMALA Architecture



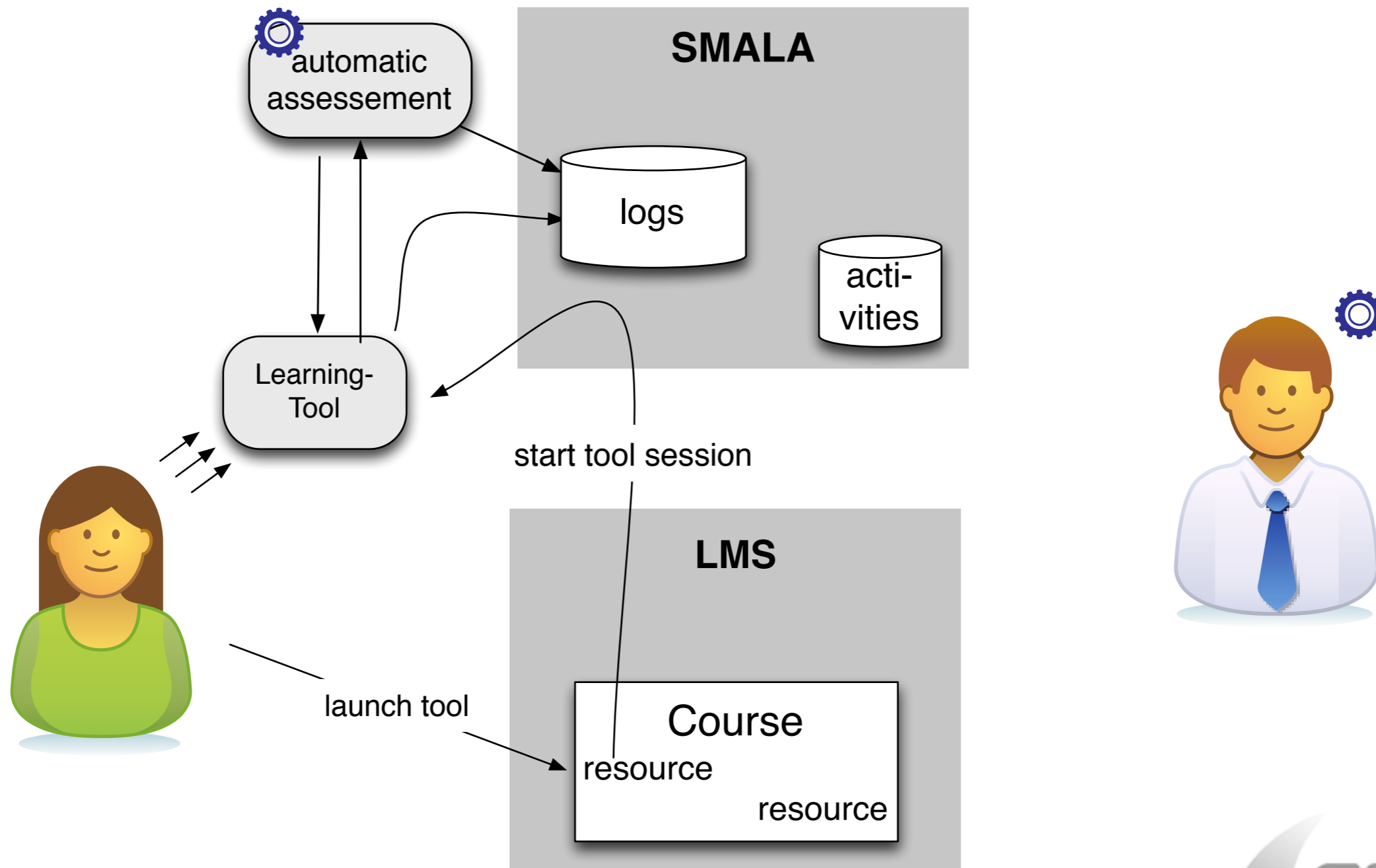
SMALA Architecture



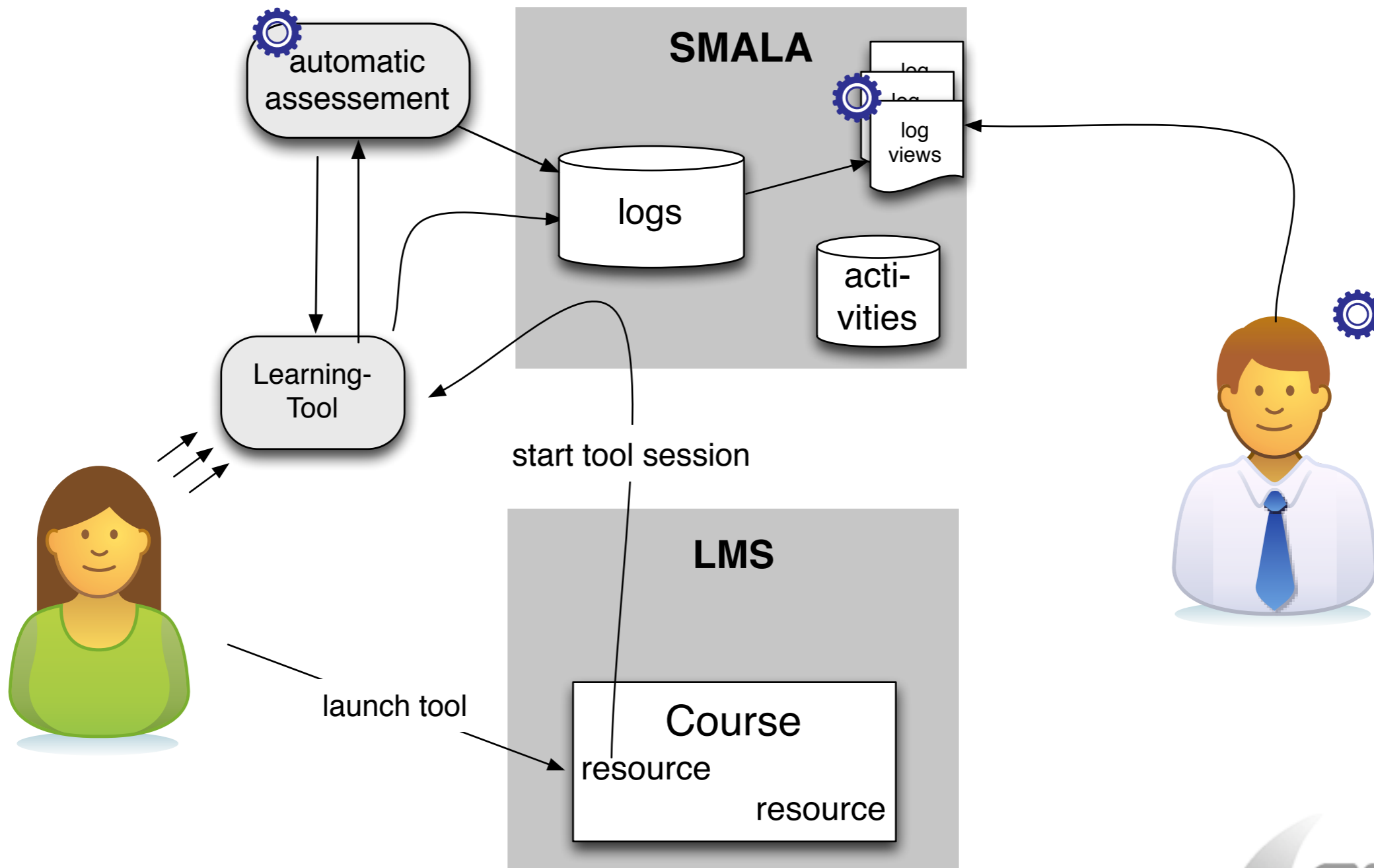
SMALA Architecture



SMALA Architecture



SMALA Architecture

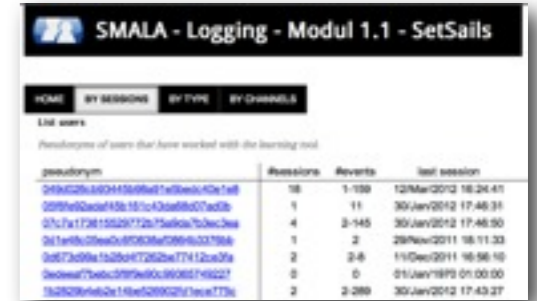


Components

- Learners' browser:
 - in Moodle or StudIP
 - identity reading \Rightarrow pseudonym, session
- Smala server: logging
 - Servlet front
 - flexible authorization (signature, origin...)
 - events in PList format
 - OpenJPA storage of events
- Smala server: log-views
 - social network authentications (teachers, admin)
 - how-to-deploy explanations
 - JPA queries
 - JSP rendering
 - all open-source

Summary views

- statistical overviews
- to get a broad feeling



Bearbeitete ComIn-M-Aufgaben:

Anzahl an bearbeiteten Aufgaben: 90
davon richtig gelöst: 1
davon falsch gelöst: 89

Aufgabe	Gesamtanzahl	richtig	falsch	Lösung Prüfen	Tipps	Tutoranfragen
induction1	29	1	28	147	30	0
induction2	6	0	6	17	4	0
induction3	4	0	4	4	0	0
induction4	4	0	4	6	1	0
induction5	5	0	5	7	1	0
induction6	4	0	4	9	5	0
induction8	5	0	5	11	3	0
induction9	33	0	33	1	0	0

Summary views

- stat
- to &

SMALA - Logging - Modul 1.1 - SetSails

HOME
BY SESSIONS
BY TYPE
BY CHANNELS

List users

Pseudonyms of users that have worked with the learning tool.

pseudonym	#sessions	#events	last session
049d026cb93445b98a91e5bedc40e1e8	18	1-159	12/Mar/2012 16:24:41
05f6fe92adaf45b161c43da68d07ad0b	1	11	30/Jan/2012 17:46:31
07c7a173815529772b75a9da7b3ec3ea	4	2-145	30/Jan/2012 17:46:50
0d1e48c05ea0c6f0838af0864b3376bb	1	2	29/Nov/2011 18:11:33
0d673d99a1b28d4f7262be77412ce3fa	2	2-8	11/Dec/2011 16:56:10
0edeeaf7bebc5f8f9e90c99365749227	0	0	01/Jan/1970 01:00:00
1b2829b4eb2e14be526902fd1ece775c	2	2-289	30/Jan/2012 17:43:27

induction5	5	0	5	7	1	0
induction6	4	0	4	9	5	0
induction8	5	0	5	11	3	0
induction9	33	0	33	1	0	0

Session Views

- individual track
- often anonymous
- understand what went
 - wrong
 - right

13:23:15 Problem anzeigen

Bearbeitete Aufgabe: induction1

Behauptung Linke Seite: $\sum_{i=1}^n k+k+1$

Behauptung Rechte Seite: $\frac{(k+1)(k+1+1)}{2}$

Problembeschreibung:

13:23:20 Naechstes Problem

Bearbeitete Aufgabe: induction1

Behauptung Linke Seite: $\sum_{i=1}^n k+k+1$

Behauptung Rechte Seite: $\frac{(k+1)(k+1+1)}{2}$

Problembeschreibung:

Tipp: Ersetze auf der linken Seite die Variable 'n' durch 'k+1'.

13:23:31 Induktionsbehauptung pruefen

13:23:33 Assessment auf ComIn-M Server

Demo: Semi-Automatic Assessment

- Squiggle M
- play randomly
- send a mail: I am lost
- check mail
 - reply

Semi-Automatic Assessment

- utility of exercise feedback:
 - eval performance, learn from error
- automatic feedback never complete
 - mostly « *the standard* »
- approach: semi-automatic assessment
 - learners use tips and feedback of the system
 - seek help when that is insufficient
 - complementarity of tool and teacher

Photo by Wolfgang Müller, PH Weingarten 2012 CC-BY



Evaluation

- ~ 150 users, 1000 sessions, 25'000 events
- conclusions:
 - tool starts and transparently logs: ok
 - no real bother about privacy
 - but have to offer alternatives
- help-seeking paradigm works
 - used little, but sufficient to answer

Related Work

- SCORM
- single sign on attempts (eg. LTI)
 - current toolset insufficient for analytics
- Jacareto: full recording... too detailed!
- Formid
 - no anonymity, scenario binding
- LOCO-analyst
 - events not enough flexible

Open Avenues

- enhance logging for SquiggleM and MoveltM
 - (show graph, show the moves' log?)
- better client implementation
 - applets a burden (but scrape well)
- summary views enrichment
 - teachers' analysis process
 - visually rich displays

Summary

- learners benefit of automated feedback
- ... but may need more
- semi-automatic-feedback
 - needs understanding what they did
- architecture proposed and deployed
 - worked well for ~150 students
 - bases on a single delivery and logging server
- privacy issues acceptably addressed

Thank you.

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