*Stoyanov, S., Stoyanova, N., Kommers, P.A.M., & Kurtev, I. (2000, November). SMILE Maker: Concept-orientation in agent-based architectures for personal assistance and collaborative problem solving. Paper presented at Conference IMC´2000; Intelligent Interactive Assistance and Mobile Multimedia Computing. Rostock-Warnemuende, Germany. http://www.rostock.igd.fhg.de/~imc2000

# SMILE Maker: Concept-Orientation in Agent-Based Architectures for Personal Assistance and Collaborative Problem Solving

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**Paper Proposal for IMC2000**
INTELLIGENT INTERACTIVE ASSISTANCE AND MOBILE MULTIMEDIA COMPUTING
Rostock-Warnemuende, Germany
November 9-10, 2000
http://www.rostock.igd.fhg.de/~imc2000

## Abstract

The paper presents some experimentally validated design solutions on the groupware module 'Partner' of SMILE Maker for mobile and personal support facilities. Three types of scenarios for collaborative problem solving have been tested. Pin-cards, Delphi and BrainMapping modes proved to have a differential effect on learning and collaborative problem solving suggesting concrete design solutions.

SMILE Maker is a web-based knowledge support system promoting with just in time, just enough and just at point of need intelligent support in dealing with ill-structured problem situations. Conceptually SMILE Maker lies in a cross-section area of four recently strongly recognized paradigms: problem solving, concept mapping, collaborative learning and instructional design.

The module 'Partner' of SMILE Maker enables a shared group environment for distributing learning resources. It supports externalisation and sharing the individual potential in terms of formal expertise and tacit knowledge, organised by the personalised meaningful perception of the problem space.

## The Next Generation of Mental Support Tools

The human and machine roles have been fixed: The user is the operator and at the same time (s)he is the client who expects something back from the system during and after the interaction. On top of that, computers are still regarded as 'work' stages, implying that the user needs a subservient attitude towards his job, employer and the traditional disciplines in his profession. The effectiveness of job performance becomes more and more the ability to escape from virtual barriers; the mental contribution to job is no longer the consequent extrapolation of rules and conventions.
Another factor is that the new mental support tools need to be portable in order to bridge travel time and also to bridge professional spheres like discipline-orientation versus management, training and social networking. It seems that mental support systems become responsible for this interconnection of personal areas. Idea generation, idea selection and idea implementation become the strategic areas for personal growth and inter social achievement.

Looking to educational, entertainment and communicative systems like the browsing via the WWW we see an ongoing trend to redefine the overall metaphor for both the system and the user role. A number of dimensions play a role in this evolutionary process:

1. Operational and effectiveness perspectives urge permanently the user to converge in order to complete tasks in time and compatible with planning schemes.
2. Users themselves demand a certain convergence during their sessions. A broad information spectrum soon leads to digression and the subsequent feeling of entropy.
3. The emulation of the more traditional social entities in virtual environments reflects the need for reconfirming anthropomorphic rules and templates in order to scaffold the centrifugal effects of participation in worldwide global communities.

One of the rescue directions is to go for better-articulated agent-architectures. The agent metaphor reflects the inherent need of users to extend ones awareness via the delegation of the more algorithmic task elements to assistants. Of course, here the consequent problem may be that also the management of agents has its price. Compare the complexity of coordinating your personnel.

Another direction is to gradually migrate from information-based environments to knowledge-based transactions that have a large metadata component in order to reduce ambiguity and the guarantee that finally expertise adds up into coherent functionality.

Finally there is the ever more accepted notion that knowledge is not only a personal asset but mainly distributed along many persons and organizations of persons. A more extreme way of rephrasing is that expertise is 'between the individuals'.

## SMILE Maker for the Conceptual Stage in Problem Solving

SMILE Maker* is a web-based knowledge support system promoting with just in time, just enough and just at point of need intelligent support in dealing with ill-structured problem situations. It is targeted to individuals and groups who try to make a sense of some complex information in open-ended problem situations, to generate alternative solutions, to select the most appropriate among them and to implement it in practice.

Initially, SMILE has been designed to support the students from Faculty of Educational Science and Technology, and Faculty of Communication especially those enrolled in the courses of Linear & Hypermedia, Media in Communication, and some courses in Master of Science Programme Educational and Training System Design. SMILE Maker is a part of the project-based learning environment proposed by those courses.

Conceptually SMILE Maker lies in a cross-section area of four recently strongly recognized paradigms: problem solving, concept mapping, collaborative learning and instructional design.

As a **problem-solving tool** SMILE Maker is a member of the family of soft methodology (Stoyanov & Kommers, 1999). It is a synergy between systematic problem solving, some mapping approaches and creative techniques. It helps users to escape from some syndromes like 'analysis paralysis', and 'functional fixedness', and to avoid some negative effects such as perceptual defense, stereotyping and expectancy. SMILE capitalizes on the strong points of the rational approaches to problem solving such as explicitness, generality and scientific soundness, but also takes into account the intuitive, non-linear and thinking-while-doing ways of solving problems (Wagner, 1992). SMILE has a potential for provoking the elicitation of user's tacit knowledge.

As a **concept-mapping tool** SMILE Maker applies a specific structured systematic concept mapping method aimed at deriving the full potential of mapping techniques. SMILE concept mapping method combines in an idiosyncratic way objective 'hard' data and personal interpretative schemes. As some other concept mapping software (MindManager, QuestMap) SMILE offers shared space for collaborative problem solving, based on concept mapping method. What makes a difference is that SMILE provides also a method for collaborative problem solving, collaborative scenarios, and organises a supportive environment for managing group interaction.

As a **collaborative tool** SMILE Maker enables a shared group environment for distributing learning resources. It supports externalisation and sharing the individual potential in terms of formal expertise and tacit knowledge, organised by the personalised meaningful perception of the problem space. It offers several scenarios for collaboration and could be used for different collaborative goals and in different settings and conditions.

As a **learning tool** SMILE Maker tries to combine the advantages of some of the dominant educational doctrines. It attempts to set up an adequate balance between Instructuvism and Constructivism educational philosophies, Content Treatment Interaction and Aptitude Treatment Interaction instructional design paradigms, and System Locus of Control and User Locus of Control in human computer interaction. SMILE is designed also to be as flexible as possible over various dimensions of different face to face and distributed learning settings.

* SMILE stands for Solution Mapping Intelligent Learning Environment

## SMILE Maker's Theoretical Framework

Conceptually SMILE Maker is based upon the 4 -ID theoretical model (Stoyanov, Aroyo & Kommers, 1999). It consists of four sub-models: SMILE Concept Mapping Method (Content), User, Learning Events, and Facilitator.

The sub-model of **learning events** includes four activities - explanation, example, procedure, and practice. They can be recognised as main stages of general learning cycle that is beyond each instructional design strategy no matter on which of the activities the attention is being focused. Learning can start from anywhere on the learning cycle - explanation, example, procedure or practice. An important consideration taken into account in SMILE is that effectiveness of learning depends on the completeness of learning cycle.

The **user** sub-model is divided into learner and problem solver sub-modules. *Learner* sub-module includes four learning styles: activist, reflector, theorist and pragmatist (Honey & Mumford, 1992). Each learning style reflects the subject's preferences to one of the learning events. *Problem solver* sub-module describes four problem solving styles: seeker, diverger, converger, and practitioner. Each of them demonstrates a bias to one of the stages of SMILE concept mapping method. A user can identify her- or him-self explicitly as either a problem solving style or learning style. Two more characteristics have been added recently: *locus of control* - external or internal, and *prior knowledge* - low, medium and high. They could be identified by the system implicitly depending on the behaviour of the user.

**Facilitator** is entity having four 'faces' that are complementary to each other - profiler, advisor, navigator, and system helper. (Stoyanov & Kommers, 1999) As a *profiler*, facilitator identifies, explicitly or implicitly, users according to their learning styles, problem solving styles, and locus of control or prior knowledge. As an *advisor*, it gives some hints to a user based upon two main principles: the completeness of SMILE concept mapping stages and the completeness of learning events cycle. Facilitator is envisaged not to adapt to a particular individual style, but to develop more versatile style. As a *navigator*, facilitator explains how to navigate through the site. It also informs user the point (s)he has arrived giving a help to save some time and to continue the work. As a *system helper*, facilitator performs some routine functions on behalf of the system - reminding for saving, download procedures, etc.

## SMILE's Concept Mapping Method

SMILE concept mapping method is a member of the concept mapping family approaches some of them, but not limited to are mind mapping (Buzan, 1996), cognitive mapping (Eden, 1995), process mapping (Hunt, 1998) and flowscaping (De Bono, 1994).

Formally, SMILE concept mapping method consists of four types of maps: map information collection, map idea generation, map idea selection, and map idea implementation. The method is built upon the systematic problem solving approach as some original creative techniques are implemented in it. They were constructed on the basis of concept mapping unique characteristics that have been hypothesised by 4E model. The main trends of this model are *expressiveness*, *externalisation*, *extension* and *entireness*. Each map represents a kind of working unit organized upon the individual perception of problem space and incorporating different sort of information.

The objective of ***map information collection*** is to scan all available information about a particular problem. ***Map idea generation*** is purposed to produce as many ideas as possible for getting a problem solution. ***Map idea selection*** is supposed to find the most appropriate candidate for a problem solution among the number of ideas that have been produced in the idea generation phase. ***Map idea implementation*** modifies problem solution in the terms of sequence of activities and events, and presents the needed steps in order to put solutions into practice.

The effectiveness of SMILE concept mapping method has been validated experimentally (Stoyanov, 1999). It has been compared with classical concept mapping approaches against the 4E hypothetical construct model. SMILE concept mapping method proved to be more effective than the classical mapping approaches as a significant difference was found on the main criteria of broad perception, divergence, convergence and planning.

## SMILE's Concept Mapping Method in Collaborative Settings

Some assumptions about the effectiveness of SMILE concept mapping method for collaborative learning and problem solving have raised when 4E model had been compared with the main characteristics and requirements of the collaborative learning (Stoyanova, 1999).

1. SMILE concept mapping ***expressiveness*** supports representation of students' cognitive and affective structure. It enables the process of *negotiation of meaning* and promotes a deeper *mutual understanding* between collaborators (Slavin, 1996). Meanings of the concepts and ideas are *clearly defined* by the position of the concept in the whole picture and its interrelationships with other concepts.

2. SMILE concept mapping allows ***externalisation*** both of factual, procedural and structural knowledge (Jonassen, 1993). It stimulates students' self-awareness. This facilitates the *group processing* (Johnson & Johnson), *group self-reflection and self-monitoring*. Collaborating by concept mapping students interact on the externalised metacognitive level.

3. SMILE concept mapping is an ***extension*** of the internal cognitive structures and processes. Students are supported to compare, combine and negotiate their external representations and to create new group and individual cognitive structures. The process of group negotiation about concept maps promotes an *internal negotiation* and *meaningful integration* of new concepts.

4. SMILE concept mapping ***entireness*** provides students with an opportunity to interact and communicate on the level of a *whole comprehensive picture* of the problem space. Visualisation of different perspectives of the whole problem space enhances the *critical reflection* and could facilitate the process of individual knowledge reconstruction. It might be a helpful hint for *creative thinking*.

## SMILE Method as a Collaborative Tool – Experimental Verification

Three types of problem solving collaboration on SMILE concept mapping method have been experimentally compared: 'Pin-cards' ' Delphi' and 'BrainMapping'.

1. 'Pin-cards' mode. Individually produced maps are exchanged between members of a group.

2. 'Delphi' mode. A moderator (the role is taken by one of the group members) facilitates the process of adjusting of individually produced concept maps, until a consensus is reached on a final common map.

3. 'BrainMapping' mode. Students apply SMILE concept mapping method on a shared workspace by drawing a common map. The group map is a result of direct interaction between individuals.

The **experimental design** is a factorial pre-test post test only. The independent variable is the mode of group interaction with three levels - 'Pin-cards' ' Delphi' and 'BrainMapping'. The dependent variable is learning effectiveness scored numerically on concept mapping production and an attitude questionnaire.

Learning effectiveness of collaborative problem solving was operationalised in three dimensions as follows:

1. Group effectiveness - the degree to which the group production meets the criteria of fluency, complexity, flexibility and innovation

2. Learner solo effectiveness - the level of individual learning achievements in terms of knowledge acquisition, reconstruction of cognition and creativity.

3. Development of co-operative attitudes - the degree to which students' capabilities to work collaboratively has been enhanced. This dimension operationally is defined by criteria of group identity, positive group climate and desire to work collaboratively.

Twenty-six students enrolled in the course Linear &Hypermedia was selected as experimental subjects of this research. They were randomly assigned to the three types of problem solving collaboration.

## Results and Discussion

The results are significantly predictive for a differential effect of the three collaborative problem solving scenarios on SMILE methods effectiveness.

### Group Effectiveness

Both groups working on BrainMapping and Delphi modes scored high on the criteria of group production output. Their group maps are with high level of *fluency, complexity* and *flexibility*. In both cases the individual inputs of the students were *incorporated* in the group maps and different perspectives were presented.

BrainMapping group showed better results than Delphi group on the criteria of innovation and creativity. BrainMapping mode supports breaking up existing patterns and shifting to more non-conventional links and perspectives. The students in BrainMapping group took real benefits from co-operation with their classmates. They developed their group maps including new ideas and concepts that could not be found in their individual maps. Their group maps were more than a sum of their individual knowledge and visions. Delphi group map was restricted to components that are derived from individual inputs.

Students in Pin-card groups scored relatively low on criteria of group map fluency, complexity, flexibility and innovation.

Both BrainMapping and Delphi groups reached *agreement* easy and were satisfied by their group solutions. Students in Delphi scenario tended to minimise contradictions and potential conflicts by saving personal autonomy. They show less personal involvement in the group process.

Students working in Pin-cards mode in fact were not able to find a common group vision about the problem. They reached relatively easy an agreement that was in fact miss-consensus. All potential contradictions were 'covered' by the individual interpretation of pseudo-similarities.

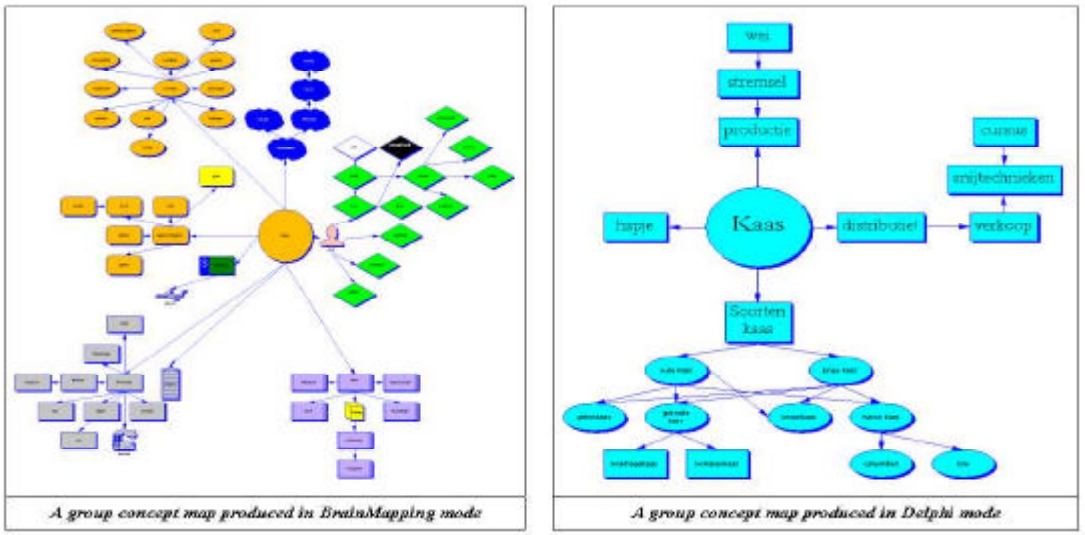


**Figure1**. Examples for group maps produced in BrainMapping mode and in Delphi mode

### Learner-Solo Effectiveness

Students in both groups of BrainMapping and Pin-cards scenarios showed better *knowledge acquisition* than those in Delphi mode as number of assimilated concepts and level of operationalization raised considerably. 'BrainMapping' and 'Pin-card' modes were also highly beneficial in terms of *extension* of individual comprehension of the problem space as inclusion of new concepts and new perspectives.

Students working on 'Delphi' mode incorporated only a few new concepts in their personal cognitive structure. Only those aspects of the group map that were developed by the personal participation of a particular student were internalised in his/her cognition.

Only the use of BrainMapping mode proved its potential for *reconstruction* of the individual cognition represented mainly by reshaping of map spatial configuration. Significant interdependence between common group problem solution and the individual outputs was found. Students working within Delphi mode internalised the general structure negotiated and accepted from the group, but they included only limited number of concepts and restricted aspects of the problem space. Students working within 'Pin' mode resist on their prior conceptual structure.

**Collaborative Attitudes**

All three scenarios scored relatively high on the scale of collaborative attitudes in the questionnaire. No significant difference was found.

| **Learning effectiveness** | **Mode of interaction** | | |
|---|---|---|---|
| | Pin-cards | Delphi | BrainMapping |
| **Group output** | | | |
| Fluency | Low | High | High |
| Complexity | Low | Medium | High |
| Flexibility | Low | High | High |
| Innovation | Low | Medium | High |
| **Learner-solo effectiveness** | | | |
| Knowledge acquisition | High | Low | High |
| Reconstruction of cognition | Low | Medium | High |
| Creativity | Medium | Low | High |
| **Collaborative attitudes** | | | |
| Group identity | High | Medium | High |
| Group climate | High | High | High |
| Desire for collaborative work | High | High | High |

**Figure 2**. *Learning effectiveness of the three modes of problem solving collaboration.*

In summary, the experiment supported the assumption that learning effectiveness in general depends on how SMILE concept mapping method is incorporated in the group collaboration. The three modes of collaboration showed differential effect toward different aspects of learning effectiveness and could be appropriate for specific collaborative goals, settings and conditions.

## SMILE Maker's Functionality Description

At the top level, SMILE Maker presents several functional components: Introduction, Guide, Resources, Scenarios and Partner. **'Introduction'** contains general information what the SMILE Maker tool is about. '**Guide'** gives hints as how to navigate through the site. From '**Resources'** one can select appropriate concept mapping and problem solving software, choose some creative problem solving techniques, see some templates taken from a broad scope of subject domains.

SMILE Maker proposes an option for selecting a scenario that matches the best user's profile. **Scenarios** are particular modes of interrelationship between four ID sub-models. Four scenarios are put in disposition: ready-made, tailor-made, self-made and atelier.

In '**Ready-made'** scenario 'Content' units are presented in predetermined order starting with 'Map information collection' and finishing with 'Map idea implementation'. The order of 'Instructional Events' also is fixed. 'Explanation' is the first and 'Practice' is the last one.

**'Tailor-made'** scenario adapts instruction to the learning preferences. User gets an opportunity to identify him/herself as one of the learning styles and than is sent to a specific path. It is conditioned by the user fixation to a learning event. Thus the paths are 'Explanation', 'Example', 'Procedure' and 'Practice'. Each path is self-contained and is dominated by one of the instructional events, but also includes pieces from other events.

The sources of variation in the **'Self-made'** scenario are both 'Content' and 'Learning Events'. There is not predefined sequence of problem solving maps. However, the content is still SMILE concept mapping method. The assumption is that the user selects a specific option because of need to perform specific actions.

**'Atelier '** scenario might be appropriate for people who are self-confident in building up their own concept mapping approach. There are several components, which a user could select from: Ideas, Maps, Templates, and 'Software' 'Ideas' stands for creative problem solving techniques. 'Maps' presents some mapping approaches like concept mapping, cognitive mapping, mind mapping, and flowscaping. 'Templates' shows some examples of combinations between mapping approaches and problem solving techniques. 'Software' gives opportunity to select and download concept mapping software.

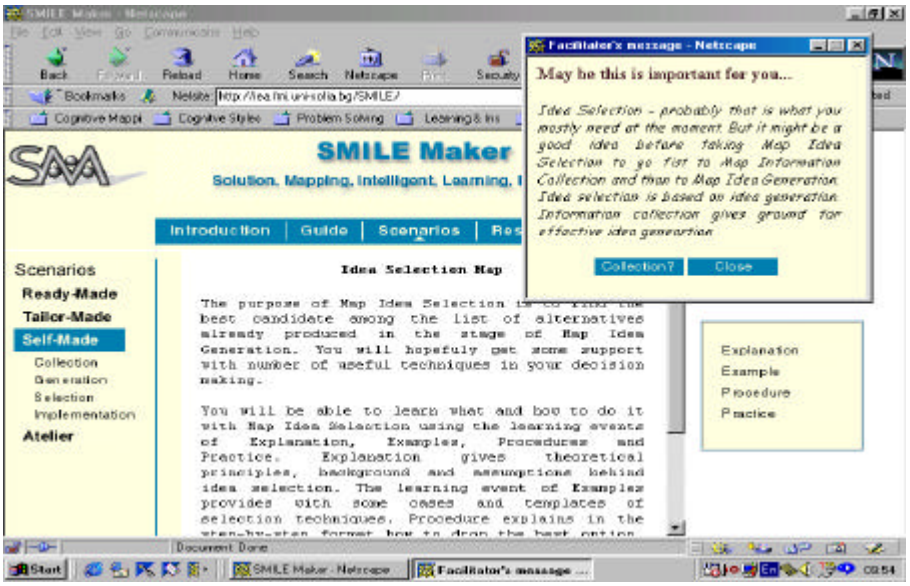


**Figure 3.** *Screenshot of SMILE Maker.*

**Module 'Partner'**

The three modes of collaborative work that were tested experimentally: 'Pin-card', 'Delphi' and 'BrainMapping' are implemented in 'Partner' as three collaborative scenarios. Users are invited to select and use one of them in a more or a less structured way, or just to create their own collaborative protocols. The use of SMILE concept mapping method and of the one of the collaborative scenarios is recommended, but not required.

**Collaborative scenarios**

Pin-cards Scenario

Pin-card scenario is targeted to groups without common group goal. It puts the emphasis on individual learning achievements gained by the exchange with others. Students in such group serve as learning resources for the others. This scenario requires equality and saves personal autonomy. The exchange of maps is realised by e-mail or by storing, searching and reviewing maps in a shared group space. Support is provided for establishing some rules of collaboration such as time schedule, level of confidentiality, maps' format, etc.

Delphi scenario

Delphi scenario is recommended for a type of learning organisations where problem solution is the main goal. It is mostly appropriate for heterogeneous groups of different subject experts with distributed tasks and competencies. It promotes a negotiation in conflicting groups. This scenario is based on a strong distribution of group roles. In fact the regulation of the group processing is allocated to the moderator. SMILE supports her/him in monitoring and managing the group process providing some guidelines. Maps' exchange could be realised by e-mail or by storing them in a shared group space. The collaborative process is saved in Case History as a sequence of maps available for review.

BrainMapping Scenario

BrainMapping scenario is the most full and promising implementation of SMILE method in collaborative settings. It opens a shared whiteboard for drawing maps, visible and accessible for all

group members. The entrance of this scenario prompts automatically a reminder and open resources for establishing collaboration protocols.

This scenario is not recommended for groups with extremely high level of cohesiveness. It is not applicable in asynchronous settings.

'Shared Workspace' is based on Java Shared Object metaphor. Each common or shared map is composed of several linked-shared objects. A master copy of such a map is stored on the central server and this copy is replicated to all clients in a single collaborative session. When the user makes some changes in the nodes, links and labels within a common map these changes become immediately visible to all users.

Partner module provides access to several resources promoting group interaction and collaborative process:

**'Group composition'** contains a members' list identifying their current status. It gives also some hints about group size, role distribution and groups' homogeneity/heterogeneity in terms of level of expertise, experience, personal style and professional status.

**'Techniques'** contains a pool of group creative problem solving techniques with rules and procedures of their application.

**'History'** saves for further review the process of collaborative problem solving as a sequence of maps. This could assist self-reflection, self-monitoring, and group processing. Any map stored in the group pool or in SMILE Gallery is in fact a sequence of maps, representing the process of problem solving and map production.

'**Communication'** offers different channels of communication such as chat and mail.

**'Gallery'** provides an access to a concept maps database where individual and group maps are stored and sorted by criteria such as: context domain, type of maps, mode of production (individual or group), etc. Specific search opportunities are available, as well. When users initiate problem solving, they could use "Gallery" as a knowledge base for similar problems and models of solutions. It offers also an opportunity for finding and selecting partners on the base of concept map personal projection.

**'Facilitator'** follows and registers users' actions, and pop-ups with some advises and just in time and just at the point of need support.

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