

Ecology of Learning Framework (ELF): Guidance for multi-level interventions for learning using Social Ecological Theory.

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Acknowledgement

This study was commissioned by TNO, an independent research organization in The Netherlands. We thank all participants for sharing their knowledge and taking part in data collection.

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Abstract 150 to 250 words, now 220

The learning of individuals is influenced by the context in which they operate and learn. Therefore, when planning interventions for learning, preferably, the whole ecology of learning should be addressed, which includes micro (individual), meso (organizational) and macro (society) levels. This paper describes the development and evaluation of a framework to guide multi-level interventions for learning, based on social ecological models. First, a systematic literature review is performed (using Ovid PsycINFO, educational database ERIC, and Scopus) to investigate the current state of knowledge regarding multi-level interventions on the micro-, meso- and macro-level for learning. Special attention is given to models and frameworks for multi-level integration. Next, a new framework is proposed, the Ecology of Learning Framework (ELF), which is based on the application of Social Ecological Theory. The framework provides an analysis method for multi-level interventions for learning in organizations. A combination of five levels of influence with four intervention-elements form the building blocks of ELF. To research the usefulness of ELF on interventions for learning, it is applied to evaluate the models found in the systematic literature review. Next, two case studies are described in which the framework was used for planning and evaluation purposes respectively. Results indicate that ELF can provide practical guidance for applying theoretical notions of Social Ecological Theory to the practice of interventions for learning.

Keywords 4-6: Social Ecological Theory; Multi-level; Interventions; Learning; micro-meso-macro

Introduction

We live in a world that is changing faster than ever before and knowledge is becoming obsolete the moment it is learned (Tranter & Warn, 2003). Citizens have to be flexible and sufficiently equipped to be able to face the new daily challenges. This implies a need for continuous development (Stubbé & Theunissen, 2008). The ability of people to learn and keep on learning throughout their life will be

increasingly important for the success of companies and countries. This view is supported by research that shows that there is a relationship between the investments in training and development activities to create a learning culture at one side and the financial performance of organisations at the other side (Aragón-Sánchez, Barba-Aragón, & Sanz-Valle, 2003). Therefore, interventions for learning will become a key determinant in future societal success.

The most well-known forms of interventions for learning are in-school education and in-company training and development programs. These are important tools, but have their limits to what they can accomplish regarding learning in a fast changing world (Cascio & Aguinis, 2005). The challenges people meet can be seen in terms of new knowledge, skills and attitudes: they need to act appropriately in new situations. Citizens need ‘practical wisdom’, they need to achieve ‘understanding’ and not mere knowledge, skill-acquisition or technical expertise for its own sake. This ‘practical wisdom’ can be acquired using learning approaches that include authentic worksites, real problems and real peers (Beckett, Agashae, & Oliver, 2002; Percival, 1996; Vann, 1996). Success of learning programs are, therefore, not only determined by the quality of education or training but also by the interpersonal, social, and structural characteristics that reflect the relationship of the student and educational program to the broader real life context (Cascio & Aguinis, 2005). As a result learning interventions may be directed to the micro level of individual learners but also at the context in which these learners operate: the meso (organizational) and macro (society) level. Moreover, an intervention that aims at a single level will probably not have as much impact, because the levels need to reinforce each other to achieve results. For learning interventions to be effective, the whole ecology of learning needs to be addressed, including micro, meso and macro levels. To our knowledge, such an overarching framework on the ecology of learning is missing. This is not surprising because traditionally, each level in the ecology has its own fields of research with their own research traditions and journals (Sallis & Fisher, 2008; Weiner, Lewis, Clauser, & Stitzenberg, 2012). Scholars in educational studies, learning sciences and psychology concentrate primarily on interventions on the micro and meso level. The field of study of HRM management, economics, and sociology is focused on the meso level, with an eye on the macro level (Jackson, Denisi, & Hitt, 2003). Policymakers and governments are primarily focused on the macro-level (Youdell, 2004). These separate fields of

research traditionally aim at separate levels with an interest in the neighbouring level. As such, the focus is not on synergy between all three levels. Therefore, the ecology of learning is not addressed in full.

From research performed in the health care domain, it is known that single interventions are less likely to have an enduring effect when compared to clusters of interventions (Klassen, MacKay, Moher, Walker, & Jones, 2000; Light, 1999; Moulding, Silagy, & Weller, 1999). Although the clusters of interventions in these studies are often performed on multiple levels, a rationale for success of multi-level interventions is often absent. There is however a conceptual basis available for multi-level interventions: Social Ecological Theory (Bronfenbrenner, 1977). Its fundamental insight is that determinants at multiple levels – including intra-personal, interpersonal, organizational, community, and policy – interact or influence human behaviour and outcomes (e.g. Golden & Earp, 2012; Sallis & Fisher, 2008; Stokols, 1992; Weiner et al., 2012). To our knowledge it is not yet studied how Social Ecological Theory research can be applied in the context of learning.

The aim of this paper is to describe the development of a framework to guide multi-level interventions for learning, based on Social Ecological Theory. First, a systematic literature review is performed to research the current state of knowledge regarding multi-level interventions on micro-, meso- and macro-level for learning. Special attention is given to models and frameworks for multi-level integration. Next, a new framework, based on the application of Social Ecological Theory to the field of learning. To research the usefulness of the ELF in learning, it is applied to evaluate the models found in the systematic review. Next, two case studies are described in which the framework was used for planning or evaluation purposes.

A systematic review on multi-level interventions for learning

Data collection

The review was conducted using the internet databases Ovid PsycINFO (period 1806 to 01-2012), educational database ERIC, and Scopus. To identify studies about learning, search terms like learning,

training and education were used (except for ERIC because this database only holds publications related to learning or education). To identify studies that may provide frameworks or models for integration of micro, meso and macro-level interventions, a combination of the terms micro, meso and macro was used. The search hits – references to publications – were imported into the internet database RefWorks. Double hits were removed and 158 hits remained. References (abstracts, keywords and titles) of these hits were studied to conclude whether they fit the selection criteria: (1) the objective should be learning, training or education, and (2) the publication should discuss a combination of micro, meso and macro-level interventions. On the basis of the abstracts of the 158 references only 14 publications met the selection criteria. The full text of these publications were studied to conclude if they should make the final selection. Two publications were omitted because they did not meet the criteria sufficiently and one was omitted because it was only available in Spanish (Silva Aguila & Aguila, 2000). This resulted in a final selection of 11 publications (Chan, 2011; D’Amour & Oandasan, 2005; Hannah & Lester, 2009; Ho et al., 2008; Johnson, 2012; Kozlowski, Chao, & Jensen, 2010; Looi, So, Toh, & Chen, 2011; Mathieu & Tesluk, 2009; Trowler, Fanghanel, & Wareham, 2005; Valcke, 1982; Youdell, 2004). In retrospect, on the basis of the selected articles no better or more representative search terms were found.

[Table 1 about here]

General characteristics of the publications under review

Table 1 shows that, except for one article, the 11 selected publications have years of publication between 2004 and 2012. The subject of micro, meso and macro levels in relation to learning interventions can be considered a rather recent development. Of the 11 studies, six (L1, L2, L4, L8, L10, and L11) had the educational domain and schooling as their subject. Two (L3 and L5) were aimed at the healthcare domain and three were undefined. In approximately half of the studies the learner was an employee and in the other half it was a student. There were no (quasi-)experiments, only case studies and/or theoretical pieces. Five of the 11 publications (L1, L3, L6, L7, and L9) take a more theoretical approach, describing the way interventions should be approached based on existing knowledge, and three of them presented models on multi-level interventions for learning. Six of the 11 publications (L2, L4, L5, L8, L10 and L11) take their lessons from a case study. These were all performed in different countries and different settings. Only two

of them (L5 and L10) described a case regarding employees. They both studied the horizontal transfer of knowledge from researchers to educators, the influences of the different levels and interventions to improve learning.

Classification of micro, meso and macro levels in the reviewed publications

Traditionally, multi-level approaches of interventions of learning include at least three levels: micro, meso and macro. However, when taking a closer look at the publications there appeared to be little consensus about the definition of each level. More than once, publications used the term meso where others call the same level macro (e.g. L2 and L9). According to L9, interventions are traditionally primarily aimed at micro or macro levels. The authors of L9 state that in recent years the aims for these interventions started to move towards each other, which results in a messy middle-ground: the meso level. L9 concludes that all three levels should be taken into account in the development of interventions because each has its own (dis)advantages. Looking closely at the examples of the levels described by the 11 publications, at least five different levels can be distinguished, ranging from the individual to the (inter)national level. These five levels are presented in Table 2 as follows: M1=Micro (learner), M2=Meso-small (group), M3=Meso-large (organization), M4=Macro-small (collection of organizations) and M5=Macro-large (country or collection of countries).

[Table 2 about here]

Interventions reported in the reviewed publications

In Table 3, the reported interventions are shown in relation to the five different levels. Often, descriptions of interventions include the actual intervention activities, supplemented with an analysis of context characteristics, target groups and desired outcomes (e.g. Golden & Earp, 2012; Jackson et al., 2003; Weiner et al., 2012). These intervention-elements are given in the header of Table 3. Two out of 11 publications did not report interventions (L7, L9). Four reported intervention activities that were actually performed (L2, L8, L10, L11). Five proposed interventions for future research (L1, L3, L4, L5, L6). Although the publications as a whole should include at least three levels because they were selected on including micro, meso and macro level, only four included three levels in their intervention activities (L1,

L5, L6, L8) and only two discussed three levels in target groups (L5, L10). Context characteristics and outcome were more often reported as multi-level: in seven publications the context was considered for three levels or more (L1, L2, L3, L4, L5,L8,L10), the same goes for outcome in six publications (L2, L4, L5, L6, L8, L11). Preferably, when performing an intervention activity at a certain level, it would be helpful when information is provided about corresponding target groups, context characteristics and outcomes at the same level. Or when an outcome is expected on a certain level, information about the target group on that level is needed to direct interventions. However, none of the publications provided complete information on relevant intervention-elements.

[Table 3 about here]

Models in the reviewed publications

Of the eleven publications, three proposed a model. The first is the model of D'Amour & Oandasan (2005, publication L3) that describes the process and outcomes of Inter-professional Education. The second is the model of Hannah & Lester (2009, publication L6) that offers a multilevel theory for building and leading learning organizations. The third one is the model of Chan (2011, publication L10) that clarifies the contexts and dynamics for sustainable knowledge building in Hong Kong classrooms. Although the models have in common that they include at least three levels of influence, they are very different in both content and appearance.

Conclusions about the systematic review

With the systematic literature review, the current state of knowledge was studied regarding multi-level interventions on micro, meso and macro level for learning. As accounts for all systematic reviews, the search for publications was limited by the search terms that were chosen to find models or frameworks about multi-level integrations. The term 'multi-level' or synonyms for micro, meso or macro-levels were not used in the search because this resulted in to many unrelated articles. Another limitation considered the time period: the search was performed in January 2012. There may be at this time newer publications

that meet the selection criteria. Due to this limitation, there are undoubtedly other publications about multi-level interventions for learning that were omitted, and we apologize for that.

Based on the 11 selected publications, it can be concluded that the explicit attention to multi-level interventions on micro, meso and macro level for learning can be considered a rather recent development, with exception of Valcke (L1). Thirty years ago, Valcke (1982) stated that a model is needed which takes micro, meso and macro levels into account, to implement computer-based learning in schools. Without exception the publications proclaim the importance of an integrated multi-level approach, but apart from that there appeared to be little consensus. They studied a variety of domains, objectives and used various research methods. Specifically, the lack of consensus about the definition of each level made comparison difficult. In this paper five different levels are distinguished, ranging from the individual to the (inter)national level.

A genuine multi-level intervention for learning should aim at more than one level. Publications were selected only when they discussed a combination of micro, meso and macro-level interventions. This did not guarantee, however, that the actual interventions reported included three levels as well. Specifically, target group description was more limited than based on the content of the intervention activities, context characteristics and outcome seemed justified. It is a prerequisite that the relevant actors at the different levels are sufficiently identified, involved and supported in interventions, otherwise the impact of the interventions may be small (Buunk & Van Vugt, 2013; Elliott & Mihalic, 2004).

Social Ecological theory to guide interventions for learning

Social Ecological theory

Although the review provided some process models that connected micro, meso and macro activities, it is difficult to use them in other contexts than the situations they are designed for. As stated in the introduction, each level within the ecology of learning is object of another field of research and as a result, models or theories that explain the connecting between levels are scarce. There is an exception: from the behavioural and social sciences focus at the micro level, evolved so called ecological models.

Their common and fundamental insight is that determinants at multiple levels – including intra-personal, interpersonal, organizational, community, and policy – interact or influence human behaviour and outcomes (e.g. Golden & Earp, 2012; Sallis & Fisher, 2008; Stokols, 1992; Weiner et al., 2012). There are many examples of ecological models in literature. Sallis and Fischer (2008) report as much as 13 Historical and Contemporary Ecological Models. Together they provide a conceptual theoretical basis for multi-level interventions (Sallis & Fisher, 2008) and as such one may speak of Social Ecological Theory (Stokols, 1996). Social Ecological Theory assumes not only that multiple levels of influence exist, but also that these levels are interactive and reinforce each other (Golden & Earp, 2012; Sallis & Fisher, 2008; Stokols, 1992). Based on these assumptions, (Weiner et al., 2012) formulated two principles of Social Ecological Theory. First, multiple factors that influence a person's situation are described as “levels of influence” (Buunk & Van Vugt, 2013; Elliott & Mihalic, 2004; Weiner et al., 2012). Most often used nowadays are the following levels: intrapersonal, interpersonal, institutional, community, and policy (Golden & Earp, 2012; McLeroy, Bibeau, Steckler, & Glanz, 1988; Sallis & Fisher, 2008). Second, the levels of influence are interdependent (Weiner et al., 2012). That is, they mutually influence each other: causal influence does not flow in only one direction; determinants at one level of influence can modify the effects of determinants at another level and changes at one level of influence can bring about changes at another level (Sallis & Fisher, 2008; Weiner et al., 2012). From these two principles it can be concluded that it takes the combination of all levels to achieve substantial changes. Interventions need to be grouped according to level and according to type of change that is aimed for on each level (Golden & Earp, 2012)

Social Ecology Theory for learning: a challenge

Social Ecological Theory offers a justification for developing multi-level interventions and as such inspired to draw prevention and intervention strategies from it (e.g. Hong & Garbarino, 2012). However, it provides little practical guidance for designing interventions (Weiner et al., 2012). For instance, it is unclear which of the possible interactions between the multiple variables at each level are most important (Sallis & Fisher, 2008) and which causal relationships are of importance. Without such guidance, multi-level intervention designers run the risk of combining interventions that produce scattered, redundant or contradictory effects. So, as promising and well-studied as it may be, it does not provide a ready-made

script for schools and organizations to improve learning of their students or employees. Therefore, a new framework is developed that does justice to the specific situation of learning interventions within the ecology of learning.

Ecology of Learning Framework (ELF)

Development of ELF

This paper introduces a new framework, the Ecology of Learning Framework (ELF), which adopts the five levels originated from the systematic review: M1=Micro (learner), M2=Meso-small (group), M3=Meso-large (organization), M4=Macro-small (collection of organizations) and M5=Macro-large (country or collection of countries). These levels agree with the often presented five levels of influence in Social Ecology Models. Next the concept of four intervention-elements is added to these levels: Target group (t), Characteristics (c), Intervention activities (i), and Outcome (o). These are elements that generally can be found in most intervention studies, whether they are about learning (e.g. Kirkpatrick, 1998) about behavioural changes in general (e.g. Jackson et al., 2003), or as described in the Social Ecological Theory literature (e.g. Bronfenbrenner, 1977; Golden & Earp, 2012; Sallis & Fisher, 2008; Valcke, 1982; Weiner et al., 2012). In accordance with Social Ecological Theory an extension to traditional input-process-output studies is introduced: the intervention-elements should be present at more than one level. According to ELF, target groups are the social units which the interventions intends to change in any of the five levels. Characteristics refer to the target groups characteristics and the physical and social context in which the target groups operate. Characteristics of one level can be the context for another level. For instance learning culture can be the characteristics of a group (M2) and the context for a learner (M1). Intervention activities are strategies for changing a given state of affairs at any of the levels. The element Outcome is the intended or achieved result of an intervention. If a certain outcome is aimed for with a certain intervention, than a positive outcome means a change in the desired direction and a negative outcome the absence of change, or even undesired by-effects. Preferably, on the individual level (M1) this outcome has to be (improved) learning, because ELF is specifically developed for guiding

and evaluating interventions for learning. Additionally, there may be unforeseen or unplanned outcomes on other levels.

The five levels of influence with the four intervention-elements are forming the building blocks of ELF. These building blocks may be an application of the first principle of Social Ecological Theory: multiple factors that influence a person's situation. The second principle of Social Ecological Theory states that these factors are interdependent and mutually influence each other. This interdependency may form a route of influence and need to be made explicit in ELF as well. A multi-level framework preferably is represented by an abstract notation that can unify data derived from various media and interactional situations and can be used to support multiple analytic practices (Suthers, Dwyer, Medina, & Vatrapu, 2010). For representation of the levels of influence of a social ecological model, often a picture with nested concentric circles is used that represent contextual layers of increasing scope (Bronfenbrenner, 1977; Sallis & Fisher, 2008; Weiner et al., 2012). Although it clearly represents the social levels of interest, this visualization makes it difficult to represent the route of influence between levels because a nesting does not guarantee a (causal) relationship between levels. As an alternative, in this study the building-blocks are placed in a table with the five levels as column headers, the four intervention-elements as boxes and the relationship between building blocks as arrows. An example of this visualisation is Figure 2.

Application of ELF to the models found in the systematic review

Of the eleven publications, three proposed a model (L3, L6, L10). This paragraph is used to transform the different models to the new generic framework for analysis of the ecology of learning. In this next section, these three models are described and then plotted schematically in the new five-level framework (M1, M2, M3, M4, M5), using the four elements (t-Target group, c-Characteristics, i-Intervention activities, and o-Outcome) with the route of influence made explicit using arrows.

The model of D'Amour & Oandasan (2005)

[Figure 1 about here]

This model (L3) describes the process and outcomes of Inter-professional Education (see Figure 1). It does not take the macro-levels (M4 en M5) into consideration, but concentrate on the influence of factors at the micro level (M1) and the meso-large level (M3). They call the factors at the meso-large level ‘Institutional Factors’ and they include Leadership/Resources and Administrative processes. The micro level is called ‘Teaching Factors’ and includes Learning context and Faculty development. The two levels influence each other, but also influence learners, their professional beliefs and attitudes and educators. These three elements are related as well. This process results in outcomes, called Health Professional Learner Competencies. A schematic ELF version of the model is presented in Figure 2 and the description according to ELF building blocks is presented in Table 3.

[Figure 2 about here]

The model of Hannah & Lester (2009)

[Figure 3 about here]

This model (L6) offers a multilevel theory for building and leading learning organizations. It shows the interactions of proposed leadership interventions across the levels (see Figure 3). It describes that the interventions on micro-level are aimed at knowledge catalysts. The interventions at the meso-small level (M2i) are aimed at placing the knowledge catalysts within semi-autonomous networks (together with other colleagues) and connecting those networks. This level has a bidirectional relationship with the micro-level (M1). Interventions at the meso-large level (M3i) have the finding, implementing and sharing of the emerging knowledge from the meso-large level (M3o) as a goal. A schematic ELF version of the model is presented in Figure 4 and the description according to ELF building blocks is presented in Table 3.

[Figure 4 about here]

The model of Chan (2011)

[Figure 5 about here]

This model (L10) clarifies the contexts and dynamics for sustainable knowledge building in Hong Kong classrooms (see Figure 5). It describes the macro-small level as main context (M4c) which influences the lower levels in a top-down fashion. There is an exception for the ministry which has a relationship with teachers and researchers. The teachers and researchers also influence each other. The Knowledge Building Teacher Network (KBTN) consists out of a group of teachers who influence researchers, the international community, and schools and classes. The schools and classes also influence the KBTN. The sustainability and scalability are factors that influence the ministry and micro-level processes and dynamics. A schematic ELF version of the model is presented in Figure 6 and the description according to ELF building blocks is presented in Table 3.

[Figure 6 about here]

Applying ELF to plan a project: the case 'Temporary employment'

Context

The aim of ELF was to provide a guideline for multi-level interventions for learning using Social Ecological Theory. To validate the usefulness of the framework, ELF was first tried in the planning phase of a project aiming at the development of multilevel learning intervention for temporary employment. Currently, there is an increase of adults with a temporary employment contract. Some of them are self-employed, but most work temporary for an employer and are part of a so-called flexible shell within organizations. In a more tight labor market due to demographic developments, the flexible worker will have a much stronger position because he/she is attractive for different employers. At this moment however, with an economic and financial recession, it is less favourable to have a temporary employment contract. Learning (formal and informal) within an organization is different for temporary employees than for employees with a fixed contract. This does not only count for the employees themselves but also for

the team, the employer, the network or sector and the country. A focus on more levels is needed to understand (and develop) interventions for learning for adults with a temporary employment contract. ELF has been used for the planning phase in a project on multi-level interventions for learning of employees.

Procedure

During the case, a team of two researchers and two representatives of the Dutch Federation of Private Employment Agencies, used the framework to focus a project proposal for learning interventions for adults with a temporary employment contract.

[Figure 7 about here]

In a three hour workshop facilitated by one of the authors of this article, participants...:

1. Defined potential target groups on all levels of influence (brainstorm with post-its)
2. Selected four main target groups for the learning interventions (discussion & voting)
3. Described relevant characteristics and contextual factors of the selected target groups (brainstorm with post-its)
4. Clustered relevant characteristics and contextual factors of the selected target groups and selected the most relevant ones (discussion)
5. Described desirable outcomes of the multilevel learning intervention for the selected target groups (brainstorm with post-its)
6. Clustered desirable outcomes of the selected target groups and selected most relevant outcomes (discussion)
7. Described potential interventions for the selected target groups (brainstorm with post-its)

8. Clustered potential interventions for the selected target groups and selected most relevant interventions (discussion)
9. Summarized findings and discussed mutual influence of target groups, characteristics and contextual factors, outcomes and interventions on all relevant levels (wrap up).

[Figure 8 about here]

[Table 4 about here]

Findings

The results of the nine steps are presented in Figure 8 and explained in Table 4.

The workshop participants found it very useful to apply the framework in the early stages of a project, as it enabled them to have an overview of all relevant stakeholders and their needs. However, they found it challenging to apply it, as there are more different stakeholders with different characteristics on level M2 than usual: the Employment Agency that 'deliver' temporary employees and the user company where they will work. Furthermore, they experienced difficulties when formulating the desirable outcomes. The participants in this case study had different backgrounds with different perspectives: for instance, the researchers considered it desirable when the user company pays more attention to the personal development of temporary employees, whereas the representatives of the Employment Agencies emphasized the availability of enough cheap labour. Lastly, the researchers consider it useful to add 'Required knowledge' as a relevant intervention-element, as usually new knowledge is necessary to design the interventions.

Applying ELF to evaluate a project: the case Multimedia Learning Material in schools

Context

A second validation of usefulness of the new framework was performed using ELF in the evaluation phase of a project to implement multimedia learning materials. ELF was used as a Quick scan to inventories the goals and ambitions of seven schools regarding the implementation these materials. The

seven schools participate in the network “Multimedia learning materials”, initiated by LeerKRACHT, a Dutch project for teachers empowerment. As part of the program these schools received support from a multimedia coach.

Procedure

Two researchers (one is an author of this article) performed the evaluation procedure. Interview data was collected from participants from seven schools (5 primary, 2 secondary). The aim was to interview from each school a teacher, a coach and the school leader. In total 17 participants (9 men and 8 women; 7 teachers, 7 school leaders, and 2 coaches) participated. Four coaches did not see a possibility to contribute during the research process, two of the coaches interviewed were found to have a double role, namely a coach/teacher and a coach/school leader).

The following steps were taken for the evaluation:

1. Development of a semi-structured interview protocol: Based on ELF, the interview protocol contained 11 main questions about the four ELF intervention elements (target groups, the context and conditions, the desired and achieved outcome, interventions carried out and planned as well as possible obstacles in their implementation) and their experiences with LeerKRACHT. Participants could also ask extra questions or make any other comment.
2. Interview: Each interview lasted about 1 hour. The interviewer did not condition or guide the participants responses to the questions. The participants were not explicitly informed about the framework because the goal was also to investigate whether participants will mention the different elements at the different levels.
3. Interview report: After each interview, a non-literal transcription was performed by the interviewer.
4. Textual model per interview: Each of the 17 individual transcriptions were used to fill in an ELF template (Figure 7). The report text was divided between the cells in the grid where applicable. Not all grids were filled in since respondents were unaware of the different levels of ELF.
5. Encoded model per interview: The 17 textual models were translated into keywords that are relevant across interviews, based on content clustering. A code was added that refers to the cell

in which the text is located. The code illustrates both level (column headers) and intervention-elements (row headers): M1t1, M3c1, etc. Next, the relationships between codes mentioned by the participants were indicated by arrows.

6. Encoded model per school/theme: Clustering of the individual encoded models into one encoded model per school or per theme (type of schools, teachers perspectives, etc). An outcome often mentioned was 'tailor-made learning'. For this outcome an extra model was constructed per school (for example, see Figure 9 and Table 5)
7. Integrated model for all schools. A compilation of the individual schools' encoded models.

[Figure 9 about here]

[Table 5 about here]

Findings

The participants did not receive any information about ELF because this would have been an extra intervention and not merely an evaluation. All references to the ELF building blocks were made spontaneously by the participants. Results showed that mostly levels 1 and 2 are mentioned spontaneously, but there were differences for the type of respondent: school leaders report more often levels 3 about policy and strategy issues, for example on finance. Teachers report more level 2 and 3 daily facilitating or obstructing factors, for example, too little time for learning. However, the differences were so small that no distinctive patterns per function could be found. Levels 4 and 5 were less often mentioned. The participants within a school produced a complementary image: there were generally no opposing perspectives. Only one contradiction was found: at a certain school, the school leader was expecting positive learning effects of a national tests (level 5) and the teacher did not.

The encoded models per school or per theme were very helpful for formulating recommendations, for instance about improving the availability of evidence based tailor-made learning materials. The integrated model for all schools was less helpful because it became almost impossible to construct routes of influence on a generic level. A comprehensive report of the case is published elsewhere (Corbalan, Theunissen, & Paradies, 2014). The researchers who performed the analyses considered the ELF a useful

approach for evaluation purposes. Using ELF provided a good insight in the challenges concerning implementation of multimedia learning materials in schools.

Conclusions and discussion

Evaluation of the Ecology of Learning Framework (ELF)

To research the usefulness of ELF in learning, it is applied to three models found in the systematic review. Although these models had different purposes and different visualisations, the language of ELF made it possible to compare them. However, these three publications did not provide enough detail for a real application of ELF. Therefore, additionally two case studies were performed: ELF was tried in the planning phase of a project aiming at the development of multi-level learning intervention for temporary employment and in the evaluation phase of a project aiming at teacher empowerment. The researchers considered ELF a useful approach for evaluation purposes.

Different perspectives on the situation

Bronfenbrenner (1977), one of the founding fathers of Social Ecological Theory, put forward that the relevant features of the ecology include not only its objective properties, but also the way in which it is perceived. Additionally he quoted the Theorem of Thomas and Swain Thomas: "If men define situations as real, they are real in their consequences" (W.I. Thomas & D. Swain Thomas, *The Child in America*, New York: Alfred A. Knopf, 1928, p. 572, quoted in Bronfenbrenner, 1977). In the two cases in this paper a difference in perspective was an issue as well. The participants in the case 'Temporary employees' had different backgrounds with clearly different perspectives. In turn, during the workshop they discussed the different perspectives of the target groups as well. The case 'Multimedia Learning Materials' included three types of participants: school leader, teacher and multimedia coach. There were individual differences as expected, but these differences were small and the participants within a school produced a complementary image. ELF made the different perspectives on the ecology of learning explicit, and as a result the consequences of these differences could be managed.

Guidelines for intervention design

As argued in this paper, it takes the combination of all levels to achieve substantial changes. Interventions need to be grouped according to level and according to type of change that is aimed for on each level (Golden & Earp, 2012). However, the literature is inconclusive about this: influencing all levels and all intervention elements may be impractical (Hannah & Lester, 2009). In the health behaviour domain it is often recommended that ecological interventions focus at least on two levels of influence. However, sometimes a single intervention will be the leverage point that causes change in the whole ecology, suggesting that even single-level interventions are not necessarily inconsistent with Social Ecological Theory.

The ELF was initially developed to provide guidelines to design and evaluate multi-level interventions. However, ELF as yet does not advise on the intervention design itself and the effectiveness of certain multi-level interventions. Still, it may be possible to draw some inspiration from intervention literature to fill in this gap, as will be discussed in the next section.

For all interventions, it is recommendable to start with identification of the learner, along with target groups that will be of influence in their ecology of learning. To identify the relevant target groups, the concept of 'stakeholder' can be borrowed from management and marketing studies. Stakeholders are the groups or individuals who can affect or are affected by the activities that make up business (Golden & Earp, 2012; Sallis & Fisher, 2008; Stokols, 1996; Weiner et al., 2012). According to Parmar et al. (2010) there are many stakeholder analyses techniques available, providing an exhaustive picture of relevant target groups together with their characteristics and needs.

After a thorough analyses of target groups, their characteristics and the desirable outcomes on all levels, the matching intervention activities need to be selected or designed. The field of educational design is filled with literature on the design of instruction (e.g. Golden & Earp, 2012), courses (e.g. Parmar et al., 2010) programs (e.g. Gustafson & Branch, 2002; van Merriënboer & Kirschner, 2007) and paradigms (e.g. Posner & Rudnitsky, 1986). However, most of these methods have only the learner in mind, which is often a target group at the M1 micro level. Another limitation is that they focus on specific settings, mostly from individual to school settings. Nevertheless, there are some approaches for the development

and evaluation of learning interventions that are potentially in line with ELF. In the next paragraph their applicability to ELF will be discussed.

First, Dick and Carey (1978) offered a multi-stage model which emphasizes the interaction between learners, context, outcomes (performance objectives), and intervention (instructional strategy). The model, called the Systematic Design of Instruction, can be used both to develop and to evaluate interventions, but they are mostly suitable at the micro or meso-small levels (Eisner, 1979). Second, the Instructional Development Institute defined a model that identifies 10 steps to plan instruction (Visscher-Voerman & Gustafson, 2004). The model takes the analysis of the target group and context (or setting), the outcomes (objectives) to develop a prototype of an intervention that will be evaluated and reviewed. Again, this model takes all the elements of ELF into account, but seems mostly suitable at the micro and meso-small levels. Third, Gustafson and Branch (2002) presented a taxonomy of instructional models and indicated that nearly all models include certain core elements of the instructional design process: Analysis, Design, Development, Implementation and Evaluation (ADDIE model) (Dick & Carey, 1978). Probably, the model can be used for both developing and evaluating the development of an intervention (formative evaluation is present at each phase of the cycle). It can be used to evaluate the intervention at each level, from individual courses of learning for a single student (micro level) to for example the common international framework of references for languages, the macro-large level according to ELF (Gerlach, V. & Ely, 1971). Last but not least, one of the most popular evaluation models is that of Kirkpatrick (1998). The model contains four levels on which a learning intervention can be evaluated. Level 1: reaction (was the intervention suitable? how favourably the students or workers have responded to the training?); level 2: knowledge (did they learn anything from the intervention?); level 3: behaviour (transfer of knowledge, skills and attitudes to the work place or other school subjects?) and level 4: results (was it worth it?). Later on level 5 was added: return on investment (did the investment pay off?) (Gustafson & Branch, 2002). Results criteria are most difficult to evaluate. They are operationalised by for example productivity gains, increased customer satisfaction, or increase in profitability of organizations, or alumni career success, graduate school admission, or service to society stability (van den

Akker, 2003). However, although Kirkpatrick's levels matches with the different levels within ELF, it does mostly focus on the influence of the intervention on the outcomes (product). In addition, Kirkpatrick's model is not explicitly used in the development process of the intervention.

To conclude, although the above mentioned models are to some extent useful for designing or evaluating of interventions, none of them included the interaction of all ELF intervention-elements across all ELF levels. Future research might investigate which of these models can be integrated within ELF to support intervention development and evaluation.

Route of influence

The second principle of Social Ecological Theory states that multiple factors are interdependent and mutually influence each other. This interdependency may form a route of influence and was made explicit in ELF as well. Weiner (2012) emphasizes that multilevel interventions should be designed based on sound causal reasoning about the likely interactions among the combined interventions and not simply on the merits of the individual interventions themselves (Kirkpatrick, 1998). When using ELF to analyse the models from the reviewed literature, it appeared that the order in which interventions should take place are not given an exhaustive treatment by the models. Although a route of influence or at least a relationship between elements was hypothesised, it was not clear why these were expected and not others. During the two case studies, several routes of influence were discussed by the participants, but the relationships between elements were purely based in common sense.

A multilevel approach leads to multiple variables at each level. As a result it may be difficult to discern which of the possible interactions are most important (Praslova, 2010). For instance, often it is unclear how exactly the interrelationship within and between levels can be defined: as mediating, as moderating or both? A mediating variable links a cause to an effect and refers to the pathway through which a cause is linked to an effect. A moderating variable influence the relationship between cause and effect and influences the strength or direction (Weiner et al., 2012). More likely, the interrelationships are a combination of mediating and moderating influences. Weiner et al. (2012) proposed five combinations of influences in the context of cancer treatment research: accumulation (each intervention makes a cumulative but discrete contribution to the outcome without being dependent on each other),

amplification (one intervention amplifies the magnitude of the effect of the other intervention(s) on the mediating process), facilitation (one intervention removes the barriers or facilitates the effect of the other interventions), cascade (an intervention at one level affects the outcome in and through interventions at other levels), and convergence (the outputs of some interventions become the inputs of other interventions and vice versa). It depends on theory and empirical evidence which causal relationships are relevant in which situation. The advantage of ELF is that all strategies can be explicitly visualized in one picture. Thus, a challenge for research is to expand understanding of these interactions across levels in the ecology of learning.

Stability of an ecological system

The challenge can even be expanded to the fact that ecological systems in general are not stable but under the influence of transitions (Sallis & Fisher, 2008). In ELF terms, changes at one level or in one intervention-element can result in completely new intervention-elements and routes of influence somewhere in the ecology of learning. Bronfenbrenner (1979) referred to ecological transitions' as a result of a person's development (Baron & Kenny, 1986; Weiner et al., 2012). These transitions include changes in role and setting as a function of a persons' maturation or of events in society (Salomon, 1996). The consequence of this notion is that one ELF analysis for a certain ecology of learning is not enough. It is better to use a longitudinal approach and perform ELF evaluations at more than one point in time.

More evidence needed

A limitation of ELF is that it provides a theoretical perspective on how to look at interactions, but it does not provide explanations or make predictions. Of course, this is why ELF is called a framework and not a model (Bronfenbrenner, 1977). However, lack of evidence for certain levels, elements and routes of influence are often mentioned as limitation of ecological models in general (e.g. Barron, 2006). In classical experimental research, the focus is on a single variable at a time and attempts to "control out" all others. In contrast, in ecological research the investigator seeks to "control in" as many theoretically relevant ecological elements as possible (Suthers et al., 2010). This certainly puts more stress on research methods (Bronfenbrenner, 1977; Sallis & Fisher, 2008; Valcke, 1982). Fortunately, current methods of

investigation are more often based on multi-variate analyses than in the days of Bronfenbrenner (e.g. Bronfenbrenner, 1977; Sallis & Fisher, 2008). Nowadays, structural equation modelling, multi-level analyses and other complex statistical programs are available at almost every institute for behavioural and social studies. Furthermore, research can benefit from the new research interest for Learning Analytics: to improve tailor-made learning using a combination of educational data mining, machine learning, collaborative filtering, latent semantic analysis and information retrieval technologies (Winn, 2003). This relatively new field of research mainly aims at the improvement of learning at the micro level. However, it will provide data analyses methods that makes it possible to combine an unimaginable amount of data from different sources. Perhaps these analyses methods in time can be used to research the ecology of learning as well, with all its levels, elements and routes of influence.

To conclude, this paper discusses a new way of approaching multi-level interventions for learning. The results so far indicate that ELF can provide practical guidance for applying the Social Ecological Theory in the practices of interventions for learning.

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Table 1. General characteristics of the 11 publications under review

Ref. no.	First author	Year	Target sector (1)	Region	Learner	Research method (2)
L1	Valcke, M.	1982	E	International	Student	T
L2	Youdell, D.	2004	E	Australia	Student	C & T
L3	D'Amour, D.	2005	H	International	Employee	T
L4	Trowler, P.	2005	E	Europe	Student	C
L5	Ho, K.	2008	H	North-America	Employee	C & T
L6	Hannah, S.T.	2009	U	International	Employee	T
L7	Kozlowski, S.W.J.	2010	U	International	Employee	T
L8	Looi, C-K.	2010	E	Asia	Student	C & T
L9	Mathieu, J.E.	2010	U	International	Employee	T
L10	Chan, C. K. K.	2011	E	Asia	Employee (teacher)	C & T
L11	Johnson, E. J.	2012	E	North-America	Student	C

(1) Target sector: E = Education, H = Healthcare, U = Undefined

(2) Research method: T = Theoretical, C = Case study

Table 2. Five levels of learning in relation to the levels reported in the 11 publications under review.

New structure of levels ->	Micro (M1)	Meso-small (M2)	Meso-large (M3)	Macro-small (M4)	Macro-large (M5)
	Learner (e.g. student or employee)	Group within organization (e.g. department or faculty)	Organization (e.g. company or school)	Collection of organizations (e.g. economic sector)	≥ Country (e.g. EU, United States of America)
Ref. no.					
L1	micro	micro	micro	meso/macro	meso/macro
L2	micro		meso		macro
L3	micro		meso	macro	macro
L4	micro	meso	macro		
L5	micro	meso	meso		macro
L6	micro	meso	macro		
L7	micro	meso	macro		
L8	micro		meso		macro
L9	micro	meso	macro		
L10	micro	micro/meso	meso	meso	macro
L11	micro	meso	meso		macro

Table 3. Multi-level intervention-elements in the 11 publications under review.

Ref no.	Interventions proposed or performed?	Target group	Context characteristics	Intervention activities	Outcome
L1	Proposed	Students (M1) Teachers (M2)	Didactical approach of teacher and of Computer Based Learning (CBL) programs (M2) Educational setting and facilities in elementary school (M3) Political view on educational innovation (M5)	Introduction of CBL (M2) Teacher training (M4) Planning & organization adaptation to CBL (M3) Computer literacy program (M4)	Accommodate to individual learner needs (M1) Cost-effective learning tools (M5)
L2	Performed	Schooling system (M5)	Potential of individual students (M1), potential of school (M3), part of the country (and socio-economic circumstances) (M5)	Marketization of education (M5)	Triage (M1, M3, M5)
L3	Proposed	Individual learner (M1); Teachers of individual learner (M1)	Beliefs of individual learners (M1); Learning context and faculty development (M2); administrative processes and leadership/resources (M3)	Improving learning context and faculty development (M2), Enhance administrators leadership and resources (M3)	Changes in knowledge, skills/behaviors and attitudes resulting in changes in style of leadership (M1)
L4	Proposed	Workgroups/departments (M2)	Cultural characteristics (M2, M3, M5)	Teaching and learning regimes (TLRs) combined with workgroups (M2)	Increasing the effectiveness of other interventions (M1, M2, M3), improving higher education (M5)

Ref no.	Interventions proposed or performed?	Target group	Context characteristics	Intervention activities	Outcome
L5	Proposed	Students (M1), faculties (M2), management (M3), academia (M5)	Academia (M1), gender, social class, racial identities (M1), use of language within institutions (M2, M3), funding (M3).	Various interventions, e.g.: Support champions (M1), support teams building an inter-professional community (M2), provide infrastructure (M3) and develop, promote and implement incentives (M5).	Integration of Inter-professional Education (M1, M2, M3, M5)
L6	Proposed	Individual employee (M1); groups of employees (M2)	Level of knowledge in employees (M1)	Leadership interventions: identification of knowledge catalysts (M1), creating knowledge network clusters (M2), re-distributing of knowledge (M3)	Improved knowledge at M1, M2, M3
L7	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
L8	Performed	Teachers and students (M1), classes (M2).	Needs and expectations (M1, M2), background of students and classroom culture (M1, M2)	Introduction of GroupScribbles using design research (M1, M2, M3)	Professional development of teachers (M1), introduction of collaborative group work (M2); changing the traditional discourse (M2);

Ref no.	Interventions proposed or performed?	Target group	Context characteristics	Intervention activities	Outcome
L9	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
L10	Performed	Classes (M2), Schools (M3), International educational community (M5)	Environment and internal processes of individual (M1); partnerships between universities, schools and the ministry (M4); cultural beliefs education policy curriculum and ICT reform (M5)	Introducing the Knowledge Building Teacher Network (M4)	Shared knowledge (M4), Improvement educational system (M5)
L11	Performed	Schools in Arizona (M3)	Immigrant backgrounds of students (M1), location of schools (M3)	Language policy for schools (M3, M5)	[intended] Increase use of English in American schools (M1, M2, M3), [reality] decrease in availability and effectiveness of education for Spanish speaking students (M1, M2).

M1=Micro, M2=Meso-small, M3=Meso-large (M3), M4=Macro-small, M5=Macro-large

Table 4. Description of the temporary employment case according to ELF

Target groups: M1t=temporary employees; M2t=Employment agency; M3t=User companies; M4t=Federation of Private Employment Agencies ABU.

Characteristics: M1c=(Interest in) the level of personal development of the temporary employee; M2c=Employment agency wants to help the temporary employees with their personal development, but lack time; M3c=User companies do not want to invest in the personal development of the temporary employees, their focus is on cheap labour.

Interventions: M1i=Enabling the temporary employee to build an e-portfolio and develop competences in their subsequent temporary jobs; M2i=training for the employment agency: to support the learning of temporary employees during their work for the user companies

Outcome: M1o=improved personal development of temporary employees; M2o/M3o= insight in and support of the development of the temporary employees by the employment agency and the user company; M4o=Better image for the industry of employment agencies.

Route of influence: The primary outcome is improved personal development of the temporary employees. The interventions are primarily aimed at level M1i, but have to be supported by interventions at M2i. The interventions should be implemented simultaneously and an extra intervention at M3i should be considered.

Table 5. Example from the case 'Multimedia learning materials: a school about tailor-made learning

according to ELF.

Target groups: M1t=students; M2t=teachers; M3t=school board; M5t=Textbook publishers

Characteristics: M2c=Teachers are very involved in the school, although some teachers are not used to ICT and are uncertain about the usefulness of Multimedia Learning Materials; M3c=ICT-facilities are essential for tailor-made learning; M5c=Textbook publishers do not provide suitable methods for tailor-made learning.

Interventions: M1i1=introduction of multimedia learning materials; M1i2=introduction of eBooks and smart boards; M2i1=the project LeerKRACHT; M2i2=teachers try to use the digital facilities

Outcome: M1o1=Primary goal is tailor-made learning. This has a positive impact on M1o2=(intended) improved learning and M1o3=increased motivation of the students; M2o1=Teachers learn from each other.

Route of influence: Because the primary goal is tailor-made learning (M1), the interventions aim at M1 and M2 level.

Figure Caption

Fig. 1. The original model of D'Amour & Oandasan (2005) with ELF building blocks

Fig. 2. Schematic ELF version of the model of D'Amour & Oandasan (2005)

Fig. 3. The original model of Hannah & Lester (2009) with ELF building blocks

Fig. 4. Schematic ELF version of the model of Hannah & Lester (2009)

Fig. 5. The original model of Chan (2011) with ELF building blocks

Fig. 6. Schematic ELF version of the model of Chan (2011)

Fig. 7. A visualisation of ELF used in the case studies

Fig. 8. Coded ELF model of the temporary employment case

Fig. 9. Coded ELF model from the multimedia learning case: a school about tailor-made learning

Fig. 1

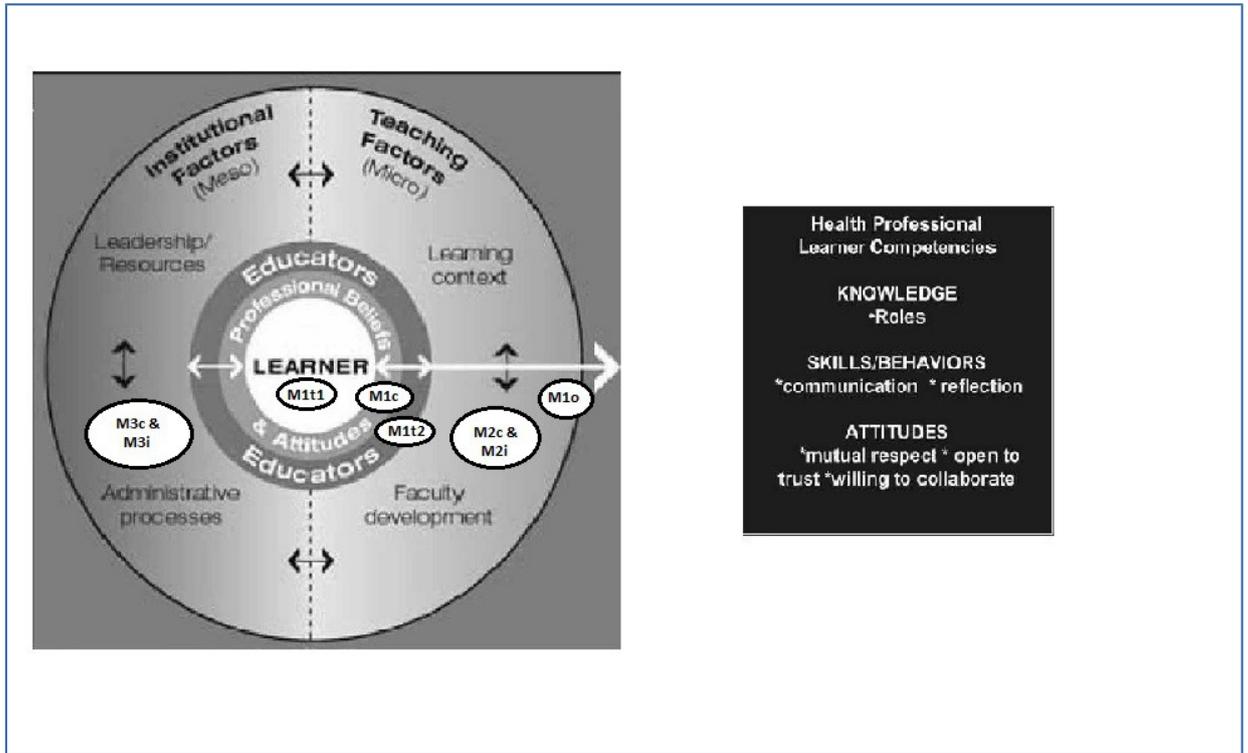


Fig. 2

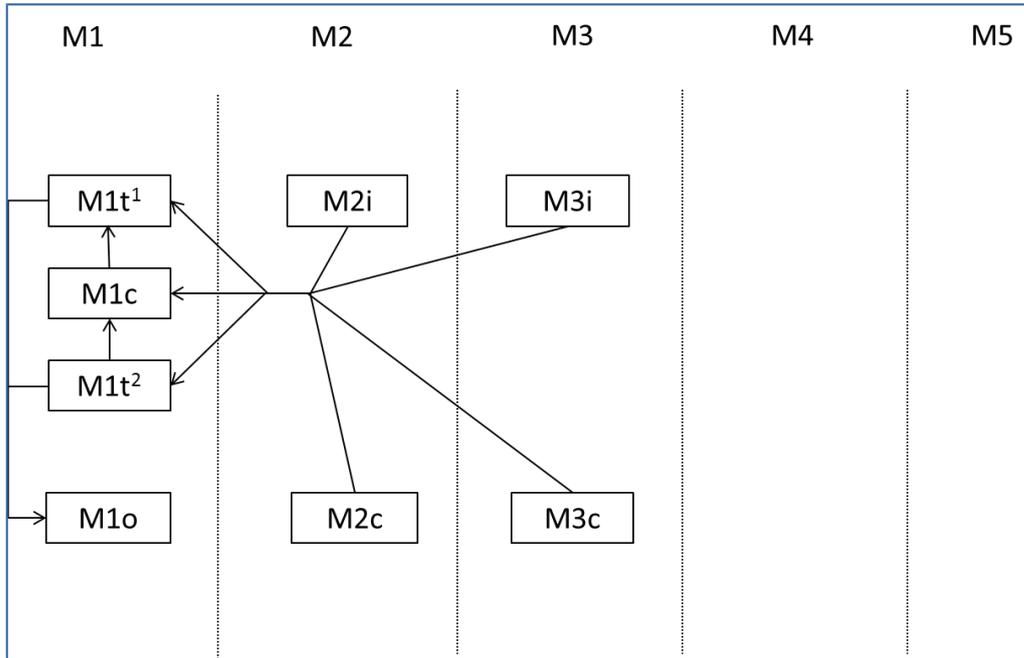


Fig. 3

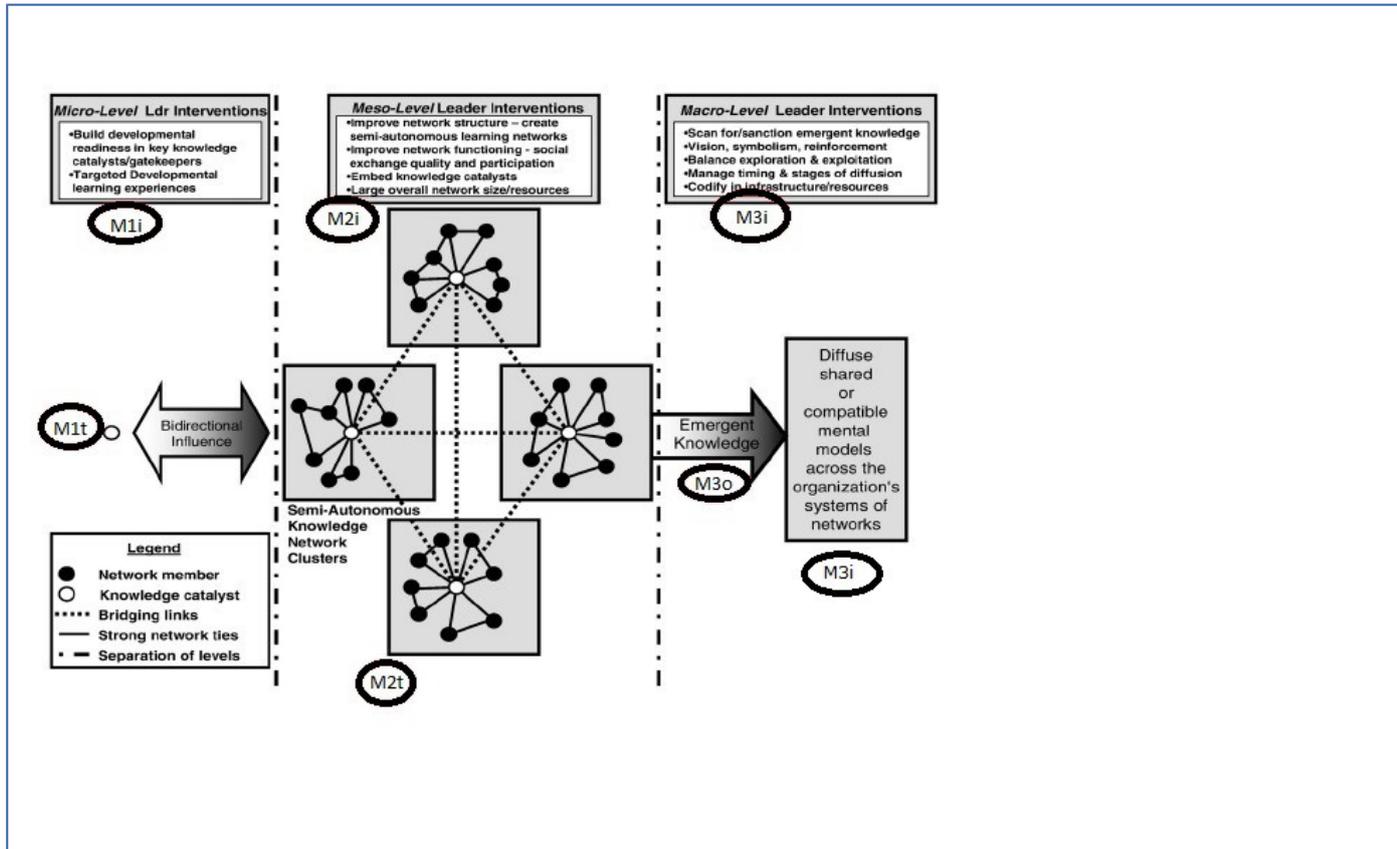


Fig. 4

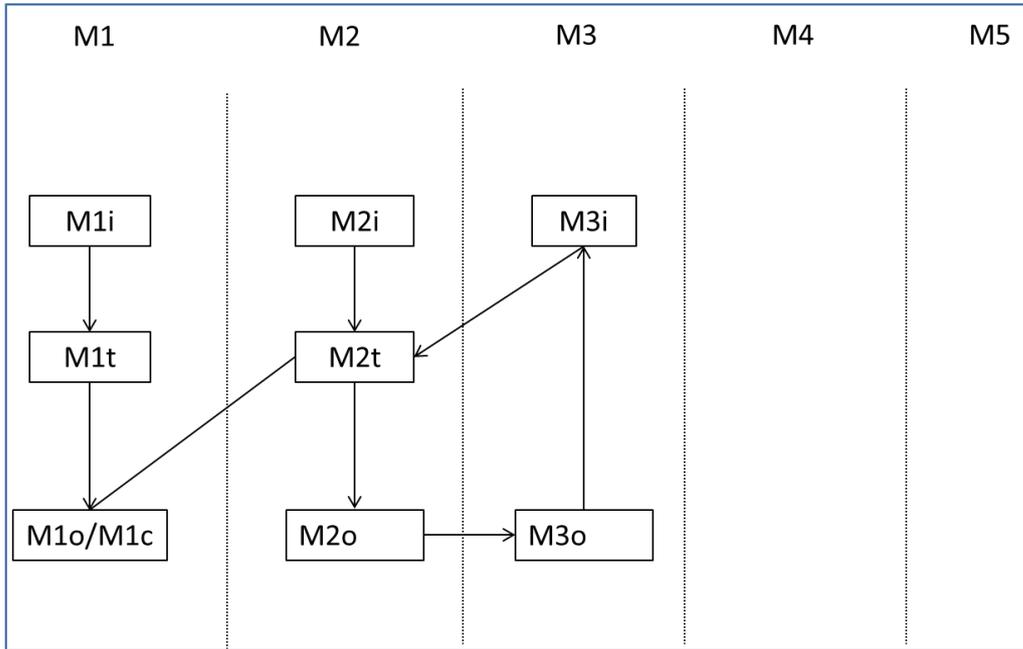


Fig.5

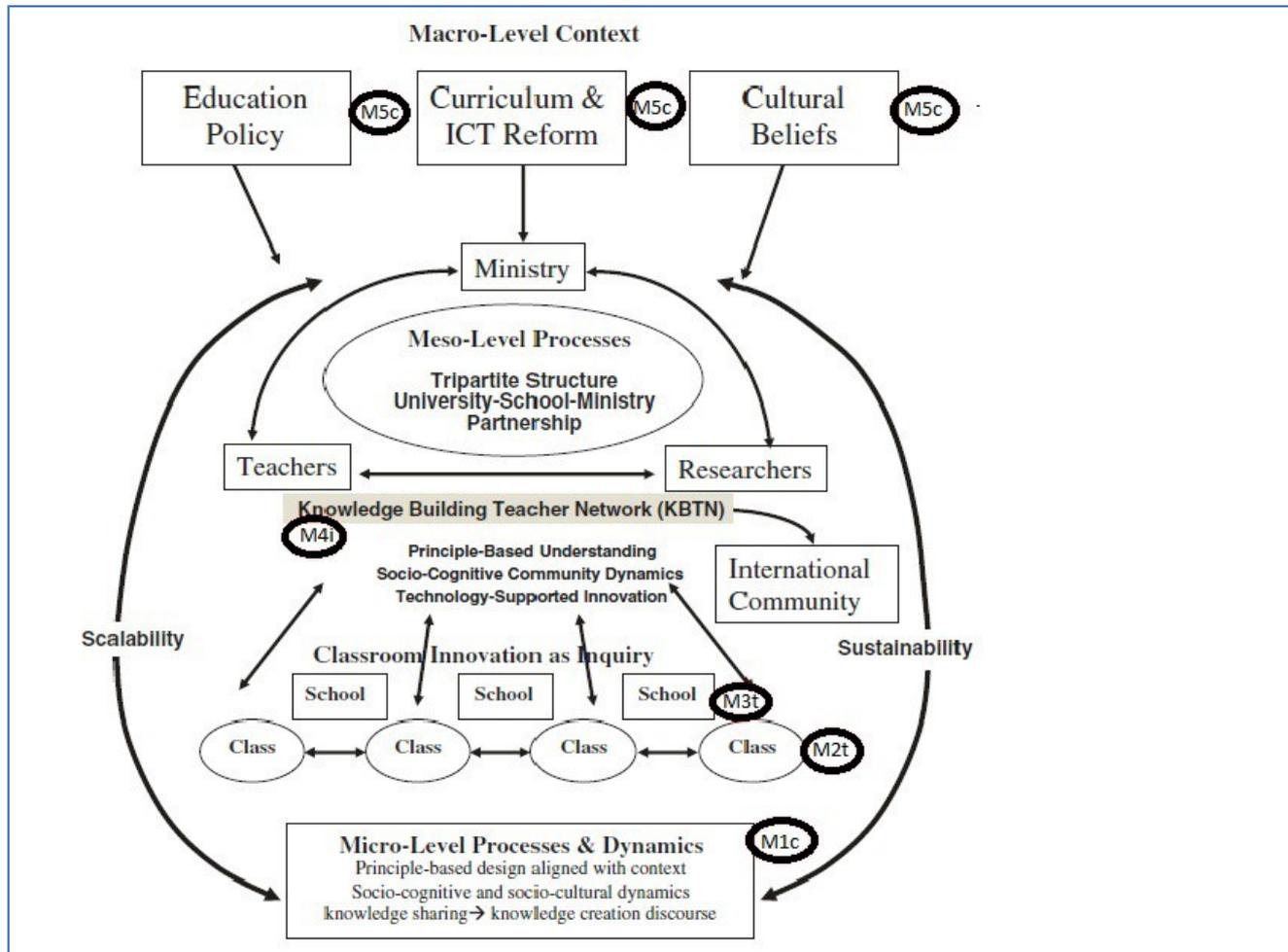


Fig.6

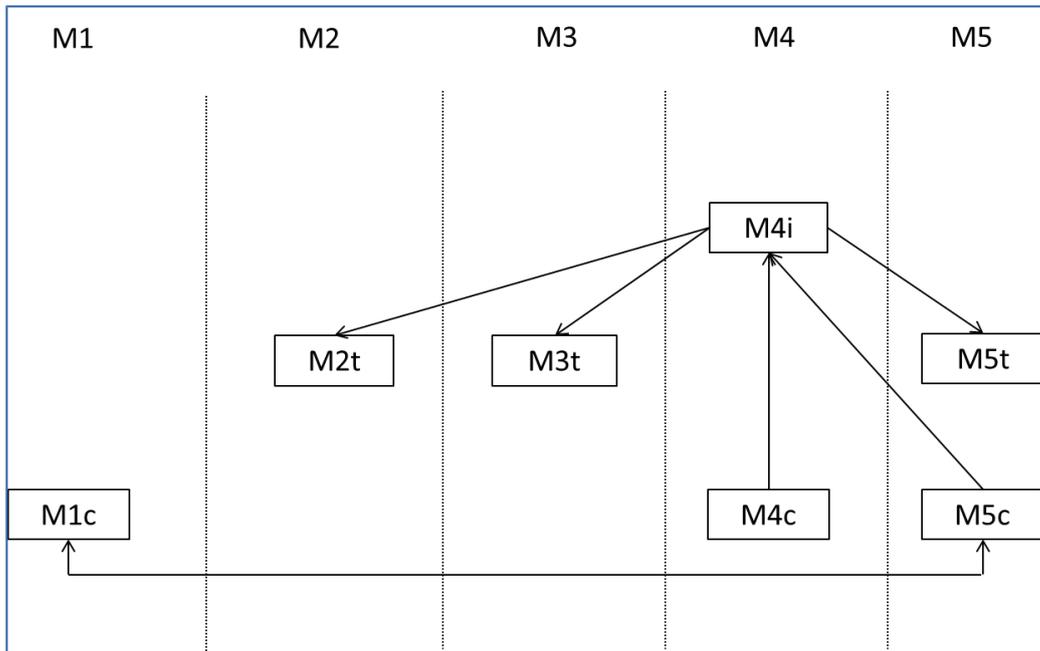


Fig.7

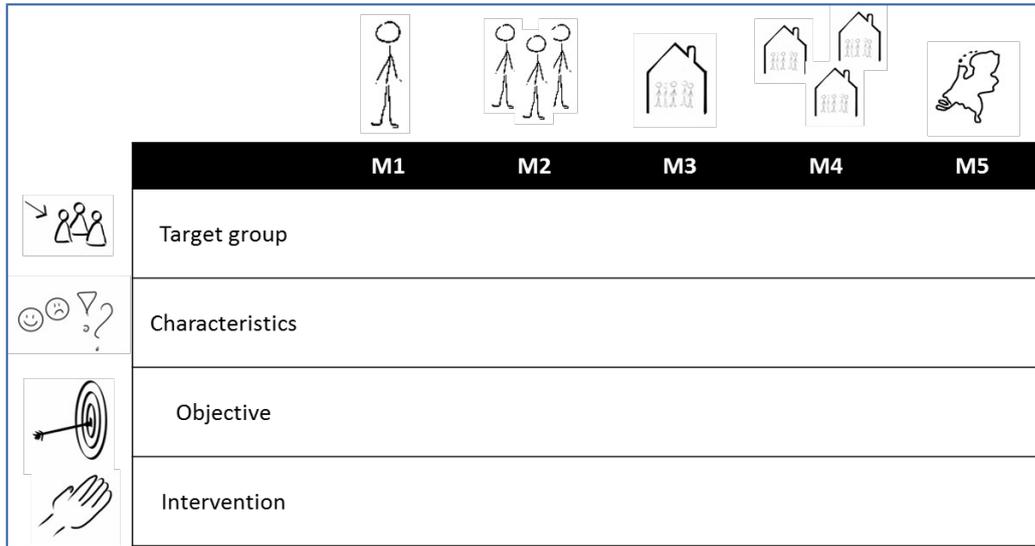


Fig.8

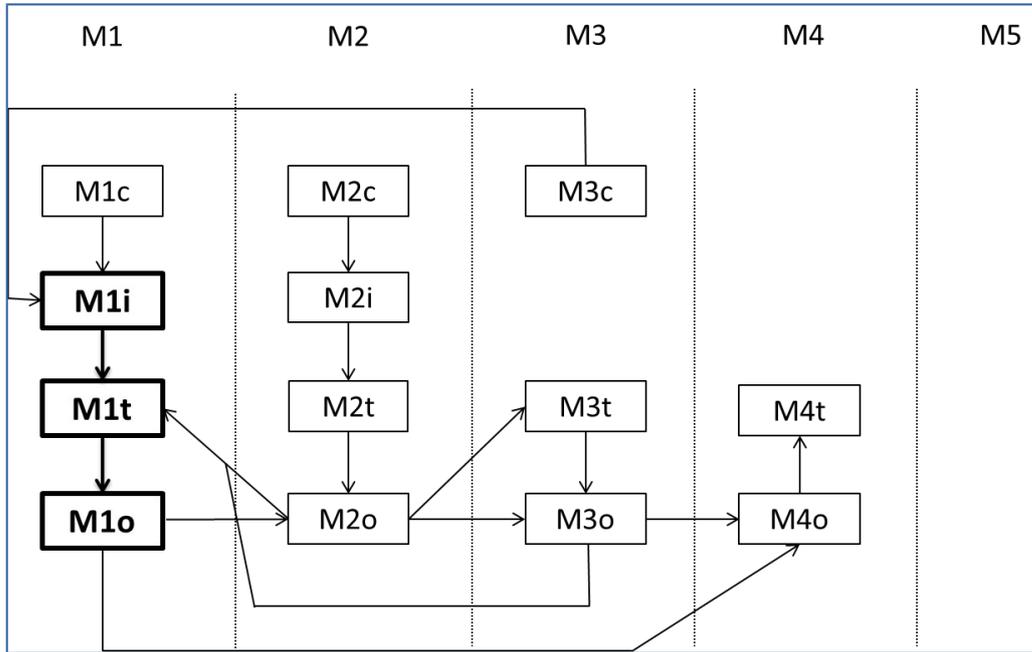


Fig. 9

