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Creativity Trainings for R&D Engineers on Team Level

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Abstract
Creativity is beyond doubt of high influence to competitive advantage for organizations. In this article we focus on the possibility of improving creativity of R&D teams. A training concept is put forward and tried out in a quasi-experimental field study with three innovation teams consisting of engineering and design students. The innovation teams are part of a two-semester course. They had to solve specified "real world problems" by inventing autonomous system devices. Two measurements were used to assess the usefulness of the one-day training in a prae post design. As an external measurement judges rated the answers to the alternate uses test. The German translation of the team climate inventory by Brodbeck, Anderson & West (2000) was used as a self-assessment of creativity. The results show that the predicted enhancement can be seen by the external measurement. The results for the self-assessment are ambiguous. Implications for further research are discussed.

Keywords: R&D Teams, Creativity, Innovation, Training, Engineering.

1. Introduction

It is almost trivial nowadays to state the importance of innovation. As an example for the omnipresence of innovation as important business factor is for example the recommendation by the Harvard Business Review online of the 10 must read articles (www.hbr.harvardbusiness.org/web/collections/10 mustreads). The first (but not only) cited article is about innovation. Overall there is an increasing emphasis placed on innovation as a key contributor to organizational success (e.g. Ford & Gioia, 2000; Wolfe, 1994).
It becomes more and more clear that improving innovative capability of a company is not only about innovation processes but also about. employees. Their innovative respectively creative capabilities and competencies are contributing to a high degree to the innovative capability of a company (Amabile, 1988; Devanna & Tichy, 1990; Jalan & Kleiner, 1995; Salley, 1991; van de Ven, 1986).

1.1 Definition of creativity

Taylor (1988) cites over 60 different definitions of creativity. Besides all differences recent research agrees on some facets in the definition of creativity (e.g. Amabile, 1983, Csikszentmihalyi, 1988, Simonton, 1990, Sternberg & Lubart, 1996, Sternberg & Lubart, 1991):

- (partly or wholly) new ideas

- about products, processes and/or services
- ultimate target is a new and useful outcome.

Amabile (1996) states that creativity for innovation does not only cover the generation of ideas that are novel and useful but also includes their implementation to create new products, services or processes. Contrary to Amabile (1996) we distinguish between the ability to generate and implement new and useful products, services or processes (the *innovative capability* of a company) and the ability to come up with new and useful ideas and make them a starting point or an ingredient of a product, service or process innovation (the *creativity* of individual employees or teams). But having ideas only about potential new and useful products, in one's own mind does not help the company to be innovative. Therefore also the next step is crucial: making these ideas a potential starting point or an ingredient of an implemented innovation. It is therefore that we also talk about innovative capability on the individual and team level as a more complete term. But for the time being we will stick to the term creativity to distinguish our focus of research on the human beings and their skills, competencies and not on the level of companies.

In the greatest part of creativity research the individual creative genius is taken as the asset for innovative capability of organizations. But looking at innovation happening in organizations teams are getting more and more important as the entity to come up with innovations. So it is no longer the "lonesome" genius inventing a new product, process or service but teams. The benefits of teamwork in R&D are beginning to be undisputable, e.g. the development of ideas is relying on communication between team members (Anderson & West, 1994; West, 1990). Communication with other team members provides the possibility that ideas or pre-ideas are enriched to more mature ideas and concepts by adding other problem views, other solutions, further detail information, or combining it with other ideas.

To sum up we understand creativity of a new product engineering team or R&D team as the ability to transfer a high number of new and useful ideas to the first implementation phase not just bringing forward some ideas.

1.2 Training concept

Various studies show that training can enhance creativity. The "first wave" of creativity training studies in the 70ies are dealing mainly with children and/or adolescents in school room environments: e.g. Productive Thinking Program (Covington et al., 1974), CoRT Program (de Bono, 1973) and Program Odyssey (Adams, 1986). Trainings conducted in the "second wave" (starting parallel in the 50ies but having a peak in the 80ies and following years) are focusing on adults as sample group and on divergent thinking as operationalization of creativity (e.g. Feldhusen, 1983; Glover, 1980; Guilford, 1950) and on problem solving (e.g. Getzels & Csikszentmihalyi, 1976; Isaksen & Parnes, 1985; Wallas, 1928; Parnes & Noller, 1972; Mumford et al., 2003) as central training issue. Meta-analysis conducted by Ma (2006), Scott et al. (2004), Torrance (1972) and Rose & Lin (1984) are showing positive results in most of the studies. Rose & Lin (1984) e.g. indicate an effect size of .64 of creativity training. Overall it seems quite reasonable to assume that training can enhance creative capabilities and competencies.

The question is if these trainings are working why are making up a new training concept. Why bother? The training studies mentioned above show certain flaws. Firstly, the external and internal validity is questionable. External validity is seldom given in the studies since most of the studies do not use "real world" problems but divergent thinking tests as operationalization of creativity. The link that divergent thinking tests really do represent creativity useful for R&D needs still has to be shown. Another problem to validity is the use of schoolroom settings. The validity for R&D departments can be questioned therefore. Threats to internal validity are also somewhat obvious. Most of the training tasks mirror the evaluation test task therefore it is maybe only a training effect which is measured but not a real enhancement of creative competencies. Secondly, all trainings described above are trying to enhance individual creativity (e.g. Cropley & Cropley, 2000; Ogot & Okudan, 2006; Puccio, Firestien, Coyle & Masucci, 2006). Creativity on a team level is more than individual idea generation as already explained before. Teamwork involves social and psychological processes that can influence the generation, evaluation, acceptance, and implementation of new ideas (see e.g. Stroebe & Nijstad, 2004).

Therefore training of creativity should be able to look beyond individual problem solving skills and divergent thinking and focus on the specific requirements at team level. This is especially true for R&D departments and other occupational settings where new products, processes and services are developed on a team level and not only by individuals.

Based on literature reviews and existing flaws in present training studies we propose a training concept for product development engineers (see table 1, compare also Goller & Kobe, 2008).

Areas	Focus on individual level	Focus on team level
Resources	- Domain-specific knowledge - Building self-awareness - Perseverance in the implementation process of ideas	- Participative Safety: o Communication skills as listening to other ideas and other team members o Cooperation with other team-members - Support for Innovation: o Acceptance of other ideas - Shared perseverance in the implementation process of ideas - Building team-cohesion
Techniques	- Problem analysis and solving - Divergent thinking	- Support for Innovation
Motivation	- Intrinsic task motivation - Acquisition of a positive attitude towards creativity	- Task Orientation

Table 1. Training concept

Since training concepts normally do not focus on team level it is interesting to explain here to some detail the focus on the team level of the concept (for further details see Goller & Kobe, 2008). Lipman-Blumen & Leavitt (1999) showed that teams can provide ideal conditions for generating new and useful products and processes. But there are also specific barriers existing on a team level for idea generation (Stroebe & Nijstad, 2004, Mumford & Gustafson, 1988, West & Anderson, 1996). Team members are unlikely to generate and communicate novel and unusual ideas if they expect these to be summarily dismissed or criticized. This can be the case if teams do not have a climate that allows creative ideas to be openly communicated, fairly evaluated and properly implemented in order for innovation to be shown (Amabile & Gryskiewicz, 1987, Anderson & West, 1994). West (1990) proposed that team creativity can be encouraged by a team climate where creative ideas are valued and supported, can be presented without fear of reprisal, and where team members are focused on achieving both organizational and task objectives. He developed a four factor model of team climate for creativity and innovation, consisting of Participative Safety (interpersonally non-threatening atmosphere and participation in teams), Support for Innovation (articulated and enacted support of attempts to introduce new and improved ways of doing things), Vision (vision, clarity, attainability, and common team goals), and Task Orientation (shared concern for excellence in performance).

The usefulness of West's (1990) proposed team climate for innovation has been examined in a range of settings using a questionnaire developed for measuring TCI (Anderson & West, 1994). Burningham & West (1995) studied oil company teams and found that Participative Safety, Support for Innovation and Task Orientation all correlated above .30 with external ratings of innovation. West & Anderson (1996) used the widest range of innovation measures in their investigation of hospital top management teams, including individuals' and teams' ratings of their innovation, lists of innovations and experts' ratings of the magnitude, radicalness and novelty of innovations listed by the teams. They found that all TCI scales correlated about .50 with overall innovation and self-reported innovation. Participative Safety and Support for Innovation correlated about .30 with the number of innovations reported by these teams. Task Orientation was significantly correlated with experts' ratings of innovation radicalness and Support for Innovation with their ratings of innovation novelty. These studies show that Participative Safety, Support for Innovation and Task Orientation is important in procuring creative team outcomes. Since these are features of a team that can not be taken for granted (see Stroebe & Nijstad, 2004, Mumford & Gustafson, 1988, West & Anderson, 1996) it is important to find ways to train these characteristics of a creative team.

3. Study

3.1 Research Goal and Hypotheses

Anderson & West (1994) describe unhelpful team climate (e.g. resistance to new ideas) as a roadblock for innovation in organizations. Our overall question is if creative capability on team level can be enhanced through training.

Hypothesis 1. The training will lead to a significant difference on the scales, Task Orientation, Participative Safety and Support for Innovation, of the team climate inventory.

Hypothesis 2. The training will have no influence on the scale Vision of the team climate inventory.

Hypothesis 3. The training will lead to a significant difference in the external measurement (alternate uses test).

3.2 Experimental setting

A two-semester undergraduate course of the ETH (Swiss Federal Institute of Technology) at Zurich was the framework course for the training. The ETH Zurich is offering engineering and managerial studies on bachelor and master level. The course is part of the curriculum of the mechanical engineering department and the credit points given are needed for the bachelor degree. The the course consists of lectures about the process of product development, innovation management, methods in the product development process, and methods of problem solving. Additionally to the lectures a "real world" problem are handed out that has to be solved by a team of students by the end of the course.
The course was taken by 21 students. In this course three so called innovation teams were randomly compiled. Each team had to come up with an innovative solution, design as well as a constructed and working prototype to the given problem. The three problems given were: constructing and designing an autonomous system fish (N=6), a self-steering yacht (N=8), an autonomous small helicopter for use in an amusement park (N=7). As an example of the prototypes designed and produced see figure 1 below.

Figure 1. Designed and produced prototype of one innovation team

The innovation teams resembled very much "real world" R&D teams because they had to deal with all processes involved in organizational R&D processes, like budgeting, coming up with their own time frame, deciding what will be build in the ETH owned shops, what will be bought, etc. All groups can be defined as interdisciplinary because students of another university with a different engineering focus were invited to be part of the teams as well as product design students from another university. Each innovation team had two student counsellors for technical and project design questions. Overall the environment and the difficulty level for the innovation teams can be compared with an R&D environment.

3.3 Training

The training was conducted in the first phase of the innovation process but after the introduction, explanation and first discussion of the "real world" problem. Every team received a one-day training. The training itself followed the concept developed by Goller & Kobe (2008). It was a mix of standard issues about team work in innovation teams and counselling parts tailored to the specific questions the teams had during the training.

Training Topic	Relation to Training Concept
Input about Teams What is a team and how does a team develop?	Building Team-Cohesion[R]
What about the definition criteria is important for us?	Support for Innovation[R]
Where are we standing in the team development clock? What do we have to develop in order to be successful?	Partizipative Safety[R] Support for Innovation[R] Building Team-Cohesion[R] Task Orientation[M] Acquisition of a positive attitude towards creativity[M]
Team task Analysis of the team behaviour and debriefing	Partizipative Safety[R] Support for Innovation[R] Shared perseverance in the implementation process of ideas[R] Building Team-Cohesion[R] Creative Problem Solving[T] Acquisition of a positive attitude towards creativity[M]
Input about communication Communication models useful in team environments	Building Self-Awareness[R]
Input and training about feedback processes and rules	Partizipative Safety[R] Support for Innovation[R] Building Team-Cohesion[R]
Defining team-rules	Partizipative Safety[R] Support for Innovation[R] Shared perseverance in the implementation process of ideas[R] Building Team-Cohesion[R] Building Self-Awareness[R] Task orientation[M]
[R] Resources; [T] Techniques; [M] Motivation	

Table 2. Topics of the training and relation to the training concept

3.4 Measurement

The effects of the training were measured by a prae post design. We used the team climate inventory by Brodbeck, Anderson & West (2000) as a self-descriptive measurement of creativity. It is the validated German translation of the team climate inventory by Anderson & West (1994). The team climate inventory consists of four factors: Vision, Participative Safety, Task Orientation and Support for Innovation. “Vision is an idea of a valued outcome which represents a higher order goal and a motivating force at work” (West, 1990, p. 310). West (1990) states that team vision has four components: clarity, visionary nature, attainability, and sharedness. In order to share ideas as well as information team members need to have a non-threatening environment of trust and support. Only in a team atmosphere like this new ideas will be proposed and brought forward. Task Orientation describes a shared interest in excelling in task performance. West (1990) proposes that this is related to team work methods, intra-team advice, feedback and appraisal of performance and ideas. Support for innovation is defined as the needed active support of team members within the team for innovative behaviour. The team climate inventory is measured on a five-point Likert-scale.

We handed out the questionnaire for the first time five days before the one-day training and the post measurement 3 weeks after the training. Since the training is dealing with “everyday life” of the team we wanted to give the team time to experience the effects of the training and re-evaluate the status of the team. The lectures during the 3 weeks after the training dealt with patent research and training in the use of a CAD system. Both lectures were dealing with technical knowledge only in order not to influence in any way the possible outcomes of the training. All questionnaires were handed out personally and were received within 2 days after the posting.

Additionally to the team climate inventory (Brodbeck, Anderson & West, 2000) we used an external measurement of creativity: the alternate uses test (Christensen et al., 1960, Guilford, 1967). In the alternate uses test subjects are asked to produce as many as possible alternate uses of an everyday object. Since the alternate uses test and its exemplary given objects (e.g. brick) is widely know we used different objects. We wanted to have a procedure as objective as possible for the generation of the alternate uses. We asked a group of 10 people (randomly selected out of the friends of the authors) to name 10 everyday objects they used in the last 24 hours. A list consisting of 34 objects was derived. The named objects could be categorized into three different clusters: technical devices, kitchen objects and others. Out of the three clusters for each measurement (prae, post) one object was drawn.

The three objects were stated to the students at the beginning of the training in a random order for each team. Since we are interested in the team level effects of the training we did not ask for individual contributions but used open brainstorming to derive answers. All answers were noted on a flipchart by the trainer (one of the authors). The team was not aware by the time of the “testing” that the answers are used to evaluate their creativity. The second measurement (post) was taken when the questionnaires where handed out (3 weeks after the training). Only after the second measurement the teams were informed about the use of the data and asked for permission.

All data was handled confidentially and had no influence on grading. All questionnaires and data collected were coded on team level and could not be traced back to the individual level due to privacy issues.

4. Results

The results will show to what degree the training will enhance the creativity of teams similar to organizational R&D teams. Furthermore it will be more evident if teambuilding is actually useful in an R&D context without further training in creativity methods.

4.1 Results and Implications of the external measurement

The alternate uses test asks subjects to list all alternate uses of a named object they can think of. The scoring is comprised of four components: originality, fluency, flexibility, and elaboration (Christensen et al., 1960, Guilford, 1967).

Elaboration is defined as the amount of detail given in the answers. Since the students were not asked to elaborate on the given answers but “just to call out their ideas” elaboration is not considered.

Fluency is defined as the total amount of the given ideas. The responses to all three objects are added up for each measurement (prae and post) and for each team. Over all (innovation teams and objects) 208 items were given in the prae measurement and 144 items were given in the post measurement. In order to find out if there are significant differences a t-test for dependent samples was calculated with the mean over the three innovation teams for each measurement point of time. No significant difference was found for fluency.

Flexibility is defined as the amount of different categories given. All given answers were clustered by two separate judges. Existing differences in the clustering were there for five given answers. They were discussed and resolved between the two judges. Over all (innovation teams and objects) 19 categories were derived in the prae measurement and 21 categories were given in the post measurement. In order to find out if there are significant differences a t-test for dependent samples was calculated with the mean over the three innovation teams for each measurement point of time. No significant difference was found.

	t	df	p
Fluency	2.637	2	n.s.
Flexibility	-2.000	2	n.s.

Table 3. T-test for fluency and flexibility

Originality is defined by comparing each response to the total amount of responses by all people participating. Since we used a group brainstorming technique we can not use this way of counting. Therefore we rely on the consensual assessment technique by Amabile (1982). There it is shown that people can assess the creativity of products without any special training and definition given. We followed the following instructions by Amabile in order to ensure the right use of the technique:

1. Judges have to have some experience with the domain in question but not an identical level of experience is required. Since we use everyday objects we do not have to consider a special domain experience.
2. Judges must make their assessments independently. The consensual assessment technique relies on subjective judgements based on implicit criteria about creativity. There should be no training and no special definition given. Therefore we asked our three judges to rate the originality/creativity of each given answer on a five-point Likert-scale (not original at all – very original) without any further detail information.
3. Each judge should view the products in a different random order. Therefore we ordered the sequence for all 6 objects differently for each judge as well as the sequence of the to be judged answers for each object. All three judges were receiving the randomly ordered answers per mail and were asked to respond within two days. The results show differences (Mprae=1.96; SDprae=0.151 and Mpost=2.34, SDpost=0.122). In order to find out if there are significant differences a t-test for dependent samples was calculated with the mean over the three innovation teams for each measurement point of time. The results were significant (see table 4).

The results for the external measurement show an interesting effect. Fluency and flexibility seem to be not affected by the training whereas originality increases significantly. Overall this is an indication that the training is useful in the sense intended. For R&D teams it is not important how many ideas and how many different categories their ideas belong to but how original, and therefore in the best sense creative and innovative, their ideas are. For innovation it is not important that masses of ideas are produced but that the ideas are of a high quality. Quality in the field of R&D is always related to the innovation and creativity concept of being new respectively original. Another point of quality for innovation is the usefulness of ideas. This we did not ask. It would be interesting if not only the originality of the answers are improved by the given training but also the usefulness. But in order to do so one would have to define usefulness for the to be given answers. The discussion about innovation shows clearly that usefulness of ideas can hardly be defined in the idea phase but is often rather settled after introduction of the product or in the ongoing innovation process. If we take this into account it probably will be hard to define usefulness. The risk will be that especially out-of-the-box ideas about alternate uses will be discarded as original and creative but not useful. The small amount of judges used could be another problem for the interpretation of data. The standard deviations of the compared means are relatively small (Mprae=1.956, SDprae=0.1511 and Mpost=2.339, SDpost=0.1221) which fits the argumentation of Amabile (1982) that there is a consensual assessment possible. Therefore we assume that the standard deviation would not be influenced significantly with the increase of judges and the result is therefore relatively stable.

	t	df	p
Originality	-4.758*	2	.041

*significant $p<0.05$

Table 4. Results t-test for originality

4.2 Results and Implications of the self-descriptive measurement

As a self-descriptive measurement of creativity we used the team climate inventory (Broadbeck, Anderson & West, 2000). The authors report for a measure of reliability internal consistency of the scales between $\alpha = .81$ und $\alpha = .89$. The average inter-rater-reliability is between $r = .90$ and $r = .96$. The validity is given as the correlation between the team climate scales and external rated indicators of creativity ($r = .32$ to $r = .64$).

Comparisons of the means of the two measurements points of time for all three teams were conducted on the different scales of the team climate inventory: Vision, Participative Safety, Task Orientation, and Support for Innovation.

	t	df	p
Vision	-0.034	2	.976
Task Orientation	-1.324	2	.317
Participative Safety	-0.696	2	.558
Support for Innovation	-0.596	2	.612

Table 5. T-test for all scales

No significant results could be found. The first scale Vision (Mprae=43.52, Mpost=43.58) is not expected to be different since the training concept does not include any contents in order to train the relevant competencies for this scale. The scales Task Orientation (Mprae=27.28, Mpost=27.55), Participative safety (Mprae=48.69, Mpost=49.68), and Support for Innovation (Mprae=30.39, Mpost=30.75) show no significant differences as well. This result is somewhat astonishing in the light of the significant result of the external indicator. It may be possible that self-descriptions are not as sensitive to change as external ratings. Personality psychology states that human beings tend to perceive themselves in a stable, consistent way. (e.g. Eysenck & Eysenck, 1985, McCrae & Costa, 1987, Cattell, 1959). The results could be an indication that self-descriptions in the asked field of behaviour are perceived as relatively stable and insofar are not due to change in the self-description in a short time. Whereas the external ratings are oriented on the results of creative behaviour and are not influenced by personality factors.

The changes in all scales are going in the right direction, but they are not significant. If we look at the results from a methodological point of view it is obvious that the sample size (N=3) is rather small. The data could only be collected on a team level for each innovation team out of confidentiality issues. Therefore the individual data sets could not be collected and used. Bortz (2005) is referring to the effect size as a way to find appropriate sample sizes for expected effects. The table below is a reference for optimal sample sizes. Therefore it is not astonishing that no significant effects could be found. Even if we would expect to have a strong effect we would still need N=11.

Effect Size		Optimal Sample Size
0.20	small effect	156
0.50	medium effect	26
0.80	strong effect	11

Table 6. Relation effect size and sample size

For exploratory reasons we use for each individual data set the innovation team mean. As a result we can use 21 data sets which will enable us to find hints for an existing effect in our training sample. We insert the group mean of each group for the individual data sets in the group (N_{group1}=7; N_{group2}=6, N_{group3}=8). We have now N=21 and will calculate the t-test for dependent sample sizes on an overall level (prae post).

As can be seen in table 7, the scale Vision shows again no significant difference between the two measurement points of time (Mprä=43.59, SDprä=2.642; Mpost=43.72, SDpost=1.533) as predicted.

	t	df	p
Vision	-0.327	20	.747
Task Orientation	-3.860**	20	.001
Participative Safety	-2.776*	20	.012
Support for Innovation	-2.036	20	.055

** significant p<0.01
*significant p<0.05

Table 7. Exploratory t-test

The scale Task Orientation shows a highly significant difference between the two measurement points of time (Mprä=27.37, SDprä=1.087; Mpost=27.62, SDpost=0.982). The scale Participative Safety shows a significant difference between the two measurement points of time (Mprä=48.64, SDprä=0.854; Mpost=49.87, SDpost=1.682). The scale Support for Innovation does not show a significant effect (Mprä=30.42, SDprä=1.201; Mpost=30.80, SDpost=0.566). But Support for Innovation shows a trend towards significance. The results of the exploratory t-test are quite promising. It could be possible that without the limiting sample size that the training does indeed have the predicted effects.

4.3 Summary of the results and further research

The data shows some promising answers to our research question if training can enhance creativity on team level.

Hypothesis 1. The training will lead to a significant difference on the scales, Task Orientation, Participative Safety and Support for Innovation, of the team climate inventory. Hypothesis 1 can be supported for the scales Task Orientation and Participative Safety if we take the adjusted sample size (N=21) into account. Nevertheless it would be sensible to replicate the results in a quasi-experimental field study with more teams, meaning an adequate sample size. Given the collected data (N=3) in the field study hypothesis 1 can not be supported. Support for Innovation can not be supported. Even in the exploratory t-test with the adjusted sample size (N=21) the difference between the two measurements is not significant. It is possible that Support for Innovation can not be influenced by training alone but needs some sort of counselling and therefore "deeper" and even more tailored intervention. The extension of the training into a training combined with individual team counselling sessions could be a possibility to develop the training concept further.

Hypothesis 2. The training will have no influence on the scale Vision, of the team climate inventory.

This hypothesis can be clearly supported. In all cases the scale vision did not change significantly. The result backs the quality of the implementation of the theoretical training concept. This also tackles the missing of a control group. In order to ensure that differences in the measurement are truly an effect of the intervention and not due to effects like maturation, history or testing a control group should be established (Cook & Campbell, 1979). In our field study the training was part of a two-semester course at the mechanical engineering department and the credit points of the course account for the bachelor degree. Fairness prohibits the setup of a control group within the course. Therefore we measured the scale Vision as a control measurement. The results of the exploratory t-test show exactly the proposed result: no difference on the scale Vision but significant differences between the measurements on two out of all three scales.

Hypothesis 3. The training will lead to a significant difference of the external measurement (alternate uses test). Hypothesis 3 could clearly be supported. The results show that even with a very small sample size an effect could be detected. This is promising in itself but also shows the need of further research about the influence of different measurement methods on the construct of creativity on team level.

One remark about possible generalizations of the results will conclude this article. The analysed innovation teams are in many reasons very similar to R&D teams in organizations. The innovation teams consist out of different domains (engineering and design) with a majority of engineering students and students from different universities. This resembles modern interdisciplinary R&D teams, at least to a certain extent. The teams had limited resources for their innovation task insofar that all money, material and needed expert knowledge outside the university had to be funded by the innovation team itself besides a very small starting budget. This restriction in resources is very similar to R&D teams in organizations. Another similarity was the limited control over framework variables like changing the detail idea of the innovation object and overall goal during the innovation process (happened to one of the teams due to changing ideas of their main sponsor), being forced to move the office during the innovation process (leads to additional time restrictions), a not-well adjusted IT-system for files and documents, etc. In sum the environment was modelled (voluntarily and involuntarily) as close to an organizational R&D team as possible. Even the innovation process with milestone presentations, documentation formats and sponsor events were alike.

Some differences can be found and constrict the possible generalization. The innovation teams are not alike an organizational R&D teams if companies work with long-term, stable teams. The innovation teams are much more like project teams, coming together for a certain goal and being dissolved after completion. Some of the hindering team dynamics described by e.g. West & Anderson (1996) may only occur if teams are working together for a longer time with the same manning. The biggest differences between the innovation teams and organizational R&D teams are: age of team members and supportive structures for the innovation teams within the course. All team members were in their early twenties. We do not know in what way and how this age difference to an organizational R&D team will influence the results. The given supportive structures of the course are the existence of two student-supervisors for each team. They had the task to answer upcoming questions regarding innovation process, technical and organization problems. Most R&D teams do not have a supportive structure like that. The supervisors did not have the task to help increase the creativity of the team or to counsel the team on “human resources” issues but to “overcome” the shortage of knowledge and experience of the students.

Overall the similarities between the innovation teams and organizational R&D teams outweigh the differences. The conclusion that creativity on a team level can be enhanced by training has found some supportive points with this study but still needs a lot of research.

References

Adams, M.J. (1986) Odyssey: A curriculum for thinking, Watertown, MA: Mastery Education Corporation.

Agrell, A., & Gustafson, R. (1994) The Team Climate Inventory (TCI) and group innovation: A psychometric test on a Swedisch sample of work groups, Journal of Occupational and Organizational Psychology, **67**, 143-151.

Amabile, T. M. (1982) Social Psychology of Creativity: A Consensual Assessment Technique, Journal of Personality and Social Psychology, **43**,5, 997-1013

Amabile, T.M. (1983) The social psychology of creativity, New York: Springer-Verlag.

Amabile, T.M. (1988) A model of creativity and innovation in organizations, in B.M. Staw & L.L. Cummings (Eds.), Research in organizational behavior, 10, 123-167. Greenwich, CT: JAI Press.

Amabile, T. M. (1996) Creativity in Context: Update to "the Social Psychology of Creativity", Boulder, Colorado, Westview Press Inc.

Amabile, T. M., & Gryskiewicz, S. S. (1987) Creativity in the R&D laboratory, Greensboro, NC: Center for Creative Leadershipo. Document Number)

Amabile, T.M. & Tighe, E. (1993) Questions of creativity, in Borckman, J. (Ed.), Creativity (p.7-27), New York: Simon & Schuster.

Anderson, N.R., & West, M.A. (1994) The Team Climate Inventory (TCI) and group innovation: A psychometric test on a Swedish sample of work groups, Windsor, UK: ASE/NFER-Nelson Press.

Anderson, N. R., & West, M. A. (1998) Measuring climate for work group innovation: development and validation of the team climate inventory, Journal of Organizational Behavior, **19**, 235-258.

Basadur, M.S. & Graen, G.B. (1982) Training in creative problem solving: Effects on ideation and problem finding and solving in an industrial research organization, Organizational Behavior and Human Performance, **20**, 41-70.

Bortz, J. (2005) Statistik für Human- und Sozialwissenschaftler, 6^{th} edition, Heidelberg: Springer Verlag.

Burningham, C., & West, M. A. (1995) Individual, climate, and group interaction processes as predictors of work team innovation, Small Group Research, **26**, 106-117.

Cattell, R. B. (1950) Personality a systematic theoretical and factual study, New York: McGraw Hill.Clapham, M.M. (1997) Ideational skills training: A key element in creativity training programs, Creativity Research Journal, **10**, 33-44.

Cook, D. & Campbell, D.T. (1979) Quasi-Experimentation: Design and Analysis Issues for Field Settings, Chicago: RandMcNally College Pub. Co.

Covington, M.V.; Crutchfield, R.S.; Davies, L. & Olten, R.M. (1974) The productive thinking program: A course in learning to think. Columbus, OH: Merrill.

Christensen, P.R., Guilford, J.P., Merrifield, R.P. and Wilson, R.C. (1960). Alternate uses, Sheridan Psychological Service, Beverly Hills, CA.

Cropley, A.J. (1992) More way than one: Fostering creativity, Norwood, NJ: Ablex.

Cropley, D.H. & Cropley, A.J. (2000). Fostering Creativity in Engineering Undergraduates, High Ability Studies, **11**, 2, 207-219.

Csikszentmihalyi, M. (1988) Society, culture, and person: A systems view of creativity, in R. J. Sternberg (Ed.), The nature of creativity (p. 325-339). New York, NY: Cambridge University Press.

De Bono, E. (1973) CoRT thinking. Blanford, UK: Direct Educational Services.

Devanna. M.A., & Tichy, N. (1990) Creating the competitive organization of the 21st century: The boundaryless corporation, Human Resource Management, **29**, 445-471.

Eysenck, H. J., & Eysenck, M. W. (1985) Personality and individual differences: A natural science approach, New York: Plenum.

Feldhusen, J. F. (1983) The Purdue Creative Thinking Program, in I. S. Sato (Ed.), Creativity research and educational planning (p. 44-46). Los Angeles, CA: Leadership Training Institute for Gifted and Talented.

Finke, R.A., Ward, T.B. & Smith, S.M. (1992) Creative cognition: Theory, research, and applications, Cambridge: MA: MIT Press.

Ford, C., & Gioia, D. (2000) Factors influencing creativity in the domain of managerial decision making, Journal of Management, **26**, 4, 705-732.

Getzels, S. W., & Csikszentmihalyi, M. (1976) The creative vision: A longitudinal study of problem finding in art, New York, NY: Wiley.

Glover, J. A. (1980) A creativity training workshop: Short-term, long-term, and transfer effects, Journal of Genetic Psychology, **136**, 3-16.

Goffin, K. & Mitchel, R. (2005) Innovation Management. Palgrave.

Goller, I. & Kobe, C. (2008) Developing a Team Creativity Training for Engineers, 9th CINet conference 2008, Valencia, September 7-9, 2008, p. 387-398 (CD-ROM, ISBN 978-90-77360-10-1).

Guilford, J. P. (1950) Creativity. American Psychologist, **5**, 444-454.

Guilford (1967) Creativity: yesterday, today & tomorrow, Journal of Creative Behavior, **1**, 3-14.

Isaksen, S. G., & Parnes, S. J. (1985) Curriculum planning for creative thinking and problem solving, Journal of Creative Behavior, **19**, 1-29.

Jalan, A. & Kleiner, B.H. (1995) New developments in developing creativity, Journal of Managerial Psychology, **10**, 8, 20-23.

Lipman-Blumen, J., & Leavitt, H. J. (1999) Hot groups: Seeding them, feeding them, and using them to ignite your organization, New York, NY: Oxford University Press.

Ma, H.-H. (2006) A synthetic analysis of the effectiveness of single components and packages in creativity training programs, Creativity Research Journal, **18**, 4, 435-446.

McCrae, R. R., & Costa, P. C., Jr. (1987) Validation of the five-factor model across instruments and observers, Journal of Personality and Social Psychology, 52, 81–90.

Mumford, M. D., Baughman, W. A., & Sager, C. E. (2003) Picking the right material: Cognitive processing skills and their role in creative thought, in M. A. Runco (Ed.), Critical and creative thinking (pp. 19-68). Cresskill, NJ: Hampton.

Mumford, M. D., & Gustafson, S. B. (1988) Creativity syndrom: Integration, application and innovation, Psychological Bulletin, **103**, 27-43.

Nickerson, R.S. (2005) Enhancing Creativity, in Sternberg, R. J. (Ed.): Handbook of creativity, 5th

ed., Cambridge University Press, New York.
Ogot, M. & Okudan, G.E. (2006). Integrating systematic creativity in first-year engineering design curriculum, International Journal of Engineering Education, **22**, 1, 109-115.
Oldham, G.R. & Cummings, A. (1996). Employee Creativity: Personal and contextual factors at work, Academy of Management Journal, **39**, 607-634.
Parnes, S. J., & Noller, R. B. (1972) Applied creativity: The creative studies project: Part results of the two year program, Journal of Creative Behavior, **6**, 164-186.
Puccio, G.J., Firestien, R.L., Coyle, C. & Masucci, C. (2006) A review of the effectiveness of CPS training: A focus on workplace issues, Creativity and Innovation Management, **15**, 1, 19-33.
Rose, L.H. & Lin, H.-T. (1984) A meta-analysis of long-term creativity training programs, The Journal of Creative Behavior, **18**, 1, 11-22.
Scott, G.; Leritz, L.E. & Mumford, M.D. (2004) The effectiveness of creativity training: a quantitative review, Creativity Research Journal, **16**, 4, 361-388.
Simonton, D. K. (1990) Psychology, science, and history: An introduction to historiometry, New Haven, CT: Yale University Press.
Shalley, C.E. (1991) Effects of productivity goals, creativity goals, and personal discretion on individual creativity, Journal of Applied Psychology, **76**, 179-185.
Sternberg, R.J. & Lubart, T.I. (1996). Investing in creativity, American Psychologist, **51**, 677-688.
Sternberg, R. J., & Lubart, T. I. (1996) Investing in creativity, American Psychologist, **51**, 677-688.
Stroebe, W., & Nijstad, B. A. (2004) Warum Brainstorming in Gruppen Kreativität vermindert: Eine kognitive Theorie der Leistungsverluste beim Brainstorming, Psychologische Rundschau, **54**, 1, 2-10.
Taylor, C. W. (1988) Various approaches to and definitions of creativity, in R. J. Sternberg (Ed.), The nature of creativity. New York, NY: Cambridge University Press.
Thackray, J. (1995) That vital spark (creativity enhancement in business), Management Today, July, 56-58.
Torrance, E. P. (1972) Can we teach children to think creatively?, Journal of Creative Behavior, **6**, 114-143.
Van de Ven, A.H. (1986) Central problems in the management of innovation, Management Science, **32**, 590-607.
Wallas, G. (1928) The art of thought, New York, NY, Harcourt-Brace.
West, M. A. (1990) The social psychology of innovation in groups, in M. A. West & J. L. Farr (Eds.), Innovation and creativity at work: Psychological and organizational strategies, Chichester, UK: Wiley.
West, M.A., & Anderson, N.R. (1996) Innovation in top management teams, Journal of Applied Psychology, **81**, 680-693.
Wolfe, R. (1994) Organizational Innovation: Review, critique and suggested research directions, Journal of Management Studies, **31**, 3, 405-431.