Chapter 10
Creative and Co-operative Science and Technology Education Course: Theory and Practice in Finnish Teacher Education Context

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10.1 Introduction

Previous studies have suggested different ways of emphasizing creative problem solving in small groups (e.g. Grabinger 1996; Dooley 1997; Hill 1999). A common feature of these approaches is to place students in the midst of a realistic, ill-defined, complex and meaningful problem, which has no obvious or correct solution. Students work in teams, collaborate and act as professionals and confront problems as they occur – with no absolute boundaries. Although they might receive insufficient information to solve problems, the students must settle on the best possible solution by a given date. This type of multistaged process is characteristic of effective and creative problem solving. According to Fischer (1990), the stages may include:

1. Formulating the problem
2. Recognition of facts related to the problem
3. Goal setting – ideation or generating alternatives
4. The evaluation of ideas
5. Choosing the solution
6. Testing and evaluating

When problem solving is creative, the ideas or products produced during the problem-solving process are both original and appropriate (Fisher 1990). For such purposes, various idea-generation techniques or ideation models are valuable (Smith 1998). The number of alternative solutions is important because the best way to come up with good ideas is to have plenty of choices (Parker 1991).

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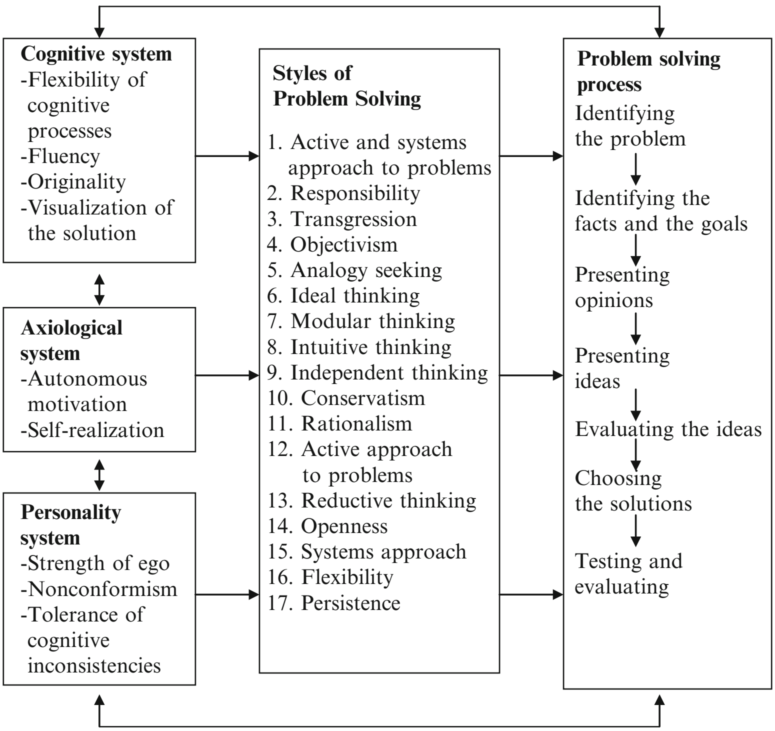

Fig. 10.1 Simplified model of the elements in the creative problem-solving process and the interaction of personal factors and styles of problem solving

Consequently, the outcome of the creative problem-solving process depends largely on the creative processes and styles of problem solving that have been learned and applied (see Fig. 10.1). In addition, there are factors of attitude (interest, motivation and confidence), cognitive ability (knowledge, memory and thinking skill) and experience (familiarity with the content, context and strategies) that influence problem-solving processes (Fisher 1990). For example, non-judgemental positive feedback and the acceptance of all ideas, even those which are absurd or impractical, are important in all creative and co-operative group processes (Higgins 1994). There should be sufficient encouragement for free ideation sessions. Evaluative critique should be given after the session has finished.

According to Strzalecki (2000), we can identify certain factors related to individuals' personal abilities and different styles of problem solving. In practice, the process of problem solving is very complicated and consists of many abstract concepts that cannot be defined completely and precisely. In Strzalecki's simplified model (Fig. 10.1), the various psychological domains connected with creative problem solving are concretised through the use of less abstract constructs. According to the model, the problem-solving process is based on the partly subconscious use of the cognitive, axiological and personality systems. If these systems do not help to find a perfect solution for a particular problem, an individual will try to find another solution by using different styles of problem solving. This simplified model of the elements in the creative problem-solving process and the interaction of personal factors and styles of problem solving is presented in Fig. 10.1.

10.2 The Creative and Co-operative Science and Technology Education Course

The plan for the creative and co-operative science and technology education course was based on the assumption that co-operative and creative problem solving would be valuable for developing a premium science and technology education study module for primary school teacher education. The goal of the course was to introduce our student teachers at the University of Helsinki to teaching methods that they could use to help pupils work co-operatively when they solve problems and make decisions during science and technology education teaching at their own schools.

As part of the course, the student teachers were asked to compose, plan and autonomously create an innovative new technological product. It could be a functioning piece of equipment or toy, system or process related to such themes as levers, crankshafts, gearwheels or moving and flying objects. Figure 10.2 presents a typical kind of product created in this exercise.

At the beginning of the course, the student teachers attended 2 h of lectures and demonstrations about creative problem solving. The sessions addressed different idea-generation techniques, such as brainstorming and analogous thinking. In addition, the student teachers became familiar with the theme through websites (Lavonen and Meisalo 2001) that presented problem-solving models and idea-generating techniques.

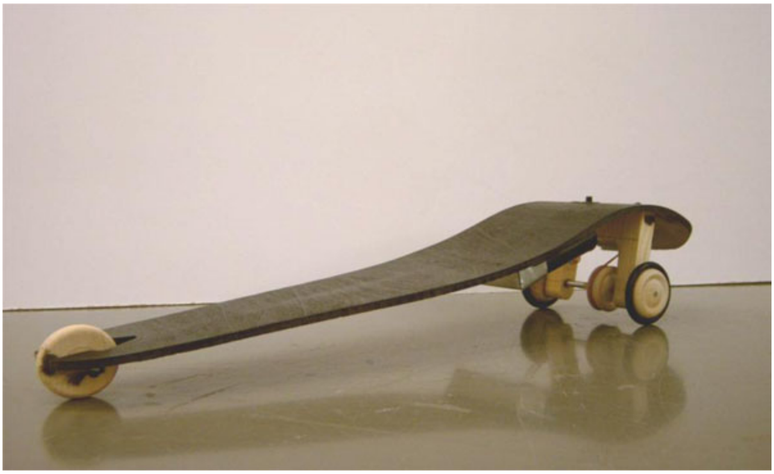

Fig. 10.2 An example of a technological product: a motorized mini roller board

The Problem: How to design a moving vehicle			
Facts: * Time limit * Electricity * Mechanics * Toy	**Opinions:** * Beautiful * Simple enough * Do we have enough skills? * Recycling material	**Goals:** * Useful * Moving vehicle * Modern * Must finish in time	**Visions:** *Artistic *Best seller *Creative
Approach A: Flying **Idea A1:** Airplane + Traditional + Interesting + Many options ? Does it fly? **Idea A2:** Helicopter + Not so usual + Innovative + Interesting + Exciting ? Is it flying **Idea A3:** Air balloon + Can really fly + Learn physics	**Approach B:** A car **Idea B1:** Police car + Easy to make + Kids like it + Interesting ? How to put something unusual **Idea B2:** Ambulance + Lights fit well with the idea + Interesting + Exciting ? How to get lights blinking **Idea B3:** Fire truck + Exciting	**Approach C:** A Ship **Idea C1:** Titanic + Easy + Traditional + Motivating story ? How to put something unusual **Idea C2:** Wing wheel + Innovative + Mechanics fit well + Interesting ? How to manage in time **Idea C3:** Submarine + Exciting + Periscope ? Does it really work?	**Approach D:** Stories **Idea D1:** Time machine + Historical perspective + Exciting + Innovative ? How to manage in time **Idea D2:** UFO + Innovative + Lights fit well + Futuristic perspective ? Mechanics **Idea D3:** Cows flying + Innovative + Not traditional ? How to keep in the air

Fig. 10.3 An example of the planning process expressed by an Overall Mapping of a Problem Situation (OMPS) constructed during the creative phase

The different abilities and skills needed in creative problem solving (e.g. creative, social and personal) and the ways to establish a creative and open atmosphere were discussed during the sessions. The sessions were followed by a 4-h workshop in which the students worked in small groups. To help the student teachers become familiar with problem-solving and decision-making processes, ideation techniques and the evaluation of ideas, we included a practical problem-solving model in the ideation process by introducing the Overall Mapping of a Problem Situation (OMPS) method (Sellwood 1991). In the workshops, the student teachers became familiar with the OMPS method by using it to plan the construction of a bridge or tower with newspapers.

During the planning phase of the project (4–8 h), groups of 3–4 students worked in 24 collaborative teams, where they generated a map of the creative process (Fig. 10.3). During this process, the student teachers had to find, formulate and specify the problem, and recognize the facts (certain rules and content that must be included in the course) and opinions related to the problem. Next, the teams set the problem or team assignment in a cogent phrase, such as the following: How can an interesting electric toy be constructed? In addition, the student teachers were required to set the goals and vision (ideal performance). Then, the student teachers had to create suitable approaches to solving the problem and generate problem-solving alternatives.

Every alternative idea was subsequently supported by presenting at least three positive reasons for its adoption (marked with + in Fig. 10.3). Non-judgemental, positive feedback and the acceptance of all ideas, even those which were absurd or impractical, were held as an important rule during all group problem-solving processes to generate various creative alternatives (Higgins 1994). Criticism of the ideas raised and posing of the question 'is it possible?' (marked with ? in Fig. 10.3) were reserved until later.

After a sufficient number of ideas had been generated, the student teachers chose the most appropriate solution by comparing the positive feedback and constructive questions that related to each idea. Typically, the final solution was a combination of several original ideas. During the ideation phase, the student teachers were encouraged to follow the OMPS method and utilize idea-generation techniques while working in groups. After selecting the final ideas, the student teachers then planned how they would build the structure or perform the process.

After generating various alternatives, evaluating them and designing and planning the product, the student teachers then created something new for their design solution process by utilizing paperboard, wood, metal and/or plastic and the appropriate tools. The teams spent approximately 12 h in the workshop, working according to their previously agreed plans. The intention was for the student teachers to be creative in their teams and modify their preliminary plans during the practical work session. Finally, each team presented their innovations to the other groups and evaluated both the innovations and the entire process, first by themselves and then with the others. The construction phase (working with the appropriate tools, using paperboard, wood, metal and other materials) was videotaped, but as interaction between the group members was based on physical action rather than verbal communication, it was not included in this study. An example of an OMPS map constructed during the creative phase is presented in Fig. 10.3.

Of the 118 student teachers participating in the course, 80% were female, and the average age of the participants was 24. According to the background information collected from the participants, 77% had little or no previous knowledge or experience of the content and methods of technology education. Less than 10% of the participating student teachers did not describe themselves as having a high level of motivation and responsibility in their work. Only about 15% of the participating student teachers thought that the course was of little significance to primary school teaching, or that the course offered little that was applicable to their work. In other words, 85–90% of the participants were satisfied with what they had learned on the course.

10.3 Empirical Research

The aim of this study was to examine student teachers' creativity by revealing the creative process and to find out the extent to which they learn creative skills, especially those involving generating alternative ideas and self-evaluating them. In addition, we tried to evaluate the interaction between student teachers in a problem-solving process that includes several phases, from recognizing a problem to testing and evaluating it, and in which a small group of student teachers together solved a problem in the context of science and technology education. The main research questions were:

1. What are the key factors in creative problem-solving processes from the point of view of primary school student teachers?
2. Did the student teachers learn any creative skills as a result of their participation in the course?
3. What kind of interaction was found during the problem-solving process?
4. What kinds of problem-solving styles were used in the problem-solving process?

10.3.1 Research Methods

In order to evaluate the creative problem-solving processes, a questionnaire consisting of 23 items was utilized. This yielded self-evaluative data on the student teachers' success regarding the conceptualization and evaluation of ideas and on their success with creative problem solving. Of the 118 participants, 85 answered the questionnaire.

The items were formulated on the basis of theoretical ideas about the features of creative problem-solving processes. For each Likert-type item, there were five alternatives, varying from 'Strongly Disagree' (=1) to 'Strongly Agree' (=5). The questionnaire included some items about the students' background, as well as items about their motivation and general success during the teaching experiment. The items were located randomly in the questionnaire, and it was accessible on the Internet. The student teachers were asked to fill in the questionnaire after the last meeting of the creative and co-operative science and technology education course.

Exploratory factor analysis was used to reduce the large number of original variables to a smaller number of factors. Furthermore, the aim was to examine how the problem-solving process was experienced by the student teachers. The Kaiser-Meyer-Olkin Measure (KMO) was .80, which is within a very reasonable range (Norusis 1988). Bartlett's test of sphericity also supported the use of a factor analytic approach (Bartlett's test = 845.9, $p < .00001$). Moreover, the skewness and kurtosis values were within a reasonable range and thus allowed the utilization of multivariate methods.

Although all our student teachers were asked to fill in a questionnaire, video recordings were used as an alternative data collection method. The recordings were made in the middle of the project, when student teachers were working in groups of three or four. The recordings were made from the beginning of the idea-generating process. Each recording continued until the student teachers had chosen the final alternative, which they further developed in the practical workshop. Each recording

Table 10.1 Description of the task categories in problem-solving activities and examples of typical student teachers' behaviour

Code	Description of the category	Example
+	Positive verbal or non-verbal feedback	That is ok
++	Very positive feedback	*That is very good*
0	Neutral feedback	*I do not know about that*
–	Negative feedback	*I do not like that idea*
1	Identifying the problem	*What is our problem in this project?*
1.2.	Facts related to the problem	*It must be a toy*
1.4.	Ideation of the problem	*A toy with some mechanics and electricity*
1.5.	Evaluation of the problem	*Is it just a toy or something else?*
2	Identifying the facts and the goals	*We must finish this in 10 h*
2.3.	Opinions related to the goals	*It must be nice and sweet*
2.4.	Ideation of the goals	*Is really learning something one of our goals?*
2.5.	Evaluation of the goals	*Is aesthetics really so important?*
3	Presenting the opinions	*These are just our own opinions, not facts*
3.5.	Evaluation of the opinions	*Do we really have to use the toy?*
3.8.	Development of the opinions	*We must built something that is useful*
4	Presenting the idea	*Can we build a car?*
4.2.	Facts related to the idea	*There must be lights on it*
4.3.	Opinions related to the idea	*Yes, but it must be simple enough*
4.5.	Evaluation of the idea	*It is easy to put electricity and mechanics on it*
4.8.	Development of the idea	*We can build a racing car*
5	Evaluation	*Is this really a good idea?*
5.3.	Opinions related to the evaluation	*First, we must have plenty of ideas*
6	Choosing the alternatives	*I like the idea of a racing car*
6.3.	Opinions related to the alternatives	*It is a good idea if we can make it simple enough*
6.5.	Evaluation related to the alternatives	*There are many positive things in this idea*

lasted for approximately 1 h. Consequently, we recorded a total of 3 h and 18 min of the student teachers' activities. The videos include all kinds of activities related to the idea-generating process, and the student teachers' discussions can be clearly heard on the tapes.

After the recordings had been made, a researcher viewed the videotapes twice and discussed the preliminary findings with his colleagues. After that, he transliterated all the verbal and non-verbal events on the videos. He played and replayed the videos at least four times to find out the specific meaning of the events and transcribed all natural talk between the student teachers. These notes comprised about 40 standard pages.

The categories we used for analysing the data reflected our theoretical background, while also taking into account the notes from the videos. Table 10.1 presents the main categories and subcategories along their definitions and typical examples.

10.4 Results of the Questionnaire

The questionnaire data were analysed using SPSS analytical software, utilizing principal axis factoring as the extraction method and varimax with Kaiser normalization as the rotation method. This method was used to determine how student teachers experienced the key factors in the creative problem-solving processes. The exact number of factors was determined by means of Cattell's scree test. Comprehensibility criteria were also used, and the number of factors was limited to four, since the meaning of the factors was readily comprehensible (Dunteman 1989). To determine the internal consistency of each factor, a Cronbach alpha coefficient, based on the average inter-item correlation, was determined for each factor. The Cronbach alpha coefficients varied between 0.83 and 0.88. Each factor therefore measured one quality, which allowed for a meaningful interpretation of the factors. On the other hand, no far-reaching generalizations were allowed regarding the structure or properties of the problem-solving processes. Factor analysis simply made it easier for us to describe how these 85 students experienced creative problem-solving processes during the course.

On an aggregate level, these four factors explained 57.2% of the common variance, with eigenvalues of 6.19, 2.14, 1.42 and 1.13, and percentages of total variance of 32.57%, 11.26%, 7.46% and 5.96%, respectively. A communality figure of 57.2% indicated that four factors could be used satisfactorily as predictors for all 19 variables. Moreover, the extent to which each item played a role in the interpretation of the factors was high. The eigenvalues indicate that Factor 1 covered most of the variance, accounting for roughly as much variance as the other factors combined.

Each of the four factors indicating the student teachers' perspectives on the problem-solving processes and the variables (items) that described the highest loading on each factor are presented in Table 10.2. There were three items that also had loadings of over 0.30 on factors other than their main factors, and these are discussed below. The factors were labelled on the basis of the researchers' discussion on the variables (items) loading on a factor. The mean and standard deviation (SD) of each item are also presented in Table 10.2.

Factor 1, *Success in problem-solving processes*, explained 32.5% of the total variance and included seven items. The first two items (F1I1 and F1I2) loading on this factor are connected to the problem-solving processes. Recognizing problems (F1I6) and restricting a problem (F1I7) are typically found in the initial phase of the problem-solving process. The creative atmosphere that is indicated in items F1I5 and F1I3 is necessary to establish a creative problem-solving process. Another prerequisite for successful problem solving would be knowledge about ideation techniques and ideation skills. These perspectives to problem-solving processes are indicated in items F1I3 and F1I4, which describe perspectives for ideation. However, they neither explain how student teachers succeeded in generating alternatives nor what the quality of their ideation was.

Factor 2, *Productive ideation,* consisted of six items and explained 11.3% of the variance. It indicated the students' opinions on their ideation skills. Two items

Table 10.2 Means and standard deviations (*SD*) and varimax (with Kaiser normalization rotated factor loadings for principal axis factoring) calculated from the items measuring primary school student teachers' (*n* = 85) opinions about the creative process on the course

	Mean	SD	Factor loading
F1: Success in problem-solving processes			
Cronbach α for the factor = 0.84			
F1I1: I learned to work according to the principles of creative processes	3.57	.94	.905
F1I2: I learned about the nature of creative processes	3.72	.92	.851
F1I3: I believe in the principle 'it is possible to generate new alternatives'	3.55	.90	.595
F1I4: I learned ideation models	3.87	.86	.570
F1I5: I learned to generate a creative atmosphere	3.11	.95	.564
F1I6: I learned to recognize problems around me	3.30	.90	.499
F1I7: I learned to identify (set) and restrict a problem	3.65	.79	.445
F2: Productive ideation			
Cronbach α for the factor = 0.83			
F2I1: I learned to generate original ideas	3.38	1.08	.709
F2I2: I learned to generate many alternatives	3.36	.89	.707
F2I3: I learned to be in turn both intuitive and systematic	3.37	.99	.655
F2I4: I learned to develop further ideas presented by other students	3.72	.90	.578
F2I5: I learned to trust the principle, 'if we have many ideas, at least some of them will be high-quality ideas'	3.91	.85	.558
F2I6: I used my creativity	3.48	.96	.487
F3: Collaborative support and evaluation			
Cronbach α for the factor = 0.87			
F3I1: I learned to give positive feedback to other students' ideas	4.02	.77	.882
F3I2: I learned to appreciate others' ideas	4.19	.76	.845
F3I3: I learned to recognize advantages in the ideas of others	4.14	.63	.657
F3I4: I take a positive (and constructive) attitude to the ideas the other students present	3.99	.78	.646
F4: Positive attitude			
Cronbach α for the factor = 0.88			
F4I1: I was positive in creative processes	3.59	.83	.930
F4I2: I took a positive attitude to creative processes	3.63	.91	.726

(F2I1 and F2I4) relate to the originality and imaginativeness of the ideas. It is important that ideas generated during a creative process are original – otherwise the process would be routine rather than creative. It is also important that students learn to combine and develop others' ideas further. The key issue for success in creative processes is how the creative power of the group can be utilized to find new, innovative ideas. The number of ideas (F2I2, F2I5) is also very important. It is known that at the beginning of an ideation session, common and familiar ideas typically come to mind. However, if a group produces many ideas, there is more change of some of them being highly original. It is important to use creativity (F2I6) and to be in turn both intuitive and systematic (F2I3) during the process of ideation.

Factor 3, *Collaborative support and evaluation*, consisted of four items and explained 7.5% of the variance. Items F3I1 and F3I4 related to whether the students learned to express their feedback positively and constructively. The two remaining items (F3I2, F3I3) dealt with positive attitudes when evaluating ideas.

The remaining two statements loaded on Factor 4, *Positive attitude*, explained 6.0% of the variance. Item F4I1 indicates whether the students behaved positively, and the other item (F4I2) deals with positive attitude, which is one of the main features in generating an open, encouraging and innovative atmosphere.

The mean values of the two first items loading on F1 were 3.6 and 3.7. Thus, most students thought they had learned about the nature of creative processes and also how to work according to the principles of creative processes. This was expected, as these topics were emphasized during both the lecture and the workshops concerning the nature of creative processes. Much time was also spent on understanding the meaning of ideation and the evaluation of ideas. The means of the items loading on the second factor indicate that, according to the self-evaluative data, the students had learned (at least reasonably well) to generate alternatives. The means of all the items loading on the third factor indicate that the students had, in their own opinion, learned how to give positive, constructive feedback regarding other students' ideas. It is worth noting that there was much discussion on how to give constructive feedback, and this was also practised during the project. The discussion even went as far as to examine the meaning and value of such behaviour during creative processes. The student teachers were familiar, for example, with how positive feedback defines what is valuable in an idea presented by another student. Moreover, positive peer feedback was important for enhancing the self-respect and confidence of other student teachers.

10.5 Results of the Video Recordings

In this study, three groups of three or four members were selected to be videotaped. The videotapes were later analysed with a focus on the steps in the creative problem-solving process and the styles of problem-solving process presented earlier in Fig. 10.1.

After defining the categories, all videotaped activities were analysed. In total, there were 570 spoken episodes with an average duration of 6.3 s during one 60-min videotaped period. In addition, 242 episodes of verbal or non-verbal feedback were registered. Most of the feedback given to other students was positive (160 episodes/67%). Neutral feedback was given in 76 episodes (31%), and negative feedback in only six episodes (2%). So the idea of non-judgemental positive feedback and the acceptance of all ideas, even those which were absurd or impractical, were realized, and there seemed to be room for free ideation.

All the episodes in the entire 60-min process were classified according to the stages of the problem-solving process (identifying the problem, identifying the facts, presenting opinions, presenting ideas, evaluation of the ideas and choosing the alternatives). These stages were explained in more detail, with examples of student teachers' typical behaviour, in Table 10.1. At the beginning of the process, most of the facts (certain rules and restrictions that must be included in the course) and goals were discussed during the first 20 min. In addition, the problem was identified, and most of the opinions were presented in the first 20-min period. However, the most typical problem-solving activity was presenting ideas, which accounted for 325 episodes (57% of all episodes). In more detail, this stage consisted of presenting an idea (98 episodes), facts related to the idea (9 episodes), opinions related to the idea (27 episodes) and development of the idea (191 episodes). Finally, a second typical problem-solving activity among student teachers was evaluation of the ideas, which accounted for 140 episodes (25% of all episodes).

In the next phase, we tried to discover the kinds of problem-solving styles that were used in each step of the problem-solving process. In this study, we focused on the six main categories of the creative process and on the styles of problem solving derived from Strzalecki's (2000) model, which was described earlier in this article. These problem-solving steps are also included in the OMPS method and are quite similar to the stages of the problem-solving process. The student teachers used many different problem-solving styles, but at the beginning, most of the styles were quite conservative and the ideas were not especially innovative. At this stage, most popular problem-solving styles were rationalism, conservatism and an active approach to problem.

The real idea-generating process started after the first 20 min and gathered pace throughout the 60-min period. Fourteen episodes (14%) where ideas were presented occurred in the first 20-min period. However, most of the ideas (58 episodes/59% of all ideas) were presented in the second 20-min period, with 26 such episodes (27%) occurring in the last 20-min period. In this phase, the problem-solving styles were much more open and flexible. The most popular styles were independent thinking, openness, flexibility and intuitive thinking. Problem-solving styles do not guarantee the quality of the ideas produced, but in this case, it was evident that the originality of the ideas and the level of imagination was not merely routine. The frequencies of each category are presented in Table 10.3.

Only 26 occasions (13%) involving the further development of ideas occurred in the first 20 min, while 70 occasions (37% of all development episodes) appeared in the second and as many as 95 occasions (50%) in the last 20-min period. It seems that if we want to get plenty of ideas, the idea-generating process must last at least 30 min. If the idea-generating process is short, the ideas and styles of problem solving are usually quite traditional and stereotyped and do not fulfil the goals of generating innovative processes in problem solving. The best way to get new, innovative ideas was to have as many ideas as possible for the student teachers to choose from and further develop.

10.6 Discussion

There have been numerous models available for curriculum changes in science and technology education and for introducing creative problem-solving processes for quite some time, both in the technology education literature and in school textbooks

Table 10.3 The frequency of problem-solving styles at each step of the problem-solving process. The categories are based on Strzalecki's (2000) model, which was presented earlier

Styles of solving problems (number of episodes)	Identifying the problem	Identifying the facts	Presenting opinions	Presenting ideas	Evaluation of the idea	Choosing the alternatives
	Frequencies	Frequencies	Frequencies	Frequencies	Frequencies	Frequencies
1. Active and systems approach to problems (26)	3	6	5	10	2	
2. Responsibility (42)	2	5	2	6	27	
3. Transgression (12)	2		3	5	2	
4. Objectivism (44)	1	3		15	25	
5. Analogy seeking (19)				19		
6. Modular thinking (21)		3	2	7	9	
7. Intuitive thinking (83)			4	75	4	
8. Conservatism (41)	6	8	12	9	6	
9. Rationalism (73)	7	5	10	36	14	1
10. Reductive thinking (42)				6	34	2
11. Openness (63)			5	52	5	1
12. Flexibility (104)		1	6	85	12	
Total (570)	**21**	**31**	**49**	**325**	**140**	**4**

(Johnsey 1995). However, in spite of some progress, the legacy of behaviourist, teacher-centred, whole-class teaching methodologies, with the teacher as expert and the student as the passive recipient of knowledge, repeatedly appears as the dominant orthodoxy in education to this day (Dakers 2005). An important function of science and technology education is to provide the opportunity to transcend from routine activities and low-level thinking, so that students can find new, innovative ideas and approaches to problem solving. This can be achieved, for example, by utilizing group dynamics or special creative methods (e.g. Smith 1998).

The present study shows that creativity cannot be taught directly, but it can be learned effectively through co-operative creative problem-solving processes. Based on the means and standard deviations of the self-evaluative data on creative process skills, we can assume that the Overall Mapping of a Problem Situation (OMPS) method helped our student teachers to understand the nature of creative processes and, in particular, that there are different phases involved in each of these processes. Factor 1 vindicates our assumption that most student teachers learned about the nature of creative processes and also how to work according to the principles of these processes. This result was to be expected as these topics were emphasized during both the lecture and the workshops.

Factors 2 and 3 indicate that the student teachers believed they had succeeded in generating alternatives and, in particular, had learned to evaluate and appreciate others' ideas. This means that the students felt they had learned to give positive feedback regarding other students' ideas, recognize the advantages of those ideas and even develop them further. We assume that a structured method, where each idea had to be supported by a presentation with at least three reasons for its adoption, was necessary for successful problem solving. Such evaluation creates a positive, non-judgemental atmosphere for creativity, and it helps participants to behave positively, as indicated in Factor 4.

The interaction data confirm that our student teachers learned to give positive feedback on other students' ideas, recognize the advantages of those ideas, and even develop them further. Our findings also suggest that the students worked co-operatively. The students shared their cognitive resources, talked, recognized facts, planned and evaluated with the aim of solving problems and producing a single outcome through dialogue and action.

The idea of the whole problem-solving process was to generate a large number of new, innovative ideas. The process started slowly, and in the beginning, only small number of ideas was produced. What is more, most of the ideas were quite conservative and not especially innovative. After the first 20 min, the idea-generating process accelerated all the time throughout the 60-min period. In addition, the problem-solving styles were much more open and flexible. The most popular styles in the last 20 min were independent thinking, openness, flexibility and intuitive thinking.

It seems that we must be patient at the beginning of the problem-solving process and try to give plenty of positive feedback, in order to build an open, supportive and permissive atmosphere. After half an hour, the idea-generating process will suddenly accelerate, and if we want to get large number of ideas, the process must last at least 30 min. In the end, the best way to get new and innovative ideas is to have plenty of ideas to choose from.

Nevertheless, some student teachers felt that they had not learnt enough about the generation of many original, new alternatives. Such skills are important when extremely new alternatives are required (Amabile 1996). From the point of view of further similar projects, it is important to note that more efficient guidance in generating alternatives is needed. Furthermore, students should receive a thorough introduction to creative problem solving in general (Williams and Williams 1997). Such training would be beneficial because many students became anxious when there was no formula or direct guidance to help them with their work. Although the students attended 2 h of lectures and demonstrations about creative problem solving and became familiar with the theme through websites, the learning process was not particularly active, as the lectures were given using traditional methods. As the student teachers were directly taught very little, they did not have sufficient planning and ideation skills. In fact, though manuals and handbooks were available all the time, the difficulty was that the student teachers did not have enough time to learn new knowledge during the activity stage.

It is easy to talk about creative problem solving in general, but organizing co-operative problem-solving situations and learning activities is not as easy as it seems (Murdock 2003), and it is even more difficult to measure and define this process with reliable concepts (Kaufman 2003). It will be interesting to see how our findings can be put into practice.

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